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The Future Doctor Profile: Assessing AI Literacy, Mental Resilience, and Ethical Competence Among Medical Students in Southwest Nigeria

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ABSTRACT

Background: The rapid integration of artificial intelligence (AI) into healthcare is reshaping the competencies required of modern physicians. Beyond technological literacy, doctors must demonstrate mental resilience and ethical competence to ensure safe, patient-centred care. However, limited empirical evidence examines these competencies together among Nigerian medical students.

Objective: To assess AI literacy, mental resilience, and ethical competence among clinical medical students in Southwestern Nigeria and examine their interrelationships within the 'Future Doctor Profile' framework.

Methods: A multi-institutional cross-sectional study was conducted among 256 clinical medical students across accredited medical schools in Southwestern Nigeria. Data was collected using a structured questionnaire assessing AI literacy, mental resilience (CD-RISC-10), and AI-related ethical competence. Descriptive statistics, Spearman correlations, and multivariable regression analyses were performed ($p<0.05$).

Results: Mean age was 22.5±2.2 years; 63.3% were female. Only 16% reported formal AI teaching, yet AI tool usage was high (mean 4.4±0.7). Mean AI literacy score was 22.3±3.9 (66.4% high), resilience score 27.3±6.9 (50.4% high), and ethical competence score 32.0±4.2 (73.0% high). Moderate positive correlations were observed between AI literacy and resilience ($\rho=0.409$), AI literacy and ethical competence ($\rho=0.385$), and resilience and ethical competence ($\rho=0.325$) (all $p<0.001$).

Conclusion: AI literacy, resilience, and ethical competence are significantly interrelated among Nigerian medical students, supporting an integrated multidimensional "Future Doctor Profile." Structured AI education, resilience support, and strengthened digital ethics training are necessary.

Keywords: *Artificial intelligence; medical education; mental resilience; digital ethics; medical students; Nigeria.*

INTRODUCTION

The practice of medicine has long been defined by the intimate doctor-patient relationship, grounded in careful history-taking, physical examination, clinical reasoning, and human judgment. For generations, physicians served as the central decision-makers, relying on biomedical knowledge, experience, and empathy to diagnose and treat illness while offering reassurance and moral guidance[1]. Technology historically played a supportive role, but the physician remained the ultimate interpreter of clinical information and guardian of compassionate care.

This traditional model is undergoing profound transformation. The convergence of electronic health records, telemedicine, wearable devices, and, most significantly, artificial intelligence (AI) is reshaping healthcare delivery. AI-powered systems now demonstrate expert-level performance in image interpretation for dermatology, radiology, and pathology[2,4], while advanced predictive analytics and clinical decision support tools enhance risk stratification, diagnosis, and treatment recommendations[3,5]. These innovations promise greater diagnostic accuracy, reduced clinician workload, and more personalised care[22]. However, they are also redefining the physician's role from sole decision-maker to intelligent collaborator who must critically interpret, validate, and when necessary, override algorithmic outputs.

As AI integration accelerates globally, a critical gap has emerged in medical education. While medical students in many regions demonstrate growing awareness of AI's potential, formal training remains limited, leaving many uncertain about its practical application and ethical implications[6,7,11]. In Nigeria, studies similarly reveal moderate to high awareness of AI coupled with low structured exposure and inconsistent readiness[8,27,28]. This mismatch between rapid technological advancement in healthcare and slow curricular adaptation raises important questions about how well the next generation of doctors is being prepared for AI-augmented practice.

Beyond technological competence, the mental demands of medical training remain intense. Medical students worldwide experience elevated rates of stress, anxiety, depression, and burnout compared with age-matched peers[12,13]. In resource-constrained settings such as Nigeria, these pressures are often compounded by large class sizes, frequent examinations, infrastructural challenges, and exposure to high patient loads during clinical rotations. Chronic stress can impair empathy, clinical reasoning, and professional identity formation[14,30]. Consequently, mental resilience, the capacity to adapt positively to adversity and maintain effective functioning under pressure, has become an essential attribute for sustained performance in modern medicine[14,15].

Ethical challenges have also grown more complex in the AI era. Algorithmic systems trained on biased or non-representative datasets risk perpetuating healthcare disparities[16]. Questions of accountability, data privacy, informed consent, and the appropriate balance between technological efficiency and human-centred care demand new layers of ethical competence[17,18,23]. Traditional bioethical principles must now be extended to address digital ethics, transparency of "black box" algorithms, and the preservation of trust in patient-physician relationships[10,34.]

