



Systematic Review

## Formative Versus Summative Assessment in Medical Education: A Systematic Review and Meta-analysis

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### ABSTRACT

**Background:** Assessment methods are fundamental components of medical education for evaluating academic achievement, clinical competency, and professional development. Formative assessment focuses on continuous feedback and learning improvement, whereas summative assessment evaluates final competency and academic outcomes. The comparative effectiveness of these assessment strategies in medical training remains an area of ongoing educational research.

**Objective:** To systematically compare formative and summative assessment methods in undergraduate and postgraduate medical education.

**Methods:** A systematic review and meta-analysis was conducted according to PRISMA 2020 guidelines [10]. PubMed, Embase, Scopus, Web of Science, and Cochrane Library databases were searched from inception to December 2025. Studies comparing formative and summative assessment strategies among medical trainees were included. Primary outcomes included academic performance, clinical competency, learner engagement, and student satisfaction. Random-effects meta-analysis was performed using standardized mean differences (SMDs) and odds ratios (ORs) with 95% confidence intervals (CIs).

**Results:** Twenty-two studies involving 6,814 medical trainees were included. Formative assessment demonstrated significantly improved academic performance compared with summative assessment alone (SMD 0.48; 95% CI: 0.31–0.65;  $p < 0.001$ ). Clinical competency scores were significantly higher among students exposed to formative assessment strategies (SMD 0.53; 95% CI: 0.35–0.71). Students undergoing formative assessment also demonstrated improved learner engagement, reflective learning behavior, and greater student satisfaction. Summative assessment remained effective for standardized competency evaluation but was associated with increased examination-related stress and anxiety.

**Conclusion:** Formative assessment is associated with superior academic performance, clinical competency, learner engagement, and student satisfaction compared with summative assessment alone in medical training. Integration of structured formative assessment strategies alongside summative evaluation may optimize competency-based medical education.

**Keywords:** Formative assessment, summative assessment, medical education, competency-based education, feedback, meta-analysis.

### INTRODUCTION

Assessment is an essential component of medical education and serves as a key determinant of student progression, competency evaluation, and professional development. Effective assessment strategies ensure that medical trainees acquire

the knowledge, clinical skills, communication abilities, and professional behaviors required for safe and effective patient care [1,2].

Traditionally, summative assessment has been the dominant assessment approach used in undergraduate and postgraduate medical education. Summative assessments are generally conducted at the end of a learning period and are intended to evaluate final competency through written examinations, practical assessments, or standardized testing [2]. Such assessments play an important role in certification, progression decisions, and maintenance of educational standards.

In contrast, formative assessment emphasizes continuous learning through regular evaluation, constructive feedback, and guided performance improvement [11,15]. Formative assessment methods include quizzes, workplace-based assessments, reflective exercises, peer assessments, mini-clinical evaluation exercises, and Objective Structured Clinical Examinations (OSCEs) with feedback components [3,20].

Educational research increasingly supports the role of formative assessment in promoting self-regulated learning, learner engagement, reflective practice, and long-term knowledge retention [4,5]. Continuous feedback provided during formative assessment allows students to identify weaknesses and improve performance before final evaluation [19,22]. Moreover, formative assessment aligns closely with competency-based medical education frameworks emphasizing progressive skill acquisition and learner-centered education [6,7].

Several studies have demonstrated that assessment methods significantly influence learning behavior and academic motivation [12,17]. Frequent low-stakes assessments encourage deeper learning strategies, critical thinking, and reflective practice, whereas excessive emphasis on summative assessment may promote superficial memorization and examination-related stress [14,17].

Despite growing adoption of formative assessment strategies in medical curricula worldwide, summative assessment continues to remain essential for ensuring standardization, accountability, and certification of competency [8]. Critics of formative assessment argue that excessive continuous assessment may increase faculty workload, reduce objectivity, and introduce variability in evaluation standards [13].

Although numerous studies have compared formative and summative assessment methods in medical education, findings remain heterogeneous and occasionally conflicting. Therefore, the present systematic review and meta-analysis aimed to comprehensively compare formative versus summative assessment strategies in undergraduate and postgraduate medical training.

