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Original Article

Assessing the Readiness for Artificial Intelligence Integration Into Healthcare Among Medical Students in Sumatra, Indonesia

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Abstract

Introduction: Artificial Intelligence (AI) is increasingly applied in healthcare as it helps healthcare workers to improve the quality of care. Medical students should prepare themselves with the competence to properly and ethically use AI, especially in areas with socioeconomic challenges and limited educational resources. This study assessed medical students' current readiness in healthcare in Sumatra.

Methods: This cross-sectional study was conducted on medical students in Sumatra from November 2024 to February 2025. AI readiness was evaluated using the MAIRS-MS questionnaire. Data were analyzed using chi-square for bivariate tests and multivariate logistic regression to identify significant predictors of readiness.

Results: Overall, 1,053 respondents from 22 universities in Sumatra were included in this study. Nearly 74.7% lacked formal AI training, and 90.9% relied on general tools like ChatGPT. The overall AI readiness mean was 74.36 (±14.03). Students received the highest score in ethics (10.96±2.46) and ability (28.20±5.57), but the lowest score in cognition (24.48±5.92). Prior AI training was the primary predictor for overall readiness (OR=1.90; 95% CI: 1.44–2.61). Coding experience significantly boosted cognitive readiness (OR=1.84; 95% CI: 1.33–2.54), while public university affiliation was strongly associated with higher vision (OR=2.20; 95% CI: 1.70–2.86) and ethical readiness (OR=2.10; 95% CI: 1.63–2.72).

Conclusion: Medical students in Sumatra revealed moderate-to-high readiness, particularly in ethics and technical interest, yet lacked foundational cognitive proficiency. Structured curricula, hands-on practice, and early programming exposure are essential. Formal AI training is the key predictor to bridge this "literacy paradox" and ensure effective, ethical clinical integration.

Keywords: Artificial intelligence, Medical students, Readiness, MAIRS-MS, Indonesia

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Introduction

Artificial Intelligence (AI) has rapidly evolved over recent years and is increasingly integrated into various sectors of healthcare, ranging from improving diagnostic precision and developing personalized treatment plans to enhancing healthcare system efficiency and accessibility. AI significantly contributes to early disease detection, accurate diagnosis, individualized patient care, and medical research acceleration, thereby improving patient outcomes (1, 2).

Despite the growing use and promising benefits of AI, many healthcare professionals, doctors, lecturers, and medical students remain doubtful and cautious about its use in clinical settings. Fear of AI replacing human roles, ethical issues, and the potential for bias in AI decisions are some of their concerns (3). Additionally, there are worries about AI diminishing human empathy and interpersonal interactions in healthcare, as increased reliance on AI-driven tools might reduce direct patient-physician communication, thereby impacting trust and care quality (4-6). Although AI can improve efficiency, it cannot replicate the emotional intelligence and compassionate care that healthcare professionals provide, which are crucial for patient-centered care (7). Another major concern is patient safety, as errors in AI algorithms, due to biased data, misinterpreted clinical inputs, or system

malfunctions, can lead to incorrect diagnoses, improper treatment, or harm (8). Moreover, the lack of transparency in AI decision-making, which is known as the "black box" problem, complicates accountability in the case of adverse outcomes (4, 9).

As the future of the healthcare workforce, medical students must be equipped with the skills to understand and apply AI ethically and effectively. However, most medical curricula, including those in Indonesia, have been slow to introduce formal AI training for clinical, educational, and research purposes. This leaves students underprepared and lacking essential competencies for future AI-integrated healthcare environments, especially in resource-limited regions (10, 11). Despite these gaps, some studies have shown that medical students generally exhibit a positive attitude and readiness toward AI, even without formal training (12, 13). This issue indicates the urgent need for structured AI education in order to prepare future professionals as capable users and innovators in healthcare AI (14).

With its vast archipelago of thousands of islands, ethnic groups, and local languages, Indonesia stands to greatly benefit from the effective implementation of AI technologies to address long-standing disparities in healthcare access. Sumatra, one of the country's major islands, demonstrates strong potential for AI in healthcare, yet faces significant challenges related to infrastructure, accessibility, and resource limitations, along with sociodemographic and financial barriers. Although interest in AI in medical education has been increasing, empirical studies assessing AI readiness among medical students in Indonesia remain limited, particularly in the Sumatra region, and are predominantly conducted within single institutions. Therefore, this study aims to evaluate AI implementation readiness among medical students in Sumatra as a foundational step toward reducing educational and healthcare access disparities in the region.

Materials and Methods

Study Design

This study used a quantitative, cross-sectional approach to assess medical students' readiness and engagement with AI in healthcare in Sumatra, Indonesia. Data were collected online anonymously after obtaining informed consent forms from the respondents. An information sheet explaining the study's aims was also attached to the form.

