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Review Article

Competency-Based Assessment in Pharmacology Education: Global Evidence and Indian Perspectives

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ABSTRACT

Background: Competency-Based Medical Education (CBME) has reshaped undergraduate medical training worldwide, emphasizing outcomes, observable competencies, and workplace-based assessment. Pharmacology, a core para-clinical subject, faces unique challenges when translating CBME assessment principles into valid, feasible evaluation strategies.

Objectives: This scoping review maps the literature on competency-based assessment practices in pharmacology education, identifies assessment tools and approaches (including blueprinting, workplace-based assessment, simulation and digital assessments), summarizes global evidence, and highlights Indian perspectives, gaps, and implementation challenges.

Methods: We followed a structured scoping review approach, searching PubMed, PMC, Google Scholar and policy documents from the National Medical Commission (NMC). Key search concepts included "competency-based assessment", "pharmacology education", "workplace-based assessment", "blueprinting", and "India". Selected sources included systematic and narrative reviews, guideline documents, and original studies relevant to pharmacology education and CBME assessment.

Results: The literature emphasizes blueprinting, workplace-based assessment (mini-CEX, DOPS, CbD), objective structured practical examinations (OSPE/OSCE), simulation-based assessments, and the use of validity evidence to support assessment decisions. Globally, pharmacy and medical education literature report benefits in learner-centered feedback, improved performance in skills-based outcomes, and increased alignment with competencies. Indian policy documents and recent studies indicate growing adoption of CBME assessment frameworks, but challenges persist—faculty development, resource constraints, variability in blueprint application, and limited para-clinical WPBA application.

Conclusions: Competency-based assessment in pharmacology is feasible and promising but underdeveloped compared to clinical disciplines. Strategic actions—standardized blueprints tailored for pharmacology, faculty training in WPBA and feedback, simulation access, and multi-institutional research—are needed to strengthen assessment validity and ensure graduate competence.

Keywords: *competency-based medical education, pharmacology, assessment, blueprinting, workplace-based assessment, India*

INTRODUCTION

Competency-Based Medical Education (CBME) is an outcome-oriented approach that focuses on demonstrable abilities rather than time-based training. CBME emphasizes the attainment of predefined competencies and outcomes that are observable and measurable.[1] Regulatory frameworks—such as the National Medical Commission (NMC) competency modules—have catalyzed CBME adoption across India and reoriented assessments toward competencies, workplace-based observation, and structured feedback. (NMC competency modules, 2019–2024).[2]

The need for competency-based medical education (CBME) in pharmacology arises from a fundamental mismatch between traditional teaching approaches and the real-world expectations placed on medical graduates. Conventional pharmacology education has largely emphasized factual recall—drug classifications, mechanisms of action, and pharmacokinetics—often assessed through written examinations. However, safe and effective prescribing requires far more than knowledge; it demands the integration of clinical reasoning, patient-specific decision-making, communication skills, and an understanding of adverse drug reactions and medication safety. In this context, CBME provides a structured framework to shift the focus from "what students know" to "what they can do," ensuring that pharmacology training produces graduates who are not only knowledgeable but also competent in applying that knowledge in clinical settings. [3]

The evolving complexity of modern therapeutics further highlights the necessity of CBME in pharmacology. With the rapid expansion of drug options, biologics, personalized medicine, and polypharmacy in aging populations, the cognitive demands on physicians have increased significantly. Pharmacology education must therefore move beyond static knowledge to foster higher-order skills such as critical appraisal of evidence, therapeutic prioritization, and risk–benefit analysis. CBME supports this transition by aligning learning objectives, teaching methods, and assessments with these complex competencies. It encourages active learning strategies, case-based discussions, and simulation exercises that mirror clinical decision-making processes, thereby preparing students to navigate the uncertainties and complexities of contemporary medical practice. [4]

In the Indian context, the introduction of CBME by the National Medical Commission reflects a broader recognition of these challenges within the healthcare system. Variability in training quality, high patient loads, and the need for standardized graduate outcomes have made it imperative to adopt an outcomes-based educational model. Pharmacology, as a bridge between basic sciences and clinical practice, is uniquely positioned to benefit from this shift. CBME enables integration with clinical disciplines, promotes early clinical exposure, and facilitates the application of pharmacological principles in patient care scenarios. This integration is essential for developing prescribing competence, which is a critical responsibility of all physicians regardless of specialty. [5]