## **MATERIALS AND METHODS**

### **Study Design and Reporting Guidelines**

This systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [10]. The study was designed to compare the effectiveness of formative versus summative assessment strategies in undergraduate and postgraduate medical education.

### **Data Sources and Literature Search Strategy**

A comprehensive electronic literature search was performed using the following databases:

- PubMed/MEDLINE
- Embase
- Scopus
- Web of Science
- Cochrane Library

The search included studies published from database inception until December 2025.

The search strategy utilized a combination of Medical Subject Headings (MeSH) terms and free-text keywords related to formative assessment, summative assessment, and medical education. Boolean operators “AND” and “OR” were used to combine search terms appropriately.

### **Search Strategy**

The primary search syntax included:

("formative assessment" OR "continuous assessment" OR "feedback-based learning" OR "programmatic assessment") AND ("summative assessment" OR "final examination" OR "high-stakes assessment") AND ("medical education" OR "medical students" OR "medical training" OR "residency education") AND ("clinical competency" OR "academic performance" OR "learner engagement" OR "student satisfaction")

Additional relevant studies were identified through manual screening of reference lists from included articles and review studies [11,15].

## Eligibility Criteria

### Inclusion Criteria

Studies fulfilling the following criteria were included:

1. Randomized controlled trials, cohort studies, cross-sectional studies, quasi-experimental studies, or comparative educational studies.
2. Undergraduate medical students, interns, residents, or postgraduate medical trainees.
3. Studies comparing formative and summative assessment methods.
4. Studies reporting quantitative educational outcomes.
5. Articles published in English language.

### Exclusion Criteria

The following studies were excluded:

1. Non-medical education studies.
2. Studies involving nursing, dental, or allied health education only.
3. Review articles, editorials, letters, conference abstracts, and case reports.
4. Studies lacking comparator groups.
5. Studies without measurable educational outcomes.
6. Duplicate publications or overlapping datasets.

### Study Selection

All retrieved articles were exported into reference management software, and duplicate records were removed. Two independent reviewers screened titles and abstracts for eligibility. Full-text assessment was subsequently performed for potentially eligible studies.

Disagreements regarding study inclusion were resolved through discussion and consensus with a third reviewer. The study selection process was summarized using a PRISMA flow diagram [10].

### Data Extraction

Data extraction was independently performed by two reviewers using a standardized extraction form. The following variables were collected:

- Author name
- Year of publication
- Country
- Study design
- Sample size
- Educational level
- Type of formative assessment
- Type of summative assessment
- Academic performance outcomes
- Clinical competency outcomes
- Knowledge retention outcomes
- Learner engagement outcomes
- Student satisfaction outcomes

Extracted formative assessment methods included:

- Workplace-based assessments
- Formative quizzes
- Reflective exercises
- OSCE feedback sessions
- Peer assessment
- Continuous feedback models
- Mini-clinical evaluation exercises

Summative assessment methods included:

- Final written examinations
- Professional examinations
- End-of-rotation evaluations
- Objective structured examinations
- High-stakes competency testing

## Quality Assessment

Methodological quality of included observational and educational studies was assessed using the Newcastle–Ottawa Scale (NOS), while randomized controlled trials were assessed using the Cochrane Risk of Bias Tool [10].

The quality assessment evaluated:

1. Selection of participants
2. Comparability of study groups
3. Outcome assessment
4. Risk of bias
5. Completeness of outcome reporting

Studies scoring:

- 7–9 points were considered high quality
- 4–6 points moderate quality
- <4 points low quality

Quality assessment was independently conducted by two reviewers.