Contemporary medical education frameworks increasingly recognise that the "doctor of the future" must embody a broader set of competencies. Scholars argue that tomorrow's physicians need to integrate technological literacy, mental adaptability, and ethical reasoning to deliver safe, equitable, and compassionate care in technology-rich environments[1,19,20,37.] Yet, most existing research examines AI literacy, mental resilience, and ethical competence in isolation. Few studies have adopted an integrated approach to assess how these domains interact to shape a holistic "Future Doctor Profile."

In Nigeria, where healthcare systems face a dual burden of high disease prevalence and accelerating digital transformation amid infrastructural and workforce constraints, this integrated understanding is particularly urgent.

Without empirical data on students' preparedness across these interconnected domains, curriculum reforms risk being fragmented and insufficiently aligned with real-world clinical demands.

This study therefore aims to assess the "Future Doctor Profile" among medical students in Nigeria by simultaneously evaluating their AI literacy, mental resilience, and ethical competence. It seeks to determine current levels in each domain, explore their interrelationships, and provide evidence to inform more holistic medical education strategies that can better prepare future physicians for the realities of AI-enabled, high-pressure, and ethically complex healthcare practice.

Theoretical Framework and Conceptual Model

The present study is grounded in three complementary theoretical perspectives that together explain the technological, psychological, and moral dimensions required of future physicians.

The Technology Acceptance Model (TAM)[9,29] posits that perceived usefulness and ease of use of technology influence attitudes, behavioural intention, and actual adoption. In this study, TAM helps explain students' engagement with AI tools and the development of AI literacy.

Resilience Theory[14,15,36] emphasises the capacity to adapt positively to adversity, maintain professional functioning under stress, and achieve post-adversity growth. It provides the theoretical basis for understanding mental resilience as a critical buffer against the intense demands of medical training and technological disruption.

Rest's Four-Component Model of Moral Behaviour[10,23] conceptualises ethical competence as comprising moral sensitivity, moral judgment, moral motivation, and moral character. This framework is particularly relevant for examining how students navigate complex ethical dilemmas introduced by AI, such as accountability, algorithmic bias, and patient autonomy.

The "Future Doctor Profile" is proposed as an integrated, multidimensional construct that brings these three domains together. Unlike traditional competency frameworks such as CanMEDS[19], which primarily organises physician roles into seven domains (Medical Expert, Communicator, Collaborator, Leader, Health Advocate, Scholar, and Professional), the Future Doctor Profile specifically foregrounds three emerging and interdependent competencies demanded by the AI era: technological intelligence (AI literacy), psychological adaptability (mental resilience), and digital moral agency (ethical competence).

While CanMEDS provides a broad, enduring structure for physician training, the Future Doctor Profile offers a focused, contextually responsive lens for the digital transformation of healthcare. It explicitly recognises that technological competence alone is insufficient without the mental resilience to manage uncertainty and the ethical grounding to ensure human-centred, equitable care. The interrelationships between these three domains are visually represented in Figure 1.

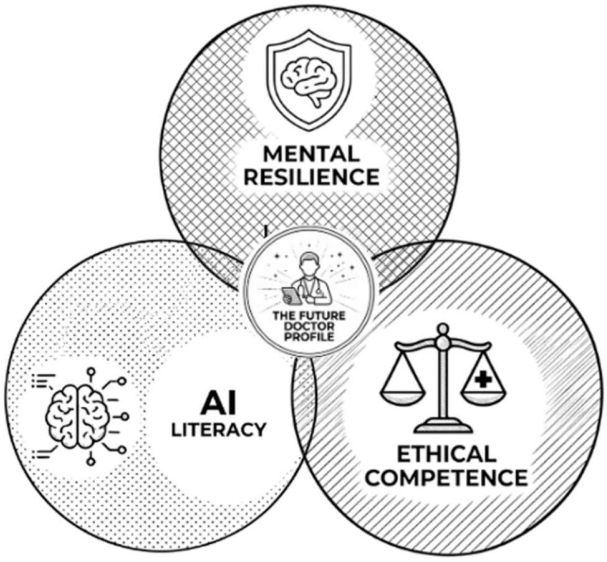

Figure 1: Conceptual model of the "Future Doctor Profile" illustrating the integration of AI Literacy, Mental Resilience, and Ethical Competence.

Specific Objectives

1. To assess the level of AI literacy among medical students, including their knowledge of AI applications in healthcare, attitudes toward AI integration, and perceived readiness to utilise AI-assisted tools in medical education and future clinical practice.
2. To determine the levels of perceived stress and mental resilience among medical students and identify associated socio-demographic patterns within the context of contemporary medical training in Nigeria.
3. To examine the ethical competence of medical students, with particular emphasis on their ability to recognise and reason through AI-related ethical dilemmas.
4. To analyse the interrelationships between AI literacy, mental resilience, and ethical competence, and to determine the extent to which these domains collectively contribute to the proposed "Future Doctor Profile" among medical students.

