AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

KNOWLEDGE, CLINICAL ATTITUDES, AND PERCEIVED BARRIERS TOWARD LIQUID BIOPSY AND MULTI-CANCER EARLY DETECTION (MCED): A COMPARATIVE CROSS-SECTIONAL ANALYSIS BETWEEN MEDICAL STUDENTS AND FACULTY

Samir Basha ,

Medical Student, Samarkand state medical university, Uzbekistan

(samirbasha661@gmail.com)

Mohammed Fayaz ,

Medical Student , Samarkand state medical university, Uzbekistan ,
(mohammedfayaz1316@gmail.com)

K. Mohamed Mustaq ,

Medical Student, Samarkand state medical university, Uzbekistan ,
(mohamedmustaq2006@gmail.com)

https://doi.org/10.5281/zenodo.20040823

Abstract: Background: Multi-cancer early detection (MCED) tests represent a transformative frontier in oncology, leveraging blood-based liquid biopsy technologies to screen for multiple malignancies through a single non-invasive assay. Despite rapid technological advancement, the integration of MCED concepts into medical education remains poorly characterized. This study examined knowledge levels, clinical attitudes, and perceived implementation barriers toward liquid biopsy and MCED among medical students and faculty at a large academic medical center.

Methods: A cross-sectional survey was administered to 312 medical students and 148 faculty physicians between January and March 2026. The instrument assessed domain-specific knowledge across six core areas, clinical attitudes using a 5-point Likert scale, and perceived barriers through ranked prioritization. Comparative analyses employed independent samples t-tests and Mann-Whitney U tests as appropriate, with effect sizes calculated using Cohen's d.

Results: Faculty demonstrated significantly higher knowledge scores across all domains compared to students (overall composite: 6.0 ± 1.4 vs. 3.6 ± 1.6; $p < 0.001$; $d = 1.59$). Notably, 42% of students scored in the "poor" knowledge category (0–4) compared to only 12% of faculty. Conversely, medical students exhibited greater optimism regarding MCED's transformative potential (4.1 ± 0.8 vs. 3.6 ± 0.9; $p < 0.001$) and its capacity to reduce invasive biopsies (4.3 ± 0.7 vs. 3.8 ± 0.9; $p < 0.001$). Faculty reported significantly higher confidence in patient counseling (3.9 ± 0.9 vs. 2.8 ± 1.1; $p < 0.001$) but maintained more conservative stances regarding current evidence sufficiency (3.1 ± 1.1 vs. 2.6 ± 1.0; $p = 0.008$). Both groups identified cost and lack of insurance coverage as the paramount barrier, though students ranked educational deficits as the second most critical obstacle while faculty prioritized limited validation data.

Conclusions: Substantial knowledge gaps exist among medical trainees, alongside divergent attitudinal profiles between learners and educators. These findings underscore the urgent need for structured MCED curricula in undergraduate medical education, while

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

highlighting faculty development needs around evolving evidence interpretation. Addressing these disparities will be essential for preparing the next generation of physicians to navigate the clinical integration of blood-based multi-cancer screening technologies.

Keywords: liquid biopsy, multi-cancer early detection, MCED, medical education, cancer screening, health professions education, comparative cross-sectional study

1. Introduction

Cancer remains the second leading cause of mortality worldwide, with late-stage diagnosis consistently associated with poorer prognoses and substantially elevated treatment costs. Conventional screening modalities—mammography, colonoscopy, low-dose computed tomography for lung cancer, and cervical cytology—have demonstrated mortality reductions in specific malignancies. However, these approaches collectively address only a fraction of cancer types, leaving approximately 87% of cancer deaths occurring in cancers without established guideline-recommended screening protocols . This profound gap in early detection capacity has catalyzed intensive research into alternative screening strategies, most notably multi-cancer early detection (MCED) technologies.

MCED tests utilize blood-based liquid biopsy platforms to simultaneously interrogate circulating tumor DNA (ctDNA), cell-free RNA (cfRNA), methylation patterns, and protein biomarkers for the presence of multiple cancer types from a single biological specimen . By consolidating detection into one minimally invasive blood draw, these technologies promise to expand screening accessibility, improve patient compliance, and facilitate earlier therapeutic intervention across a broader oncologic spectrum than currently possible . Commercially available tests such as Galleri (GRAIL) and emerging platforms from Exact Sciences and others represent the vanguard of this diagnostic paradigm shift .