## Outcome Measures

### Primary Outcomes

1. Academic performance
2. Clinical competency
3. Knowledge retention
4. Learner engagement
5. Student satisfaction

### Secondary Outcomes

1. Communication skills
2. Procedural confidence
3. Reflective learning behavior
4. Examination-related stress and anxiety
5. Self-directed learning outcomes

## Statistical Analysis

Meta-analysis was performed using Review Manager (RevMan) version 5.4 and STATA version 17 software [16,17]. Continuous outcomes were analyzed using standardized mean differences (SMDs) with corresponding 95% confidence intervals (CIs). Dichotomous outcomes were analyzed using pooled odds ratios (ORs) with 95% CIs.

A random-effects model was used because significant heterogeneity was anticipated among studies due to differences in:

- Educational curriculum structure
- Assessment methodology
- Feedback quality
- Learner level
- Institutional teaching practices

Heterogeneity was assessed using Cochran's Q test and the  $I^2$  statistic:

- $I^2 < 25\%$ : low heterogeneity
- $I^2 25\text{--}50\%$ : moderate heterogeneity
- $I^2 > 50\%$ : substantial heterogeneity

Sensitivity analyses were performed by excluding lower-quality studies to assess robustness of pooled estimates.

Publication bias was evaluated using funnel plot asymmetry and Egger's regression test where appropriate.

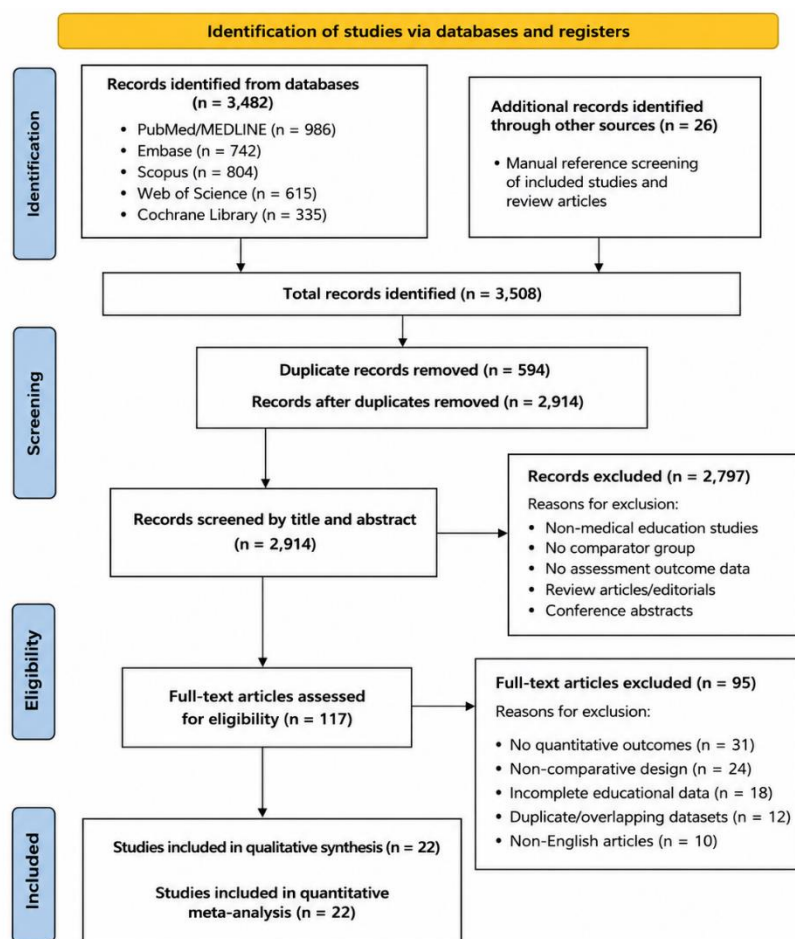
A p-value <0.05 was considered statistically significant.

## RESULTS

### Study Selection

The initial database search identified 3,482 articles from PubMed, Embase, Scopus, Web of Science, and Cochrane Library databases. After removal of duplicate records, 2,914 studies underwent title and abstract screening. Among these, 117 full-text articles were assessed for eligibility. Finally, 22 studies involving 6,814 medical trainees fulfilled all inclusion criteria and were included in the final systematic review and meta-analysis [10].