Finally, CBME in pharmacology is essential for fostering lifelong learning and professional accountability: graduates must be competent in rational prescribing, adverse drug reaction recognition and reporting, therapeutic decision-making, and patient counseling. This aligns with the global consensus that "safe and effective prescribing is a core competency expected of all medical graduates" (WHO Patient Safety Curriculum).[6] The rapidly changing landscape of therapeutics requires physicians to continuously update their knowledge and adapt their practices. By emphasizing reflection, feedback, and self-directed learning, CBME cultivates habits

that extend beyond undergraduate training. It also promotes a culture of accountability, where competence is demonstrated through performance rather than assumed based on time spent in training. In this way, CBME not only improves immediate educational outcomes but also contributes to the long-term goal of enhancing patient safety and quality of care.

However, para-clinical subjects face practical constraints for workplace-based assessment (WPBA) and skills observation compared with clinical disciplines.[7] One of the most fundamental difficulties lies in translating abstract competencies into measurable and observable outcomes within a para-clinical discipline. Unlike clinical subjects, where bedside interactions naturally lend themselves to direct observation, pharmacology competencies—such as therapeutic reasoning, rational prescribing, and pharmacovigilance—are often cognitive and context-dependent. This makes it challenging to design assessment strategies that are both authentic and feasible, leading many institutions to continue relying on traditional written examinations despite CBME mandates. [8]

A closely related challenge is the limited integration between pharmacology teaching and real clinical environments. CBME emphasizes workplace-based assessment and contextual learning, yet pharmacology is frequently taught in isolation during the early years of medical training. Opportunities for direct observation of prescribing behavior or patient counseling are therefore constrained. Even when clinical pharmacology components are introduced, variability in institutional infrastructure and coordination between departments often limits their effectiveness. This disconnects between curricular intent and ground-level implementation creates a gap that CBME seeks to bridge but has not yet fully resolved. [9]

Another important issue is the lack of validated, discipline-specific assessment tools for pharmacology. Much of the existing evidence on CBME assessment is derived from clinical disciplines or pharmacy education, with limited direct applicability to undergraduate medical pharmacology. Tools such as mini-CEX, DOPS, and case-based discussions require adaptation to fit pharmacology-specific tasks, and there is a paucity of robust psychometric data supporting their use in this context. This lack of evidence creates uncertainty among educators and hampers the standardization of assessment practices across institutions. [10]

Taken together, these challenges highlight the complexity of implementing CBME in pharmacology and the gaps in both evidence and practice. A scoping review is therefore warranted to systematically map existing approaches, identify successful strategies and limitations, and provide a structured foundation for future research and policy development. This scoping review aims to map global evidence on competency-based assessment approaches applicable to pharmacology education, synthesize Indian experiences and guidance, and propose directions for research and implementation.

MATERIALS & METHODS

This scoping review used a pragmatic search and mapping approach aimed at breadth rather than exhaustive systematic synthesis. Databases searched included PubMed/PMC, Google Scholar, and policy platforms (NMC) between January 2000 and February 2026. Keywords combined terms for competency-based assessment, pharmacology education, blueprinting, workplace-based assessment, simulation, and India. We prioritized:

1. Policy/guideline documents (NMC CBME modules and guidelines).
2. Systematic and scoping reviews on CBME assessment and pharmacy education.
3. Foundational WPBA literature (mini-CEX, DOPS, CbD).
4. Recent Indian empirical studies and educational innovations in pharmacology assessment.

Screening emphasized relevance to pharmacology as a discipline or to assessment approaches transferable to para-clinical contexts. Data extraction captured assessment types, validity/reliability evidence, implementation facilitators/ barriers, and Indian contextual factors.

RESULT

The mapped literature clustered around several themes relevant to competency-based pharmacology assessment: blueprinting, workplace-based assessment, OSPE/OSCE and simulation-based assessment, digital/AI tools, faculty development, and Indian policy/ implementation experiences.

Blueprinting and Assessment Design

Blueprinting emerged as a recurrent recommendation to ensure assessments align with competencies, cognitive levels, and learning outcomes. A well-constructed blueprint maps competencies to assessment methods and weightings, helping reduce sampling error and improving content validity. Blueprinting enhances content validity by ensuring appropriate sampling across learning objectives and competencies. Recent practical guidance and studies demonstrate blueprinting's role in creating defensible theory and practical papers in medical and pharmacology education. Furthermore, assessment drives learning, and blueprinting ensures that what is assessed reflects what is intended to be learned. [11]

In pharmacology, typical blueprint domains include factual knowledge (pharmacokinetics/pharmacodynamics), therapeutic reasoning (drug selection, dosing), prescription writing, ADR recognition, and communication skills. Studies show that blueprinting increases the representativeness of assessments and facilitates transparent score interpretation for stakeholders.