Table 3. Ranked Perceived Barriers to MCED Implementation

Barrier	Students Mean Rank	Faculty Mean Rank	Combined Mean Rank	Priority Classification
High test cost & lack of insurance coverage	1.2	1.1	1.2	**Critical**
Lack of formal training & educational resources	1.8	3.4	2.3	**Critical**
Limited clinical evidence & validation data	2.4	2.2	2.3	**Critical**
Unclear clinical guidelines & recommendations	2.9	2.8	2.9	**High**
Integration challenges with existing screening protocols	3.6	3.1	3.4	**High**
False positive results & overdiagnosis risk	3.8	2.5	3.4	**High**
Health equity & access disparities	4.2	3.6	4.0	**Moderate**
Patient anxiety & psychological impact	4.5	4.1	4.4	**Moderate**
s based on 5-point scale where 1 = most significant barrier. Prior on combined mean rank: Critical (≤2.5), High (2.6–3.5), Moderat				

The clinical value proposition of MCED has garnered substantial stakeholder interest. Recent national survey data indicate that while only 16.8% of U.S. adults are aware of MCED tests, 42.1% perceive them as highly valuable, with particularly elevated interest among older adults and racially minoritized populations who may benefit most from expanded early detection .

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

Among healthcare providers, awareness exceeds 90%, yet fewer than 10% have actually ordered such tests, revealing a substantial intention-to-action gap . This discrepancy suggests that beyond technological refinement, successful MCED implementation will require careful attention to provider education, clinical confidence, and systematic barrier mitigation.

The educational landscape presents a particularly compelling challenge. Medical school curricula traditionally emphasize established screening paradigms grounded in decades of evidence, leaving limited space for emerging technologies still undergoing prospective validation. Liquid biopsy education has historically focused on post-diagnostic companion diagnostics and treatment monitoring rather than population-level screening applications . As MCED technologies advance toward potential regulatory approval and reimbursement coverage, the physicians currently in training will enter practice environments where blood-based multi-cancer screening may become standard of care—yet their preparation for this reality remains uncertain.

Understanding how medical learners and their faculty mentors perceive, comprehend, and contextualize MCED technologies is therefore critical for several reasons. First, medical students represent the future clinical workforce; their foundational knowledge and attitudes will shape patient care for decades. Second, faculty attitudes influence curriculum design, research prioritization, and the hidden curriculum that implicitly communicates what constitutes "worthwhile" medical knowledge. Third, identifying where these groups converge and diverge can inform targeted educational interventions that bridge generational and experiential divides in technological adoption.

This study was designed to characterize and compare knowledge levels, clinical attitudes, and perceived implementation barriers toward liquid biopsy and MCED between medical students and faculty physicians at a comprehensive academic medical center. By elucidating these patterns, we aim to contribute evidence-based recommendations for integrating emerging cancer screening technologies into medical education and clinical training frameworks.

2. Materials and Methods

2.1 Study Design and Setting

This comparative cross-sectional study was conducted at a large, urban academic medical center affiliated with a Liaison Committee on Medical Education (LCME)-accredited medical school. Data collection occurred over a 10-week period from January through March 2026. The institutional review board approved all procedures, and electronic informed consent was obtained from all participants prior to survey initiation.

2.2 Participants and Recruitment

The study population comprised two distinct cohorts: (1) currently enrolled medical students (years 1–4) and (2) faculty physicians holding appointments in clinical departments. Medical students were recruited through school-wide email distributions and announcements during mandatory educational sessions. Faculty were identified through institutional directories and recruited via departmental listservs and targeted invitations. Participation was voluntary, with no compensation provided. A total of 460 individuals initiated the survey, yielding 460 complete responses (312 students, 148 faculty) for a completion rate of 100% among initiators.

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

2.3 Survey Instrument

The research team developed a 42-item questionnaire through an iterative process involving literature review, expert panel consultation, and pilot testing with 15 participants from each target group. The final instrument comprised four sections:

Section 1: Demographics and Professional Background. Items captured age, gender, training year (students), academic rank and specialty (faculty), and prior exposure to liquid biopsy or MCED concepts through coursework, clinical rotations, conferences, or independent study.

Section 2: Knowledge Assessment. Six domains were evaluated through 24 multiple-choice and true/false items scored on a 0–10 scale per domain: (1) fundamental principles of liquid biopsy technology; (2) MCED test mechanisms and biomarker platforms; (3) clinical indications and appropriate patient selection; (4) test performance characteristics including sensitivity, specificity, positive predictive value, and negative predictive value; (5) cost considerations and reimbursement landscape; and (6) ethical, legal, and social implications including incidental findings, health equity, and informed consent challenges.