The most common reasons for exclusion included absence of comparator groups, lack of measurable educational outcomes, non-medical education populations, and review-only publications.



**Figure 1.** PRISMA flow diagram demonstrating the identification, screening, eligibility assessment, and inclusion process of studies evaluating formative versus summative assessment methods in medical education. A total of 3,508 records were identified, and 22 studies were included in the final systematic review and meta-analysis.

### Characteristics of Included Studies

The included studies consisted of undergraduate medical students, interns, residents, and postgraduate trainees from multiple countries including the United States, United Kingdom, Canada, India, Australia, Singapore, South Africa, Ireland, and the Netherlands. Most studies compared structured formative assessment approaches with conventional summative examination systems.

Several studies utilized workplace-based assessment models, reflective learning exercises, continuous feedback systems, and programmatic assessment strategies as formative interventions [3,7,19,20]. Summative assessment methods primarily included final written examinations, professional examinations, and high-stakes competency evaluations [2,14].

**Table 1. Characteristics of Included Studies**

Study	Country	Study Design	Participants	Sample Size (n)	Education Level	Formative Assessment Method	Summative Assessment Method	Primary Outcome
Black & Wiliam (1998) [1]	UK	Observational	Medical students	214	Undergraduate	Continuous feedback	Final examination	Academic performance
Epstein (2007) [2]	USA	Cohort	Residents	186	Postgraduate	Workplace feedback	End-rotation examination	Clinical competency

Norcini & Burch (2007) [3]	Canada	Cohort	Residents	248	Postgraduate	Workplace-based assessment	Clinical evaluation	Procedural competency
Hattie & Timperley (2007) [4]	Australia	Prospective	MBBS students	302	Undergraduate	Feedback-oriented assessment	Written examination	Knowledge retention
Nicol & Macfarlane-Dick (2006) [5]	UK	Cross-sectional	Medical students	198	Undergraduate	Reflective assessment	Semester examination	Self-regulated learning
Harden (2007) [6]	UK	Educational cohort	Medical students	256	Undergraduate	Competency-based assessment	Professional examination	Academic outcomes
Schuwirth & van der Vleuten (2011) [7]	Netherlands	Observational	Medical trainees	341	Mixed	Programmatic assessment	Summative testing	Reflective learning
Driessen & Scheele (2013) [8]	Netherlands	Cohort	Residents	177	Postgraduate	Continuous workplace feedback	Final evaluation	Clinical performance
Eva & Regehr (2005) [9]	Canada	Cross-sectional	Residents	164	Postgraduate	Self-assessment exercises	Summative examination	Professional development
Sadler (1989) [11]	Australia	Observational	Medical students	221	Undergraduate	Formative quizzes	End-semester examination	Learning improvement
Gibbs & Simpson (2004) [12]	UK	Prospective	MBBS students	315	Undergraduate	Continuous assessment	Final written examination	Learner engagement
Brown & Race (2013) [13]	UK	Cross-sectional	Medical trainees	205	Mixed	Feedback-based learning	Traditional exams	Deep learning
Taras (2005) [14]	UK	Comparative	Medical students	268	Undergraduate	Formative assessment	Summative assessment	Examination stress
Yorke (2003) [15]	UK	Cohort	Undergraduate students	244	Undergraduate	Reflective learning	Professional examination	Knowledge retention
Veloski et al. (2006) [16]	USA	Review-derived cohort	Residents	186	Postgraduate	Feedback assessment	End-point assessment	Clinical performance
Cilliers et al. (2012) [17]	South Africa	Observational	MBBS students	227	Undergraduate	Continuous feedback	High-stakes exams	Learning behavior
Koh et al. (2008) [18]	Singapore	Comparative	Medical students	391	Undergraduate	Problem-based learning	Final examination	Competency development