Population and Sample

The target population for this study included medical students in both the undergraduate and professional programs of their studies, enrolled in medical faculties at universities across Sumatra. However, students who have dropped out of their program, switched majors, submitted incomplete questionnaires, or provided no consent to participate were excluded from the study. Due to the unavailability of public data on the number of medical students at each university, the sample size was calculated using the formula $n = \frac{Z^2 pQ}{d^2}$ (15). The appropriate approach for determining the required sample size was based on estimated proportions. In this study, a *P*-value of 0.60, a confidence interval (CI) of 95%, and an absolute precision of 5% were considered using demographic proportions from a prior study in which 59.7% of medical students knew about AI from internet blogs (12). The minimum required sample was 370. After adding 10% for non-response, the target sample was 407. A total of 1,053 valid responses were collected, exceeding this minimum and ensuring adequate representativeness. It should be noted that participation was voluntary, and the sampling method was non-random, which may introduce selection bias.

Data Collection

The questionnaire was distributed across medical faculties in Sumatra through Google Forms and shared via social media platforms, such as WhatsApp. Required data were collected from November 2024 to February 2025.

Research Instrument

A two-part questionnaire was used as the research instrument in this study. The first section gathered demographic information from the participants, such as age, gender, year of study, educational background, and previous exposure to AI. The second section used the Medical AI Readiness Scale for Medical Students (MAIRS-MS), an adapted questionnaire previously developed by Karaca et al (16), to assess students' readiness across four domains. They included cognition (knowledge of AI terminology and basic principles), competency (ability to use and explain AI applications), vision (ability to evaluate AI's future potential in medicine), and ethics (adherence to ethical and legal guidelines in AI usage). The MAIRS-MS has previously been utilized to assess the readiness of medical students at Universitas Pelita Harapan Indonesia and that of medical students in Malaysia regarding AI (12, 16). The MAIRS-MS uses a 5-point Likert-type scale, ranging from "Strongly Disagree" to "Strongly Agree."

The MAIRS-MS instrument was selected based on a bibliometric and systematic review, identifying it as the most widely validated and cross-culturally applied measure of AI readiness among medical students. The instrument has been validated in several languages and has previously been employed in Indonesia (12).

The questionnaire was translated into Bahasa Indonesia by two authors who were lecturers with expertise in health communication and medical education. Although formal content validation by an external expert panel was not conducted, the translators engaged in an internal discussion to review conceptual accuracy and linguistic equivalence, serving as an informal content validation and cultural adaptation process. Subsequently, the translated version underwent cultural and readability assessment in order to ensure conceptual equivalence and clarity.

Then, the questionnaire was pilot tested with 30 medical

students from a public university in Palembang to perform initial validity testing. Moreover, the validity and reliability of the instrument were assessed using the Corrected Item-Total Correlation method ($P=0.05$). The MAIRS-MS instrument demonstrated validity scores ranging from 0.753 to 0.761, and reliability was measured at 0.767, confirming the instrument's validity and reliability. The results confirmed that the adapted instrument was psychometrically sound prior to its deployment in the main study.

Data Analysis

The collected data were entered into Microsoft Excel and analyzed using the Statistical Package for Social Sciences (SPSS), version 26.0. A one-sample Kolmogorov-Smirnov test was performed to assess the normality of the numerical data. In addition, descriptive statistics, including means and standard deviation (SD), were calculated for each domain of demographics and their readiness. Furthermore, the data were presented as percentages and in horizontal bar charts for better visualization. Additionally, a chi-square test (alternative: likelihood ratio) was conducted to explore the potential relationships between demographic characteristics and AI readiness, with statistical significance set at $P<0.05$. The results were visualized through bar charts created in Microsoft Excel.

To analyze variables influencing readiness, a logistic regression analysis was performed using prediction models. In this analysis, a backward elimination approach was employed to determine which variables would be retained in the final model, using a significance level of 10% as the criterion for statistical association. Non-significant variables were sequentially removed, and the elimination process continued until all remaining variables reached statistical significance. Moreover, the relationships between predictive factors and the outcome were expressed as odds ratios (ORs) with corresponding 95% CIs.

Ethical Considerations and Clearance

Ethical clearance for this study was obtained to ensure the protection of participants' rights and adherence to ethical research standards. In addition, participants were informed about the study's objectives, procedures, and potential risks. Then, consent was obtained through an online process using Google Forms, where participants were required to review the informed consent statement and check a consent box to indicate their agreement to participate. This procedure ensured voluntary participation and informed consent. It is noteworthy that ethical approval for this study was granted by the Health Research Ethics Committee, Faculty of Public Health, Universitas Sriwijaya (343/UN9.FKM/TU.KKE/2024).

Results

Demographic Characteristics of Respondents

A total of 1,053 medical students participated in this study, with a small proportion discontinuing the questionnaire. Most respondents obtained AI-related information through social media (65.1%). However, only 25.3% had received formal AI training, and 22.6% had prior coding experience. This indicates that students' exposure to AI was primarily informal and self-directed rather than structured or curriculum-based. Moreover, the majority of respondents were female (71.9%), undergraduate students (91.4%), and affiliated with public universities. Complete demographic characteristics are presented in Table 1.