METHODS

Study Design

This multicentre cross-sectional analytical study assessed artificial intelligence (AI) literacy, mental resilience, and ethical competence, along with their interrelationships, among clinical-phase medical students in Southwestern Nigeria.

Study Setting and Population

The study was conducted in Southwest Nigeria, a region comprising six states (Lagos, Oyo, Ogun, Osun, Ondo, and Ekiti). This zone is one of the most urbanised and educationally advanced parts of the country and hosts several Medical and Dental Council of Nigeria (MDCN)-accredited medical schools offering the Bachelor of Medicine, Bachelor of Surgery (MB;BS) programme. Thirteen universities were included in the study: University of Ibadan, Ladoke Akintola University of Technology (LAUTECH), Bowen University, University of Lagos, Lagos State University College of Medicine, Eko University of Medical Sciences (Eko UNIMED), Olabisi Onabanjo University (OOU), Babcock University, Obafemi Awolowo University (OAU), Osun State University, Ekiti State University (EKSU), Afe Babalola University (ABUAD),

and University of Medical Sciences, Ondo (UNIMED). These institutions represent a mix of federal, state-owned, and private universities, providing diversity in institutional contexts, resources, and student populations. The target population consisted of undergraduate medical students in clinical years 4 to 6 who had commenced ward rotations and patient care activities.

Sample Size
A total of 256 clinical-phase medical students participated in the study.

Sampling Technique
Participants were recruited using a non-probability sampling approach combining convenience and voluntary response sampling. Recruitment was facilitated through institutional class communication platforms, official mailing lists, and in-person sessions with support from trained research assistants. All eligible students who provided informed consent were included consecutively until the target sample was reached.

Inclusion and Exclusion Criteria
Inclusion criteria were enrolment in Years 4-6 of the MBBS programme and having started clinical rotations. Visiting or exchange students not formally enrolled in the participating institutions were excluded.

Data Collection Instrument
Data were collected using a structured, self-administered questionnaire developed and adapted from relevant validated instruments. The questionnaire consisted of four sections:

Section A: Socio-demographic and academic characteristics (age, gender, year of study, and institution).
Section B: AI literacy, assessed with 12 items covering awareness of AI applications in healthcare, frequency of use, confidence in interpreting AI outputs, and trust in AI recommendations[8,9,25].
Section C: mental resilience, measured using the validated 10-item Connor-Davidson Resilience Scale (CD-RISC-10)[14,15]. Three supplementary items explored common stressors and coping strategies during clinical training.
Section D: Ethical competence regarding AI-assisted healthcare, assessed with 12 items addressing accountability for AI errors, patient consent and autonomy, data privacy, and integration of algorithmic recommendations with clinical judgment[10,17,23].

Responses were recorded on 5-point Likert scales (except for the standard CD-RISC-10 format). Composite scores were calculated for each domain, with higher scores indicating greater AI literacy, resilience, and ethical competence.

Validity and Reliability
The questionnaire was developed by adapting items from previously validated instruments and refining them for the Nigerian medical education context. The AI literacy scale initially consisted of 12 items adapted from existing tools[8,9,25]. Following pre-testing on 26 clinical-year medical students from a non-participating institution and subsequent exploratory factor analysis, six items with the strongest factor loadings and clearest conceptual relevance were retained in the final scale. This process improved clarity, reduced respondent burden, and maintained good internal consistency (Cronbach's $\alpha = 0.822$).

Content validity was evaluated by a panel of three experts comprising a medical educator, a bioethicist, and a biostatistician. The Connor-Davidson Resilience Scale (CD-RISC-10) has well-established reliability and validity in medical student populations[14,15]. The AI-related ethical competence scale, adapted from recent literature[10,17,23], demonstrated acceptable but borderline internal consistency (Cronbach's $\alpha = 0.669$) in the current sample.

Data Collection Procedure

Data collection was carried out over a six-week period using both paper-based and electronic (Google Forms) questionnaires, depending on institutional internet access. Trained research assistants supported administration and ensured standardised procedures. Paper responses were double entered into statistical software to minimise errors.

Ethical Considerations

Ethical approval was obtained from the Institutional Research Ethics Committee of the University of Medical Sciences Teaching Hospital (UNIMEDTH), Ondo, and relevant ethics boards of participating institutions. Informed consent was obtained from all participants prior to data collection. Participation was voluntary, and anonymity and confidentiality were maintained by not collecting personally identifiable information. Participants could withdraw at any time without repercussions.

Data Analysis

Data were analysed using SPSS version 27. Descriptive statistics including frequencies, percentages, means with standard deviations, or medians with interquartile ranges (as appropriate) were used to summarise participant characteristics and domain scores. Scale reliability was assessed using Cronbach's alpha in the study sample.