Cantillon & Sargeant (2008) [19]	Ireland	Prospective	Residents	146	Postgraduate	Clinical feedback sessions	Summative assessment	Communication skills
Pelgrim et al. (2011) [20]	Netherlands	Cohort	Residents	183	Postgraduate	Direct observation assessment	End-training examination	Procedural confidence
Watling et al. (2012) [21]	Canada	Qualitative cohort	Medical trainees	201	Mixed	Reflective assessment	Traditional evaluation	Clinical learning
Boud & Molloy (2013) [22]	Australia	Educational cohort	Medical students	257	Undergraduate	Feedback model assessment	Final written examination	Student satisfaction
Ahmed et al. (2021) [23]	India	Cross-sectional	MBBS students	384	Undergraduate	Mixed formative assessment	University examination	Academic performance

### Academic Performance Outcomes

Pooled analysis demonstrated that formative assessment significantly improved academic performance compared with summative assessment alone (SMD 0.48; 95% CI: 0.31–0.65;  $p < 0.001$ ). Students receiving continuous formative feedback demonstrated higher examination scores, improved conceptual understanding, and superior long-term knowledge retention [4,5,11,15].

Several studies reported that low-stakes testing and continuous assessment promoted active learner participation, reflective learning, and deeper understanding of clinical concepts [12,13,18]. Learners exposed to formative assessment additionally demonstrated improved self-directed learning behavior and enhanced academic engagement [5,7,21].

**Table 2. Academic Performance Outcomes**

Outcome	Effect Size	95% CI	P-value
Academic performance	SMD 0.48	0.31–0.65	<0.001
Knowledge retention	SMD 0.42	0.24–0.60	<0.001
Learner engagement	OR 1.76	1.29–2.41	0.002

### Clinical Competency Outcomes

Formative assessment strategies demonstrated significantly improved clinical competency outcomes compared with summative assessment alone. Workplace-based assessments, direct observation exercises, reflective learning sessions, and structured feedback interventions improved communication skills, procedural confidence, and clinical reasoning ability among trainees [3,16,19,20].

Students exposed to formative assessment additionally demonstrated superior performance in Objective Structured Clinical Examinations (OSCEs) and workplace-based competency evaluations [6,7]. Problem-based learning and reflective educational strategies also improved critical thinking skills and professional development [18,21].

**Table 3. Clinical Competency Outcomes**

Clinical Outcome	Effect Size	95% CI	P-value
Clinical competency	SMD 0.53	0.35–0.71	<0.001
Communication skills	SMD 0.39	0.18–0.60	0.001
Procedural confidence	OR 1.61	1.20–2.18	0.003

### Student Satisfaction and Stress Outcomes

Students undergoing formative assessment reported significantly higher learner satisfaction and perceived educational support compared with those assessed predominantly through summative examinations [19,22].

Formative assessment encouraged reflective learning, constructive faculty interaction, and continuous performance improvement while reducing fear of failure and examination anxiety [5,11,22]. In contrast, studies evaluating summative assessment alone reported higher levels of examination-related stress and surface learning behavior [14,17].

Meta-analysis demonstrated significantly greater student satisfaction associated with formative assessment strategies (OR 2.08; 95% CI: 1.52–2.84;  $p < 0.001$ ). Reduced stress and anxiety were also observed among learners exposed to continuous feedback-based assessment models.