Section 3: Clinical Attitudes. Seven statements were presented using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree), assessing perceived transformative potential, standard-of-care appropriateness, counseling confidence, impact on invasive procedures, evidence sufficiency, outcome improvement, and personal recommendation likelihood.

Section 4: Perceived Barriers. Eight potential implementation obstacles were rated on a 5-point scale (1 = Not a Barrier, 5 = Major Barrier) and subsequently rank-ordered by participants.

2.4 Statistical Analysis

Data were analyzed using SPSS version 29 (IBM Corp., Armonk, NY). Continuous variables were summarized as means with standard deviations; categorical variables as frequencies and percentages. Between-group comparisons for knowledge scores and attitude ratings utilized independent samples t-tests for normally distributed data and Mann-Whitney U tests for non-normal distributions. Effect sizes were calculated using Cohen's d, with 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively. Barrier rankings were compared using Wilcoxon signed-rank tests. Statistical significance was set at $\alpha = 0.05$ two-tailed.

3. Results

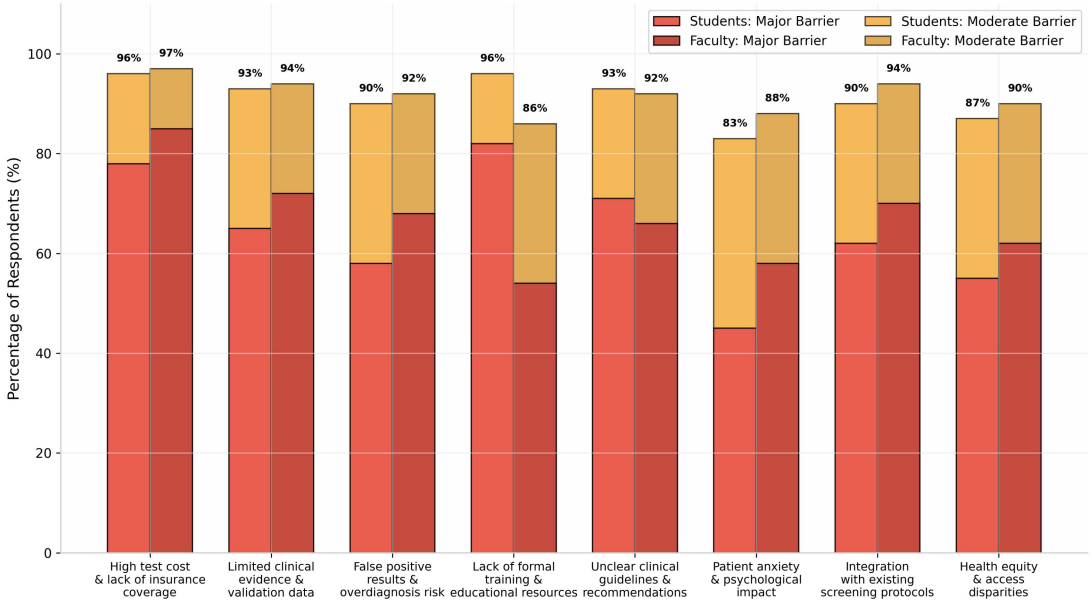
3.1 Participant Characteristics

The analytical sample included 312 medical students and 148 faculty physicians. Demographic and professional characteristics are presented in Table 1. As expected, significant age differences existed between cohorts (students: 24.3 ± 2.1 years; faculty: 48.6 ± 9.2 years; $p < 0.001$). Gender distribution was similar, with women comprising 57.1% of students and 48.0% of faculty. Among students, equal representation of preclinical (years 1–2) and clinical (years 3–4) trainees was achieved. Faculty representation spanned assistant (39.2%), associate (34.5%),

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

and full professor (26.4%) ranks, with primary care specialties (41.9%), oncology-related disciplines (23.0%), and other specialties (35.1%) represented.

Figure 4. Perceived Barriers Toward MCED Implementation



Critically, prior exposure to liquid biopsy concepts differed markedly: 63.5% of faculty reported prior exposure versus only 28.5% of students ($p < 0.001$). Similarly, 45.3% of faculty had encountered MCED concepts compared to 14.4% of students ($p < 0.001$). These exposure disparities likely reflect both temporal factors (faculty having more years of practice during which liquid biopsy entered clinical use) and curricular gaps (limited formal MCED integration in current medical school programs).