Differences in scores across socio-demographic groups were examined using independent t-tests or one-way ANOVA, with non-parametric equivalents applied when assumptions were violated. Bivariate associations between AI literacy, mental resilience, and ethical competence were evaluated using Pearson's or Spearman's correlation coefficients. Multiple linear regression analyses were performed to identify independent predictors of each domain while controlling for age, gender, year of study, and institution. All statistical tests were two-tailed, with significance set at $p < 0.05$.

RESULTS

A total of 256 clinical-phase medical students (Years 4-6) from 13 accredited medical schools in Southwestern Nigeria participated in this multicentre cross-sectional study.

Socio-demographic and Academic Characteristics

The mean age of participants was 22.5 ± 2.2 years, with females comprising 63.3% (n=162) and males 36.7% (n=94). Participants were distributed across clinical years as follows: Year 4 (25.8%, n=66), Year 5 (41.8%, n=107), and Year 6 (32.4%, n=83). Only 16.0% (n=41) reported having received formal teaching on artificial intelligence (AI) in medicine, despite a high mean frequency of AI tool use (4.4 ± 0.7 on a 1-5 scale).

Table 1. Sociodemographic and academic characteristics (N = 256)

Variable	Category / Summary	n (%) / Mean ± SD
Age (years)	Mean ± SD	22.5 ± 2.2
Gender	Male	94 (36.7%)
	Female	162 (63.3%)
Year of study	Year 4	66 (25.8%)
	Year 5	107 (41.8%)

	Year 6	83 (32.4%)
Formal teaching on AI in medicine	Yes	41 (16.0%)
	No	215 (84.0%)
AI tool use frequency (1-5)	Mean ± SD	4.4 ± 0.7

Reliability of Study Instruments

The AI literacy scale demonstrated good internal consistency (Cronbach's α = 0.822). The Connor-Davidson Resilience Scale (CD-RISC-10) showed excellent reliability (α = 0.905), while the ethical competence scale had acceptable but borderline reliability (α = 0.669)).

Table 2. Reliability of scales

Construct	Items (n)	Scale range	Cronbach's α
AI literacy (Likert 1-5)	6	6-30	0.822
Mental resilience (CD-RISC-10; 0-4)	10	0-40	0.905
Ethical competence (Likert 1-5)	8	8-40	0.669

AI Literacy

Despite limited formal education, participants demonstrated relatively high AI literacy. The mean AI literacy score (6 items, range 6-30) was 22.3 ± 3.9, with 66.4% of students classified in the high category, 31.3% in moderate category and 2.3% in low category. Item-level responses revealed strong confidence in using AI tools for learning (75.8%) and awareness of AI limitations and risks (70.3%). However, only 54.7% agreed they could critically evaluate AI-generated information.

Table 3. AI literacy item responses (N = 256)

AI literacy item	Agree/Strongly agree n (%)	Neutral n (%)	Disagree/Strongly disagree n (%)
Understand basic AI concepts in healthcare	165 (64.5%)	68 (26.6%)	23 (9.0%)
Aware of current AI applications in diagnosis/treatment	162 (63.3%)	52 (20.3%)	42 (16.4%)
Can critically evaluate AI-generated information	140 (54.7%)	81 (31.6%)	35 (13.7%)

Know limitations/risks of AI in clinical decisions	180 (70.3%)	47 (18.4%)	29 (11.3%)
Confident using AI tools to support learning	194 (75.8%)	43 (16.8%)	19 (7.4%)
Would trust AI suggestions only after clinical verification	192 (75.0%)	48 (18.8%)	16 (6.3%)

In multivariable linear regression, frequency of AI tool use was the only significant independent predictor of higher AI literacy scores (B = 0.88, 95% CI 0.21-1.55, p = 0.010). Formal AI teaching showed a positive trend but did not reach statistical significance (p = 0.068). The model explained 5.3% of the variance in AI literacy ($R^2 = 0.053$).

Table 4. Predictors of AI literacy (OLS regression)

Predictor	**B**	**95% CI**	**p-value**
Age	0.10	−0.17 to 0.37	0.471
Male (vs Female)	−0.06	−1.09 to 0.97	0.910
Year of study	0.08	−0.68 to 0.84	0.836
Formal AI teaching (Yes vs No)	1.22	−0.09 to 2.53	0.068
AI tool use frequency (1-5)	0.88	0.21 to 1.55	0.010

Mental Resilience

The mean resilience score on the CD-RISC-10 (range 0-40) was 27.3 ± 6.9. Using predefined categories, 50.4% of participants demonstrated high resilience, 43.4% moderate, and 6.3% low resilience. Item-level analysis showed strongest endorsement for adaptability and ability to bounce back after hardship.