Workplace-Based Assessment (WPBA) in Para-clinical Contexts

WPBA tools—mini-CEX, DOPS, and case-based discussion (CbD)—are widely reported in clinical education and increasingly advocated for CBME. These methods enable direct observation, formative feedback, and assessment of applied competencies. Foundational reviews describe WPBA benefits and implementation principles, emphasizing faculty training and structured feedback. Additionally, the primary purpose of WPBA is to provide feedback to trainees to guide learning and improve performance.

The application of Workplace-Based Assessment (WPBA) in the field of pharmacology, while less prevalent than in core clinical disciplines, is demonstrably feasible and holds significant pedagogical value. The current lower adoption rate generally mirrors broader challenges encountered when integrating WPBA tools outside of traditional, direct patient care environments, necessitating careful contextual adaptation and substantial faculty engagement for successful implementation.

Several WPBA tools can be effectively leveraged within pharmacology education to assess distinct competencies:

- *Mini Clinical Evaluation Exercise (Mini-CEX)*: This tool is highly valuable for assessing a student's proficiency in essential communication and practical skills related to therapeutics, such as the ability to clearly and empathetically counsel a patient about their medications, or to succinctly and accurately explain potential adverse drug effects and necessary precautions.
- *Directly Observed Procedural Skills (DOPS)*: DOPS can be precisely tailored to evaluate core procedural tasks in clinical pharmacology, including the systematic process of prescription writing (ensuring legal requirements, clarity, and safety) and the crucial skill of medication reconciliation (comparing a patient's current list of medications

with new orders to resolve discrepancies).

- *Case-Based Discussion (CbD)*: CbD offers a powerful method to probe a student's deeper cognitive processes and therapeutic reasoning. By discussing a documented case or clinical scenario, educators can assess the student's ability to logically analyze patient factors, apply pharmacological principles to select appropriate drug therapy, anticipate drug interactions, and justify their management decisions.

Reflecting the global trend toward competency-based medical education (CBME), studies and commentaries specifically from the Indian context advocate strongly for the deliberate adaptation and integration of WPBA methods into para-clinical practical sessions and dedicated clinical pharmacology postings. This strategic implementation is viewed as a vital mechanism to effectively bridge the persistent gap between theoretical knowledge acquired in the classroom and the practical application of pharmacological principles in clinical settings, thereby producing graduates who are more competent and practice-ready.

OSPE/OSCE and Simulation-Based Assessment

Objective structured practical examinations (OSPE) and objective structured clinical examinations (OSCE) provide station-based, standardized assessment of skills and competencies. As originally conceptualized, "OSCE is designed to assess clinical competence in a planned and structured way with attention to objectivity". In pharmacology, OSPE stations can target prescription writing, ADR reporting, drug information retrieval, and simulated patient counseling. Simulation-based assessments (including high-fidelity mannequins or standardized patients) add realism for complex scenarios and have shown promise in pharmacy and medical education for assessing performance under realistic conditions. Literature supports that simulation allows learners to practice and be assessed in a safe environment that mimics real clinical scenarios.

Simulation centers and structured OSPEs enhance reliability and provide opportunities for direct observation, but resource intensity and faculty availability are barriers, especially in low-resource settings. High-fidelity simulation, while educationally effective, is resource intensive and requires institutional commitment.

Digital and AI-Assisted Assessment

Digital platforms and AI tools (question banks, virtual patients, automated scoring) are emerging as adjuncts for formative assessment and learner support. Reviews note opportunities—adaptive learning, automated feedback—but caution about academic integrity, regulatory oversight, and the need for validation. Indian discourse highlights both enthusiasm and skepticism toward AI applications in CBME.

Faculty Development and Assessment Literacy

Multiple reviews and Indian guideline documents stress the centrality of faculty development to implement CBME assessments effectively. Faculty require training in blueprinting, WPBA conduct and feedback, OSPE design, and psychometrics. Without sustained development, assessments risk poor validity, inconsistent scoring, and variable student experiences. Indian implementation reports frequently cite faculty readiness and time constraints as primary barriers.