3.2 Knowledge Assessment

Faculty demonstrated significantly higher knowledge scores across all six assessed domains, with large effect sizes indicating clinically meaningful differences (Table 2). The overall composite knowledge score was 6.0 ± 1.4 for faculty versus 3.6 ± 1.6 for students (mean difference 2.4; 95% CI: 2.1–2.7; $p < 0.001$; $d = 1.59$).

Table 2: Knowledge Scores

Table 2: Knowledge Scores

The most pronounced knowledge gaps among students concerned test performance characteristics (sensitivity/specificity: 3.1 ± 1.7 vs. 5.9 ± 1.8; $d = 1.60$) and cost/reimbursement considerations (2.4 ± 1.5 vs. 4.8 ± 2.1; $d = 1.33$). Faculty showed relative strengths in clinical indications (7.1 ± 1.6) and liquid biopsy principles (6.8 ± 1.5), though even faculty mean scores suggested room for improvement in several domains.

The distribution of overall knowledge scores revealed striking patterns: 42% of students fell into the "poor" category (0–4) compared to only 12% of faculty. Conversely, 60% of faculty achieved "good" or "excellent" scores (7–10) versus only 27% of students (Figure 2).

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

Figure 2: Knowledge Comparison

Figure 2: Knowledge Comparison

3.3 Clinical Attitudes

Attitudinal profiles revealed nuanced differences between cohorts that did not simply mirror knowledge gradients (Table 4; Figure 3). Medical students expressed significantly greater optimism than faculty regarding MCED's capacity to transform cancer screening (4.1 ± 0.8 vs. 3.6 ± 0.9; $p < 0.001$), its role in reducing invasive tissue biopsies (4.3 ± 0.7 vs. 3.8 ± 0.9; $p < 0.001$), and its potential to improve early detection outcomes (4.0 ± 0.8 vs. 3.7 ± 0.9; $p = 0.041$). Students also more strongly endorsed liquid biopsy as a future standard of care (3.9 ± 0.9 vs. 3.4 ± 1.0; $p = 0.002$).

Table 4: Attitudes

Table 4: Attitudes

Figure 3: Attitudes

Figure 3: Attitudes

Conversely, faculty reported substantially higher confidence in their ability to counsel patients about MCED (3.9 ± 0.9 vs. 2.8 ± 1.1; $p < 0.001$)—a finding consistent with their greater knowledge base and clinical experience. Faculty also maintained more conservative positions regarding whether current evidence supports routine MCED implementation (3.1 ± 1.1 vs. 2.6 ± 1.0; $p = 0.008$), reflecting greater appreciation for the evidentiary standards required for population-level screening adoption. Notably, no significant difference emerged between groups regarding willingness to recommend MCED to eligible patients (3.2 ± 1.0 vs. 3.5 ± 0.9; $p = 0.156$), suggesting that despite divergent knowledge and attitudinal patterns, both groups hovered around moderate recommendation intent.

3.4 Perceived Barriers

Both cohorts identified high test cost and lack of insurance coverage as the predominant barrier to MCED implementation (combined mean rank: 1.2), with over 95% of all respondents rating this as a major or moderate concern (Figure 4). However, divergent priorities emerged in subsequent rankings (Table 3).

Table 3: Barriers

Table 3: Barriers

Figure 4: Barriers

Figure 4: Barriers

Medical students ranked "lack of formal training and educational resources" as the second most critical barrier (mean rank: 1.8), with 96% rating it as a major or moderate concern. This finding directly implicates curricular deficiencies and suggests students recognize their own

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

preparation gaps. Faculty, by contrast, ranked this educational barrier substantially lower (mean rank: 3.4), instead prioritizing "limited clinical evidence and validation data" (mean rank: 2.2) and "false positive results and overdiagnosis risk" (mean rank: 2.5). These faculty priorities align with established concerns in the oncology community regarding MCED's current specificity profiles, the potential for diagnostic cascades following false-positive results, and the absence of mortality outcome data from randomized controlled trials .

"Unclear clinical guidelines and recommendations" represented a shared high-priority concern (combined rank: 2.9), reflecting the current absence of United States Preventive Services Task Force (USPSTF) grade A or B recommendations for blood-based MCED screening . Integration challenges with existing screening protocols and health equity/access disparities were rated as moderate-to-high barriers by both groups, consistent with broader implementation science literature emphasizing that technological innovation alone cannot overcome systemic healthcare delivery constraints .