Table 5. Resilience distribution (CD-RISC-10)

Measure	Value
Resilience score (0-40), Mean ± SD	27.3 ± 6.9
Low (0-16)	16 (6.3%)
Moderate (17-27)	111 (43.4%)
High (28-40)	129 (50.4%)

Males reported significantly higher mean resilience scores than females (28.60 vs 26.54, p = 0.021). No significant differences were observed across years of study.

Table 6. Resilience by gender and year of study

Comparison	Group means	Test	p-value
Gender	Male: 28.60 vs Female: 26.54	t-test	0.021
Year of study	Y4: 27.86; Y5: 26.35; Y6: 28.07	ANOVA	0.168

Ethical Competence in AI-assisted Healthcare

Participants demonstrated high ethical competence, with a mean score of 32.0 ± 4.2 (8 items, range 8-40). 73% were classified in the high category, 26.6% in the moderate category and 0.4% in the low category. Strong agreement was observed for clinician responsibility when AI contributes to error (78.5%) and the need for strong protection of patient data used in AI systems (94.1%). In contrast, endorsement was lower for informing patients when AI is involved in their care (52.3%) and including AI use in informed consent processes (56.3%).

Table 7. Ethics item responses (N = 256)

Ethics item	Agree/Strongly agree n (%)	Neutral n (%)	Disagree/Strongly disagree n (%)
Doctor remains responsible when AI contributes to error	201 (78.5%)	38 (14.8%)	17 (6.6%)
Would know how to respond if AI gives incorrect recommendation	157 (61.3%)	72 (28.1%)	27 (10.5%)
Patients should be informed when AI is involved in care	134 (52.3%)	67 (26.2%)	55 (21.5%)
Informed consent should include disclosure of AI use	144 (56.3%)	66 (25.8%)	46 (18.0%)
Patient data used in AI systems must be strongly protected	241 (94.1%)	11 (4.3%)	4 (1.6%)
Aware of ethical concerns related to AI and privacy	206 (80.5%)	37 (14.5%)	13 (5.1%)
Would override AI if it conflicts with clinical judgment	219 (85.5%)	28 (10.9%)	9 (3.5%)

AI should assist, not replace, decision-making	228 (89.1%)	20 (7.8%)	8 (3.1%)

Interrelationships Among Domains (Future Doctor Profile)

Moderate positive Spearman correlations were observed between the three constructs: AI literacy and resilience ($\varrho = 0.409$, $p < 0.001$), AI literacy and ethical competence ($\varrho = 0.385$, $p < 0.001$), and resilience and ethical competence ($\varrho = 0.325$, $p < 0.001$) (Table 8).

Table 8. Spearman correlations between primary constructs

Pair	Spearman ϱ	p-value
AI literacy ↔ Resilience	0.409	<0.001
AI literacy ↔ Ethical competence	0.385	<0.001
Resilience ↔ Ethical competence	0.325	<0.001

In multivariable linear regression models, AI literacy and ethical competence were independently associated with resilience ($R^2 = 0.231$), while AI literacy and resilience were independently associated with ethical competence ($R^2 = 0.262$) (Table 9A, Table 9B). These associations, though modest, provide for preliminary empirical support for the interrelated nature of the proposed "Future Doctor Profile".

Table 9A. Multivariable regression models (predictors of resilience and ethical competence)

Predictor	B	95% CI	p-value
Male (vs Female)	1.81	0.17 to 3.45	0.031
AI literacy score	0.55	0.32 to 0.78	<0.001
Ethical competence score	0.37	0.16 to 0.57	<0.001
Age	−0.08	−0.52 to 0.36	0.717
Year of study	−0.37	−1.59 to 0.84	0.546

Table 9B. Multivariable regression models (predictors of resilience and ethical competence)

Predictor	B	95% CI	p-value
AI literacy score	0.42	0.29 to 0.56	<0.001
Resilience score	0.135	0.06 to 0.21	0.001
Age	−0.02	−0.29 to 0.24	0.871

Male (vs Female)	0.07	−0.94 to 1.08	0.887
Year of study	−0.08	−0.82 to 0.66	0.840

These findings provide empirical support for an integrated "Future Doctor Profile" in which the three domains are mutually reinforcing.

Scores varied modestly across institutions, with the largest response from the University of Medical Sciences, Ondo (n=82). Detailed institutional comparisons are presented in supplementary materials.

DISCUSSION

This multicentre cross-sectional study provides one of the first integrated assessments of the "Future Doctor Profile" among clinical medical students in Southwestern Nigeria by simultaneously examining AI literacy, mental resilience, and ethical competence.