Indian Policy and Empirical Studies

Regulatory drivers: regulatory bodies play a critical role in driving curricular reform toward competency-based models. The NMC's competency modules and CBME guidelines have formalized competency lists and encouraged WPBA and formative assessments across undergraduate years. These policy documents form the backbone for curricular reform in India.

Empirical evidence: Recent Indian studies show variable but growing uptake of CBME-aligned assessments in pharmacology. Examples include blueprinting exercises for theory papers and small-scale WPBA pilots adapted to pharmacology practicals. Reported benefits include improved alignment with competencies and enhanced student engagement; persistent challenges include resource constraints, inconsistent blueprint application, and variable faculty assessment literacy.

Table 1. Competency-Based Assessment Methods in Pharmacology Education

Assessment Method	Core Competencies Assessed	Application in Pharmacology	Strengths	Limitations
Blueprinting	Alignment of competencies, cognitive levels	Mapping pharmacology syllabus (PK/PD, therapeutics, ADRs) to exams	Improves content validity; ensures balanced assessment	Requires expertise; time-intensive
Written Exams (SAQ/MCQ)	Knowledge, clinical reasoning	Drug mechanisms, therapeutic choices, adverse effects	Scalable; objective (MCQs)	Limited assessment of skills/attitudes
OSPE/OSCE	Skills, application, communication	Prescription writing, ADR reporting, patient counseling	Standardized; high reliability	Resource- and faculty-intensive
Workplace-Based Assessment (mini-CEX, DOPS, CbD)	Applied competence, communication, professionalism	Counseling patients, prescription audit, therapeutic reasoning	Real-world relevance; rich feedback	Feasibility challenges in para-clinical settings
Simulation-Based Assessment	Clinical decision-making, emergency response	ADR management, poisoning cases, rational prescribing	Safe, realistic environment	High cost; infrastructure needed
Digital/AI-Based Tools	Knowledge, adaptive learning, formative feedback	Virtual patients, drug selection exercises	Immediate feedback; scalable	Concerns about validity, academic integrity
Portfolio/Logbook	Longitudinal competence, reflection	Prescription records, ADR reports, case reflections	Encourages reflective learning	Subjective; requires faculty mentoring

Table 2. Implementation of CBME Assessment in Pharmacology: Indian Context

Domain	Current Status in India	Challenges Identified	Potential Solutions
Policy Framework	NMC CBME curriculum mandates competency-based assessment	Variable interpretation across institutions	Standardized national guidelines for pharmacology assessment
Blueprinting	Increasing adoption in theory and practical exams	Inconsistent application; limited faculty training	Faculty development workshops; shared blueprint templates
WPBA Implementation	Limited pilot use in pharmacology practicals	Lack of clinical exposure; time constraints	Integrate with clinical postings; adapt tools for simulated settings
OSPE/OSCE	Used in some institutions	Resource and manpower constraints	Regional simulation centers; shared resources
Simulation-Based Assessment	Emerging but limited	High cost; infrastructure gaps	Inter-institutional collaboration; low-cost simulation models
Faculty Development	Recognized as essential	Inadequate training; workload burden	Structured FDPs; incentives for participation
Assessment Culture	Transitioning from traditional exams	Resistance to change; lack of assessment	Continuous sensitization; institutional leadership

		literacy	support
Research & Validation	Sparse pharmacology-specific studies	Limited psychometric evidence	Multi-center collaborative research initiatives

Synthesis: Strengths, Gaps and Transferability

***Strengths of current evidence*:**
- Clear consensus that assessment should align with defined competencies and use multiple methods (written, observed, practical, workplace-based) to capture different facets of competence.
- Demonstrated benefits of blueprinting and station-based assessments in improving content validity and reliability.
- WPBA provides formative feedback and assesses applied competencies—valuable when adapted to para-clinical tasks.

***Key gaps*:**
- Limited discipline-specific research focused solely on pharmacology assessment using CBME principles; much of the evidence is extrapolated from clinical or pharmacy education literature.
- Sparse robust psychometric studies validating WPBA or simulation-based tools in para-clinical contexts.
- Implementation barriers in India: faculty readiness, time, infrastructure, and assessment culture inertia.

***Transferability considerations*:**
- Tools successful in clinical settings can be adapted to pharmacology with contextual modifications (e.g., simulated counseling stations, prescription DOPS), but require local piloting and validation.