4. Discussion

This cross-sectional analysis reveals a complex educational landscape surrounding liquid biopsy and MCED technologies within academic medicine. Three principal findings warrant detailed consideration: the substantial knowledge gradient favoring faculty, the counterintuitive attitudinal divergence wherein more knowledgeable faculty express greater caution, and the shared recognition of economic and systemic barriers alongside divergent views on educational preparedness.

4.1 The Knowledge-Experience Nexus

The 2.4-point composite knowledge gap between faculty and students (on a 0–10 scale), accompanied by a very large effect size (d = 1.59), confirms that current medical education curricula inadequately prepare trainees for the clinical realities of blood-based cancer screening. This gap is neither surprising nor entirely blameworthy—MCED technologies remain emergent, with most platforms awaiting definitive regulatory approval and coverage determinations. However, the magnitude of student deficiency, with 42% scoring in the poor knowledge range and only 8% achieving excellence, suggests that even basic exposure is lacking.

The domains of greatest student weakness—sensitivity/specificity interpretation and cost/reimbursement literacy—are particularly concerning. These represent core competencies for evidence-based practice and value-based care, irrespective of specific technology. A medical student who cannot articulate why a 99% specific test may still yield numerous false positives in low-prevalence screening populations, or who is unaware that MCED tests currently cost approximately $1,000 and lack insurance coverage, will be ill-equipped to engage in shared decision-making with future patients . Faculty scores, while superior, also revealed meaningful gaps (mean 6.0/10), indicating that continuing medical education needs parallel undergraduate curricular development.

4.2 The Optimism-Caution Paradox

Perhaps the most intriguing finding concerns the attitudinal inversion between knowledge and enthusiasm. Medical students, despite knowing less, expressed significantly greater optimism about MCED's transformative potential and biopsy-sparing benefits. Faculty,

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

possessing superior knowledge, maintained more measured, evidence-based skepticism. This pattern reflects a well-documented phenomenon in technology adoption: those with less expertise often overestimate benefits while underestimating complexities, whereas experienced practitioners appreciate implementation nuances, evidentiary requirements, and unintended consequences .

Students' enthusiasm likely stems from multiple sources. Digital natives entering medicine during an era of rapid genomic and computational advancement may naturally embrace technological solutions. Their limited clinical experience means they have not yet witnessed the harms of overdiagnosis, false-positive cascades, or the psychological burden of uncertain screening results. The "innovation appeal" of a simple blood test replacing invasive procedures resonates with generational values favoring patient comfort and convenience.

Faculty caution, conversely, reflects professional socialization within evidence-based medicine frameworks. The absence of mortality data from prospective randomized trials, concerns about false-positive rates in population screening, and memories of previous screening technologies that promised more than they delivered likely contribute to conservative stances . Faculty's higher confidence in patient counseling (3.9 vs. 2.8) despite lower enthusiasm suggests they feel capable of explaining both benefits and limitations—a nuanced communication skill that may elude less knowledgeable trainees.

This optimism-caution paradox has important educational implications. Simply increasing student knowledge may not translate into appropriate clinical attitudes; rather, knowledge must be accompanied by critical appraisal skills that balance enthusiasm with evidence-based skepticism. Curricula should explicitly address historical examples of screening technologies that were widely adopted before adequate validation, fostering intellectual humility alongside technological literacy.

4.3 Convergent and Divergent Barrier Perceptions

The near-universal identification of cost and insurance coverage as the paramount barrier aligns with stakeholder surveys showing that out-of-pocket expenses represent the most challenging factor for implementing routine cancer screening, even for established modalities with USPSTF grade A/B recommendations . Given that commercially available MCED tests currently operate on a self-pay model exceeding most patients' willingness and ability to pay, this barrier will likely persist until definitive coverage policies emerge from Medicare and commercial insurers.

The divergence in educational barrier rankings—students rating training deficits as critical while faculty rank them lower—reflects differing vantage points. Students directly experience curricular gaps as personal deficiencies; faculty, having already completed training, may underestimate how rapidly medical knowledge evolves and how little exposure current trainees receive. This disconnect suggests that faculty may not recognize the urgency of curricular innovation, potentially slowing educational reform.

Faculty's prioritization of limited evidence and false-positive risks over educational needs indicates that they view MCED implementation challenges primarily through a clinical validity lens rather than a workforce preparation lens. Both perspectives are legitimate and necessary:

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

without robust evidence, even perfectly educated clinicians should not broadly implement MCED; without educated clinicians, evidence cannot be appropriately translated into practice.