By proposing and empirically examining this profile, the study addresses an important gap in medical education research in low- and middle-income settings. The findings reveal relatively high informal AI engagement despite limited formal training, generally moderate-to-high resilience with gender differences, strong ethical awareness in some domains but notable gaps in patient transparency, and moderate positive interrelationships among the three constructs.

AI Literacy: Self-Directed but Incomplete

Despite only 16% of participants reporting formal teaching on AI in medicine, students demonstrated relatively high AI literacy, with two-thirds classified in the high category. Frequent self-reported use of AI tools emerged as the strongest predictor of higher AI literacy scores. This pattern aligns with the Technology Acceptance Model (TAM), which posits that perceived usefulness and ease of use drive technology adoption and subsequent competence[9,29]. In this context, practical exposure through readily available generative AI tools appears to be shaping students' confidence and familiarity more rapidly than structured curricular input.

However, the relatively high neutral responses regarding the ability to critically evaluate AI-generated information (31.6%) highlight a potential vulnerability. Informal, self-directed learning may foster enthusiasm and basic operational skills but often falls short in developing deeper critical appraisal, bias detection, and understanding of algorithmic limitations. This finding echoes previous studies in both high- and low-resource settings showing high awareness but inconsistent formal preparation[6,8,27,28].

Mental Resilience

Participants reported moderate-to-high levels of mental resilience, with half demonstrating high scores on the CD-RISC-10. This is encouraging given the well-documented stressors of medical training in Nigeria. Nevertheless, 6.3% of students fell into the low resilience category, and female students reported significantly lower resilience than their male counterparts. These gender differences may reflect varying sociocultural expectations, stress appraisal, or reporting patterns commonly observed in medical education research[12,30].

From the perspective of Resilience Theory, students showed strong adaptive capacity (ability to adapt and bounce back) but lower endorsement of post-traumatic growth statements such as "coping with stress makes me stronger." This suggests that while many students demonstrate functional resilience, there remains room to cultivate more proactive and growth-oriented coping mechanisms.

Ethical Competence in the AI Era

Ethical competence scores were high overall, with strong agreement of clinician accountability when AI contributes to error (78.5%) and the imperative to protect patient data (94.1%). These findings indicate good moral sensitivity and judgment regarding core professional responsibilities in technology-assisted care[17,23].

However, attitudes toward patient transparency were notably more divided. Only 52.3% of students agreed that patients should be informed when AI is involved in their care, and 56.3% supported explicit disclosure of AI use in informed consent processes, with approximately one-fifth actively disagreeing. This ambivalence represents a critical gap. In the evolving landscape of AI ethics, transparency and informed consent are central to maintaining patient autonomy and public trust in healthcare systems[10,17,34]. Failure to adequately address disclosure may erode trust, particularly in resource-limited settings where patients may already harbour concerns about technological interventions.

This finding aligns with several international studies. For instance, medical students in Europe and the Middle East have similarly shown strong support for clinician oversight and data protection but expressed hesitation regarding mandatory patient disclosure of AI involvement[6,39,43]. Such inconsistencies highlight a broader global challenge in translating ethical principles into practical behaviours within AI-augmented medicine. Strengthening case-based digital ethics training that explicitly explores real-world scenarios involving transparency, shared decision-making, and patient autonomy is therefore essential for Nigerian medical education.

Interrelationships and the Future Doctor Profile

A central contribution of this study is the demonstration of significant moderate positive interrelationships found among AI literacy, mental resilience, and ethical competence. All three pairwise Spearman correlations were statistically significant and moderate in strength. Multivariable regression analyses showed that the three domains were independently associated with one another, although the models explained a relatively modest proportion of variance ($R^2 = 0.053$-0.262). These findings provide exploratory empirical support for the proposed Future Doctor Profile (Figure 1), which integrates three core competencies: technological competence (AI literacy), psychological adaptability (mental resilience), and digital moral agency (ethical competence).

Unlike the CanMEDS framework[19], which delineates broad, well-established physician roles, the Future Doctor Profile offers a focused, context-specific model tailored to the AI-driven transformation of healthcare. The observed interrelationships suggest that these competencies are mutually reinforcing rather than independent.

Within the Technology Acceptance Model (TAM), higher AI literacy correlates with perceived competence and reduces technology-related anxiety, thereby bolstering resilience. Resilience Theory posits that mentally adaptable individuals are better equipped to engage critically and ethically with emerging technologies. Finally, Rest's Four-Component Model of Moral Behaviour explains how ethical competence is strengthened by the combined presence of technological understanding and mental stability[19,20].

IMPLICATIONS FOR MEDICAL EDUCATION AND POLICY

The findings have several practical implications for Nigerian medical education. First, the heavy reliance on informal AI exposure underscores the urgent need to move beyond optional or ad-hoc exposure toward structured, longitudinal AI literacy curricula that emphasise critical appraisal, bias recognition, and safe integration into clinical reasoning.