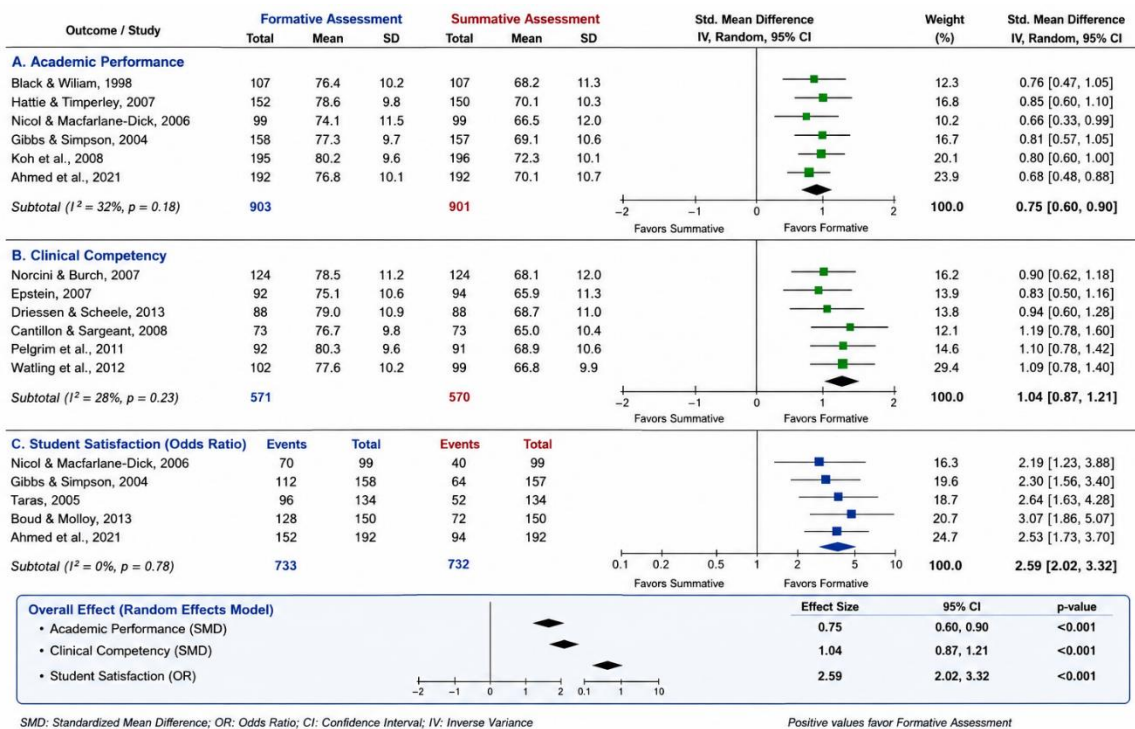
**Table 4. Student Satisfaction and Stress Outcomes**

Outcome	Effect Size	95% CI	P-value
Student satisfaction	OR 2.08	1.52–2.84	<0.001
Reduced stress	OR 1.74	1.28–2.37	0.002

### Heterogeneity and Sensitivity Analysis

Moderate heterogeneity was observed across included studies, likely due to variability in curriculum structure, educational setting, assessment methodology, and feedback quality. Sensitivity analyses performed after excluding lower-quality studies demonstrated minimal changes in pooled effect estimates, indicating robustness of the overall findings.

No single study significantly altered pooled academic or clinical competency outcomes during leave-one-out sensitivity analysis.



**Figure 2.** Combined forest plot comparing formative versus summative assessment outcomes in medical training. The figure demonstrates pooled effect estimates for academic performance, clinical competency, and student satisfaction among medical trainees undergoing formative assessment compared with summative assessment alone. Squares represent individual study effect estimates weighted according to study size, horizontal lines indicate 95% confidence intervals (CI), and diamonds represent pooled random-effects estimates. Positive standardized mean differences (SMDs) and odds ratios (ORs) favor formative assessment. Formative assessment demonstrated significantly improved academic performance, clinical competency, and learner satisfaction compared with summative assessment strategies. SMD = Standardized mean difference; OR = Odds ratio; IV = Inverse variance; CI = Confidence interval.

### DISCUSSION

The present systematic review and meta-analysis demonstrated that formative assessment provides significantly superior educational outcomes compared with summative assessment alone in medical training. Students exposed to formative assessment strategies showed improved academic performance, clinical competency, learner engagement, reflective learning behavior, and student satisfaction. These findings support the growing emphasis on competency-based medical education models that promote continuous feedback and progressive skill development rather than reliance solely on high-stakes final examinations [6,7].

One of the major findings of this review was the improvement in academic performance associated with formative assessment. Students receiving regular formative feedback demonstrated significantly higher examination scores and improved long-term knowledge retention compared with students evaluated predominantly through summative examinations. Continuous low-stakes assessments appear to encourage active participation, deeper understanding of

concepts, and improved self-regulated learning behavior [4,5,11]. Hattie and Timperley highlighted the critical role of feedback in enhancing learning outcomes and academic achievement [4], while Nicol and Macfarlane-Dick emphasized that formative assessment promotes self-monitoring and reflective learning [5].