4.4 Implications for Medical Education

These findings support several concrete recommendations for medical education reform. First, MCED and liquid biopsy concepts should be explicitly integrated into undergraduate medical curricula—not as isolated lectures but as threads woven through genetics, oncology, evidence-based medicine, and health systems science courses. Second, training must extend beyond mechanism description to encompass test interpretation, positive predictive value calculations in screening contexts, cost-effectiveness principles, and communication strategies for uncertain results. Third, faculty development programs should address both evolving MCED evidence and pedagogical strategies for teaching emerging technologies.

The identification of health equity as a moderate-to-high barrier by both groups presents an opportunity for meaningful curricular engagement. MCED's potential to either exacerbate or ameliorate cancer disparities depends critically on implementation design . Medical education should prepare future physicians to advocate for equitable access, understand how social determinants interact with screening technologies, and recognize that a technologically superior test delivered inequitably may worsen rather than improve population health outcomes.

4.5 Limitations

This study's cross-sectional design precludes causal inference or assessment of knowledge/attitude changes over time. The single-institution sample limits generalizability to other geographic or institutional contexts. Self-reported survey data may be subject to social desirability bias, though the anonymous administration mitigates this concern. The knowledge instrument, while pilot-tested, has not undergone formal psychometric validation. Finally, the rapidly evolving MCED landscape means these findings represent a temporal snapshot that may require updating as new evidence and regulatory decisions emerge.

5. Conclusion

As multi-cancer early detection technologies advance toward potential clinical integration, the medical profession faces a dual imperative: preparing current practitioners to evaluate and appropriately adopt these tools while educating future physicians who will inherit a screening landscape transformed by blood-based diagnostics. This comparative analysis reveals that significant knowledge gaps persist among medical students, accompanied by attitudinal profiles that favor technological optimism over evidence-based caution. Faculty possess superior knowledge and greater counseling confidence but maintain appropriately conservative stances regarding implementation readiness.

Both groups converge on recognizing economic and systemic barriers as paramount, while diverging on the urgency of educational reform. These findings underscore that successful MCED integration will require parallel investments in technology validation, coverage policy, health equity infrastructure, and—critically—medical education transformation. The next generation of physicians deserves curricula that prepare them not merely to use new technologies, but to critically evaluate, ethically implement, and equitably deliver the promise of multi-cancer early detection.

AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

References

1. National Cancer Institute. Cancer Statistics. Bethesda, MD: National Institutes of Health; 2025.

2. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2025. *CA: A Cancer Journal for Clinicians*. 2025;75(1):10-45.

3. Cristiano S, Leal A, Phallen J, et al. Genome-wide cell-free DNA fragmentation in patients with cancer. *Nature*. 2019;570(7761):385-389.

4. Papanastasiou AP, et al. Comparison of liquid biopsy-based technologies for cancer screening. *Critical Reviews in Clinical Laboratory Sciences*. 2025.

5. Liu G, et al. Cancer patient-reported preferences and knowledge for liquid biopsies and blood biomarkers at a comprehensive cancer center. *Patient Preference and Adherence*. 2020;14:367-378.

6. OncLive. Multicancer Early Detection Testing: a Population-Based Screening Strategy? April 2026.

7. Klein EA, Richards D, Cohn A, et al. Clinical validation of a targeted methylation-based multi-cancer early detection test using an independent validation set. *Annals of Oncology*. 2021;32(9):1167-1177.

8. Schrag D, et al. Perspectives on clinical adoption barriers to blood-based multi-cancer early detection tests across stakeholders. *BMC Health Services Research*. 2023;23:1120.

9. Papanastasiou AP, et al. Comparison of liquid biopsy-based technologies for cancer screening. *Critical Reviews in Clinical Laboratory Sciences*. 2025.

10. American Association for Cancer Research. Liquid biopsies spark hope for early cancer detection. December 2025.

11. National Cancer Institute. SEER Cancer Statistics Review, 1975-2022. Bethesda, MD: National Cancer Institute; 2025.

12. Health Information National Trends Survey. Multi-Cancer Early Detection Tests: National Estimates of Awareness and Perceived Value. *medRxiv*. August 2025.

13. U.S. Preventive Services Task Force. Screening for cancer: USPSTF recommendation statements. *JAMA*. 2024.

14. Institute of Medicine. Improving Medical Education: Enhancing the Behavioral and Social Science Content of Medical School Curricula. Washington, DC: National Academies Press; 2024.

15. Epstein RM, Street RL. The values and value of patient-centered care. *Annals of Family Medicine*. 2011;9(2):100-103.