Second, the observed gender disparity in resilience and the presence of a vulnerable subgroup call for targeted student wellbeing programmes, including resilience-building interventions integrated with digital health training.

Third, the inconsistency in attitudes toward AI disclosure and informed consent highlights the need for strengthened case-based digital ethics education that explicitly addresses transparency, accountability, and patient-centred care in AI-augmented practice.

STRENGTHS AND LIMITATIONS

Strengths of this study include its multicentre design across 13 institutions in Southwestern Nigeria, the use of validated instruments (particularly the CD-RISC-10), and the novel integration of three critical domains into a unified "Future Doctor Profile" framework. This represents one of the first attempts in the Nigerian context to examine these competencies concurrently.

Limitations should also be acknowledged. The non-probability (convenience and voluntary response) sampling method may have introduced selection bias, potentially over-representing students with greater interest in or access to technology. This limits generalisability, particularly to regions with lower digital infrastructure. The cross-sectional design precludes causal inferences about the directionality of relationships. Self-reported data are subject to social desirability and recall bias. The ethical competence scale showed borderline internal consistency, which may limit the precision of findings related to this domain and highlights the need for further validation in future studies. In addition, although the reduction of the AI literacy scale from 12 to 6 items was guided by pre-testing and exploratory factor analysis, it may have resulted in the loss of some aspects of the original construct.

Finally, although the sample covered multiple institutions in Southwestern Nigeria, findings may not be fully generalisable to other geopolitical zones with different levels of digital infrastructure.

CONCLUSION

This study offers important insights into the preparedness of clinical medical students in Southwestern Nigeria for the rapidly evolving landscape of AI-augmented healthcare. By adopting an integrated framework, the findings reveal that students exhibit relatively high AI literacy, largely driven by frequent informal use of AI tools rather than formal curricular exposure. Mental resilience levels were generally moderate to high, though notable gender differences and a small but vulnerable subgroup with low resilience were identified. Ethical competence was strong in areas of clinician accountability and data protection, yet students showed greater uncertainty regarding patient transparency and the inclusion of AI use in informed consent processes.

Crucially, the study demonstrates statistically significant positive interrelationships among AI literacy, mental resilience, and ethical competence. These domains do not exist in isolation but appear to be mutually reinforcing, providing empirical validation for the proposed "Future Doctor Profile" as a multidimensional construct essential for contemporary medical practice. Higher AI literacy was associated with better resilience and ethical reasoning, while greater resilience supported stronger ethical competence. This integrated perspective moves beyond traditional siloed assessments and highlights the need for holistic competency development in medical education.

The results underscore a clear mismatch between the rapid adoption of AI tools among students and the slow pace of formal integration within Nigerian medical curricula. While students demonstrate initiative and adaptability through self-directed learning, reliance on informal exposure risks producing uneven critical appraisal skills, overconfidence without sufficient depth, and inconsistent application of ethical principles in technology-assisted care.

These findings carry significant implications for medical education stakeholders in Nigeria and similar low- and middle-income settings. Medical schools, regulatory bodies such as the Medical and Dental Council of Nigeria (MDCN), and curriculum developers should prioritise the systematic embedding of AI literacy modules that emphasise not only

technical familiarity but also critical evaluation, bias detection, and responsible use. Concurrently, structured resilience-building interventions, particularly those addressing gender-specific needs and high-stress clinical environments, should be integrated into training. Digital ethics education must also be strengthened through case-based learning that explicitly tackles emerging issues such as algorithmic transparency, patient autonomy, and shared decision-making in AI-supported care.

Preparing the "future doctor" requires more than producing technically competent graduates. It demands the cultivation of resilient, ethically grounded physicians who can harness the power of artificial intelligence while preserving the human essence of medicine. By addressing the gaps identified in this study through deliberate curricular reform, faculty development, and policy support, Nigerian medical education can better equip the next generation of doctors to deliver safe, equitable, and compassionate care in an increasingly digital healthcare ecosystem.

Future research should employ longitudinal designs to track the development of these competencies over the course of training and explore the effectiveness of integrated educational interventions targeting the "Future Doctor Profile."

DECLARATION

We hereby confirm that this manuscript is our original work and has not been submitted to or is not under consideration for publication in any other journal or institution.

Ethics approval and consent to participate: Ethical approval was obtained from the Institutional Research Ethics Committee of the University of Medical Sciences Teaching Hospital (UNIMEDTH), Ondo, as well as relevant ethics boards of participating institutions. The study was conducted in accordance with established ethical standards for research involving human participants.