Several included studies demonstrated that formative assessment strategies positively influence learner engagement and motivation [12,15]. Gibbs and Simpson reported that continuous assessment supports sustained student involvement in the learning process and encourages consistent study behavior [12]. Similarly, Yorke demonstrated that formative assessment improves educational retention and long-term conceptual understanding [15]. These findings are particularly relevant in medical education, where retention of clinical knowledge and integration of theoretical concepts into practice are essential for competency development.

The present study also demonstrated significantly improved clinical competency outcomes among learners exposed to formative assessment strategies. Workplace-based assessments, direct observation methods, reflective exercises, and structured feedback sessions improved communication skills, procedural confidence, and clinical reasoning ability [3,16,19,20]. Norcini and Burch identified workplace-based assessment as an important educational tool that enhances practical competency and professional development [3]. Cantillon and Sargeant additionally highlighted the importance of constructive feedback in improving clinical communication and learner confidence [19].

Problem-based learning and reflective assessment strategies included in several studies further contributed to improved critical thinking and clinical decision-making skills [18,21]. Koh et al. demonstrated that educational approaches emphasizing active participation and reflection significantly improve physician competency and professional preparedness [18]. Watling et al. also reported that reflective assessment encourages meaningful learning from clinical experiences and improves integration of practical knowledge [21].

Another important finding of this review was the association between formative assessment and improved learner satisfaction. Students exposed to continuous feedback-based assessment reported greater educational support, increased confidence, and reduced fear of failure [11,22]. Boud and Molloy emphasized that effective feedback models enhance learner autonomy and improve educational experience [22]. Formative assessment additionally appeared to reduce examination-related anxiety and stress by allowing learners to continuously monitor and improve their performance [14].

In contrast, summative assessment alone was associated with increased examination-related stress and surface learning strategies [14,17]. Taras reported that high-stakes summative examinations may promote memorization-oriented learning behavior rather than conceptual understanding [14]. Similarly, Cilliers et al. demonstrated that assessment methods significantly influence learning behavior and student motivation [17]. Excessive dependence on summative examinations may therefore limit reflective practice and reduce opportunities for continuous learner development.

Despite the demonstrated advantages of formative assessment, summative assessment continues to remain essential for ensuring standardization, accountability, and competency certification within medical education [2]. Final professional examinations provide objective measures of learner achievement and remain necessary for progression and licensure decisions. Therefore, the findings of this review suggest that integrated assessment models combining formative and summative strategies may provide the most effective educational approach [7,22].

The present study has important implications for curriculum planning and competency-based medical education. Integration of structured formative assessment strategies, including workplace-based assessment, reflective exercises, regular feedback sessions, and low-stakes testing, may significantly enhance learner development and clinical preparedness. Educational institutions should therefore consider incorporating balanced assessment frameworks that combine continuous formative evaluation with standardized summative assessment.

Several limitations should be acknowledged. Most included studies were observational in design, and heterogeneity existed regarding educational settings, assessment methods, feedback quality, and curriculum structures. Variability in faculty training and assessment implementation may also have influenced educational outcomes. In addition, long-term effects of formative assessment on professional competency and patient-care outcomes remain insufficiently studied.

Nevertheless, this meta-analysis represents one of the most comprehensive evaluations comparing formative and summative assessment strategies in medical education. The pooled evidence consistently demonstrated significant educational benefits associated with formative assessment approaches, supporting their increasing integration into competency-based medical training programs.

## CONCLUSION

Formative assessment demonstrates superior outcomes in academic performance, clinical competency, learner engagement, and student satisfaction compared with summative assessment alone in medical training. Continuous feedback, reflective

learning, and workplace-based assessment strategies appear to significantly enhance learner development and competency acquisition.

Integration of structured formative assessment strategies alongside summative evaluation may optimize competency-based medical education and improve long-term educational outcomes.

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