DISCUSSION

This scoping review mapped global and Indian literature relevant to competency-based assessment in pharmacology education. The findings support a multi-method assessment strategy: blueprinting ensures representativeness; station-based OSPE/OSCE and simulation capture applied skills; WPBA and structured feedback promote real-world competence and professional development.

Challenges for the implementation of CBME in pharmacology are practical in nature as Pharmacology involves a vast amount of foundational knowledge that doesn't always translate easily into discrete, observable tasks. Unlike bedside clinical skills, many pharmacology competencies are cognitive or paper-based (therapeutic reasoning, prescription writing) and traditionally assessed via written exams. Yet, WPBA and station-based assessments can be designed to assess these domains effectively—through observed prescription tasks, simulated patient counseling, and case-based discussions focusing on therapeutic decision-making. Successful implementation depends heavily on faculty development, institutional buy-in, and allocation of resources for simulation and standardized assessments. [12]

A critical yet underemphasized dimension of competency-based assessment in pharmacology is the concept of programmatic assessment. Rather than relying on isolated high-stakes examinations, programmatic assessment advocates for the deliberate aggregation of multiple low- and high-stakes assessment data points over time to inform robust decisions about competence. As articulated in the literature, "no single assessment method can provide sufficient evidence for competence; meaningful decisions require multiple data points collected longitudinally" (van der Vleuten et al.).[13] In the context of pharmacology, this approach is particularly valuable because competencies such as rational prescribing and therapeutic reasoning develop progressively and are best captured through repeated observations, case discussions, and structured feedback. Embedding blueprinting, OSPE/OSCE, and adapted

WPBA within a programmatic framework could therefore enhance both validity and educational impact, moving assessment from episodic evaluation toward continuous learning.

Indian policy momentum (NMC modules, CBME guidelines) provides an enabling environment, but translation into consistent practice requires clear, discipline-specific blueprints, validated assessment instruments for para-clinical tasks, and multicenter research to generate psychometric evidence. International lessons—especially from pharmacy education where simulation and performance assessment are more mature—offer transferable models but must be adapted to local constraints and cultural contexts. [14]

Another important consideration is the alignment between assessment practices and real-world prescribing responsibilities, often referred to as constructive alignment. While traditional pharmacology assessments have emphasized factual recall, CBME requires a shift toward evaluating authentic tasks that reflect clinical practice. Educational theory emphasizes that "students learn what they are assessed on, and assessment should therefore reflect the intended learning outcomes and professional tasks" (Biggs).[15] In pharmacology, this implies prioritizing assessment of prescription writing, drug selection in clinical scenarios, adverse drug reaction reporting, and patient counseling over purely theoretical knowledge. Furthermore, incorporating interprofessional and systems-based elements—such as medication safety and pharmacovigilance—can better prepare graduates for healthcare delivery contexts. Aligning assessment with these real-world competencies not only improves readiness for clinical practice but also reinforces the broader goal of CBME: producing safe, effective, and reflective practitioners.

Recommendations

For educators and institutions:

1. Develop discipline-specific assessment blueprints for pharmacology that map NMC competencies to assessment methods and cognitive levels.
2. Pilot WPBA tools (mini-CEX, DOPS, CbD) during clinical pharmacology rotations and practical sessions; collect validity and feasibility data.
3. Implement station-based OSPE/OSCE stations for prescription writing, ADR reporting, and counseling with standardized checklists.
4. Invest in faculty development programs focusing on assessment literacy, feedback skills, and psychometrics.
5. Use simulation and standardized patients where feasible; collaborate regionally to share simulation resources.
6. Encourage multi-institutional research to validate assessment tools and publish psychometric evidence.

For researchers:

- Conduct rigorous validation studies for WPBA and OSPE tools tailored to pharmacology.
- Evaluate the impact of CBME-aligned assessments on prescribing competence and patient-related outcomes.

Limitations

This scoping review used a pragmatic search strategy and did not attempt exhaustive systematic searching or formal quality appraisal. While it prioritized policy documents, reviews, and transferable evidence, some relevant primary studies may have been missed. The rapid evolution of CBME and AI tools also means recent developments (post-February 2026) may not be fully captured.

CONCLUSION

Competency-based assessment in pharmacology education is both necessary and achievable. A blended assessment approach—underpinned by clear blueprints, station-based assessments, WPBA adapted to para-clinical tasks, and strong faculty development—offers the best path to ensure graduates are competent prescribers and medication stewards. India's policy

frameworks create momentum; the next steps are discipline-specific implementation, validation studies, and capacity building.

Declaration by Authors

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