Informed consent was obtained from all participants prior to data collection. Participation was entirely voluntary, and anonymity and confidentiality were ensured by not collecting any personally identifiable information. Participants were informed of their right to withdraw from the study at any time without any repercussions.

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Authors' contributions: EF conceived the study. OO drafted the introduction. OT and IO conducted the literature review. OO developed the methodology. OE performed the analysis. EF synthesized the findings and wrote the conclusion. ID supervised the study and approved the final manuscript. All authors reviewed, edited, and approved the final version of the manuscript.

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APPENDIX 1: QUESTIONNAIRE

You are invited to participate in an anonymous study titled: The Future Doctor Profile: Assessing AI Literacy, Mental Resilience, and Ethical Competence Among Medical Students in Southwest Nigeria, examining AI literacy, mental resilience, and ethical competence among clinical medical students in Southwest Nigeria. Eligibility requires current enrolment in Year 4, 5, or 6 at a selected university. The questionnaire takes approximately 8-10 minutes to complete. No personally identifying information (name, student ID, email) will be collected; responses are completely untraceable. Participation is entirely voluntary, and submission of the completed questionnaire implies your informed consent. There are no penalties for non-participation or withdrawal. Thank you for your contribution.

□ Yes, I consent.

INSTRUCTIONS:

Please answer all questions honestly. Your responses are completely anonymous. This questionnaire will take approximately 8-10 minutes to complete.

STUDY QUESTIONNAIRE

AI Literacy, Mental Resilience, and Ethical Competence among Clinical Medical Students

SECTION A: DEMOGRAPHIC CHARACTERISTICS

1. Age (in years): _____
2. Gender: □ Male □ Female □ Prefer not to say
3. Current year of study: □ Year 4 □ Year 5 □ Year 6
4. Institution:
   - University of Ibadan
   - Ladoke Akintola University
   - University of Lagos
   - Lagos State University College of Medicine
   - Obafemi Awolowo University
   - Osun State University
   - Federal University of Technology, Akure
   - University of Medical Sciences, Ondo
   - Federal University, Oye-Ekiti
   - Afe Babalola University
   - Babcock University
   - Olabisi Onabanjo University
   - Other: _____
5. Have you received any formal teaching on Artificial Intelligence in medicine? □ Yes □ No
6. How often do you use AI tools (e.g., ChatGPT, clinical AI apps)? □ Never □ Rarely □ Sometimes □ Often □ Very often

SECTION B: AI LITERACY

Please indicate your level of agreement.

1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree

No.	Item	1	2	3	4	5
7	I understand basic concepts of artificial intelligence in healthcare	□	□	□	□	□
8	I am aware of current AI applications in medical diagnosis or treatment	□	□	□	□	□
9	I can critically evaluate information generated by AI tools	□	□	□	□	□
10	I know the limitations and risks of AI in clinical decision-making	□	□	□	□	□
11	I feel confident using AI tools to support my learning	□	□	□	□	□
12	I would trust AI suggestions only after verifying them clinically	□	□	□	□	□

SECTION C: MENTAL RESILIENCE

Connor-Davidson Resilience Scale (CD-RISC-10)

Over the past month, how true have these statements been for you?

0 = Not true at all 1 = Rarely true 2 = Sometimes true 3 = Often true 4 = True nearly all the time

No.	Item	0	1	2	3	4
13	I am able to adapt when changes occur	□	□	□	□	□
14	I can deal with whatever comes my way	□	□	□	□	□
15	I try to see the humorous side of problems	□	□	□	□	□
16	Coping with stress makes me stronger	□	□	□	□	□
17	I tend to bounce back after hardship	□	□	□	□	□
18	I can achieve my goals despite obstacles	□	□	□	□	□
19	Under pressure, I stay focused	□	□	□	□	□
20	I am not easily discouraged by failure	□	□	□	□	□
21	I think of myself as a strong person	□	□	□	□	□
22	I can handle unpleasant feelings	□	□	□	□	□

SECTION D: ETHICAL COMPETENCE IN AI-ASSISTED HEALTHCARE

Please indicate your level of agreement.

1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree

No.	Item	1	2	3	4	5
23	The doctor remains responsible when AI contributes to a clinical error	□	□	□	□	□
24	I would know how to respond if an AI system gives an incorrect recommendation	□	□	□	□	□
25	Patients should be informed when AI is involved in their care	□	□	□	□	□
26	Informed consent should include disclosure of AI use	□	□	□	□	□
27	Patient data used in AI systems must be strongly protected	□	□	□	□	□
28	I am aware of ethical concerns related to AI and patient privacy	□	□	□	□	□
29	I would override an AI recommendation if it conflicts with my clinical judgment	□	□	□	□	□
30	AI should assist, not replace, clinical decision-making	□	□	□	□	□

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