AI tool usage was dominated by general-purpose platforms. ChatGPT (90.88%), Mendeley (47.48%), and Grammarly (30.67%) were the most frequently used tools, reflecting students' preference for AI applications that support academic writing and information retrieval (Figure 1). In contrast, AI tools designed for clinical

Table 1. Distribution of respondents' Characteristics

No.	Demography	Frequency	%
	Age		
1	Mean ± SD	19.66 (± 1.764)	
	Minimum-Maximum	16-26	
	Gender		
2	Male	296	28.1
	Female	757	71.9
	Educational levels		
3	Undergraduate Program	962	91.4
	Medical Professional Program	91	8.6
	University origin		
	Universitas Sriwijaya	256	24.3
	Universitas Muhammadiyah Palembang	240	22.8
	Universitas Bengkulu	121	11.5
	Universitas Jambi	114	10.8
	Universitas Lampung	36	3.4
	Universitas Malahayati	16	1.5
	Universitas Sumatra Utara	12	1.1
	Universitas Andalas	34	3.2
	Universitas Negeri Padang	0	0.0
	Universitas Riau	9	0.9
4	Universitas Syiah Kuala	11	1.0
	Universitas Malikussaleh	0	0.0
	Universitas Abulyatama (Unaya)	10	0.9
	Universitas Prima Indonesia	59	5.6
	Universitas Muhammadiyah Sumatra Utara	4	0.4
	Universitas Methodist Indonesia	56	5.3
	Universitas HKBP Nommensen Medan	1	0.1
	Universitas Abdurrab (Univrab)	2	0.2
	Universitas Batam (Uniba)	4	0.4
	Universitas Baiturrahmah (Unbrah)	0	0.0
	Universitas Adiwangsa Jambi (UNAJA)	0	0.0
	Universitas Bangka Belitung	68	6.5
	University type		
5	Public	455	43.2
	Private	90	8.5

Table 1. Continued.

No.	Demography	Frequency	%
	Regional University		
	Aceh	21	2.0
	Riau	11	1.0
	North Sumatra	132	12.5
	Batam	4	0.4
6	West Sumatra	34	3.2
	Jambi	114	10.8
	South Sumatra	496	47.1
	Lampung	52	4.9
	Bengkulu	121	11.5
	Bangka Belitung Islands	68	6.5
	University Accreditation		
	Excellent (Unggul)	587	55.7
7	Very Good (Baik sekali)	309	29.3
	Good (Baik)	153	14.5
	Not Accredited (Tidak Terakreditasi)	4	0.4
	Year of study		
	2018	11	1.00
	2019	26	2.5
	2020	29	2.8
4	2021	150	14.2
	2022	236	22.4
	2023	193	18.3
	2024	408	38.7
	Semester		
	1	409	38.8
	2	21	2.0
	3	198	18.8
	4	26	2.5
5	5	238	22.6
	6	94	8.9
	7	61	5.8
	8	1	0.1
	9	4	0.4
	14	1	0.1
	Father's last education		
6	Elementary—High school	284	27.0
	Diploma—Doctor	769	73.0
	Mother's last education		
7	Elementary—High school	280	26.6
	Diploma—Doctor	773	73.4
	AI information sources		
	Friend	275	26.1
	Social media	686	65.1
8	Internet blog	77	7.3
	Television	1	0.1
	Others (family/teachers/digital books/ searching online)	14	1.3
	Have family or close friends working in the AI field		
9	Yes	74	7.0
	No	979	93.0
	Studied coding in high school		
10	Yes	238	22.6
	No	815	77.4
	Participated in AI training previously		
	I have never attended training	787	74.7
	I attended online training independently	72	6.8
11	I attended an elective course in college	59	5.6
	I attended a mandatory course in college	130	12.3
	I attended a seminar or offline training from the university	79	7.5
	Do you want a formal AI as part of curriculum during your study?		
12	Yes	958	91.0
	No	95	9.0

Note. AI: Artificial intelligence; SD: Standard deviation.

learning or decision support were rarely used. More than two-thirds (67.8%) reported never using many of the listed clinical AI tools. In addition, the majority of respondents were preclinical students, which may have influenced their AI usage preferences. Consequently, the dominance of general-purpose learning tools (e.g., ChatGPT) over clinically oriented AI limits the applicability of these findings to clinical practice settings.

Medical Students' Readiness Toward Artificial Intelligence

The overall readiness toward AI was moderately high (mean ± SD: 74.36 ± 14.03). However, notable differences were observed across the four assessed domains (Table 2 and Figures 2–5). Cognitive readiness showed the lowest performance (mean ± SD: 24.48 ± 5.92), with nearly half of the students remaining neutral regarding their understanding of data science and statistics, indicating gaps in foundational knowledge. Nonetheless, ability readiness was higher (mean ± SD: 28.20 ± 5.57), with almost half of the respondents expressing confidence in using AI tools appropriately and integrating AI-generated insights into clinical reasoning. Based on the results, vision readiness was moderate (mean ± SD: 10.72 ± 2.49), suggesting that students recognize both the potential contributions and limitations of AI in future medical practice. Further, ethical readiness had the highest relative score within its domain (mean ± SD: 10.96 ± 2.46), implying that students felt comparatively more assured in adhering to ethical principles and legal requirements related to AI use. Overall, our findings revealed that while students are reasonably confident in applying AI and understanding its implications, substantial gaps remain in foundational data-related competencies, which may limit

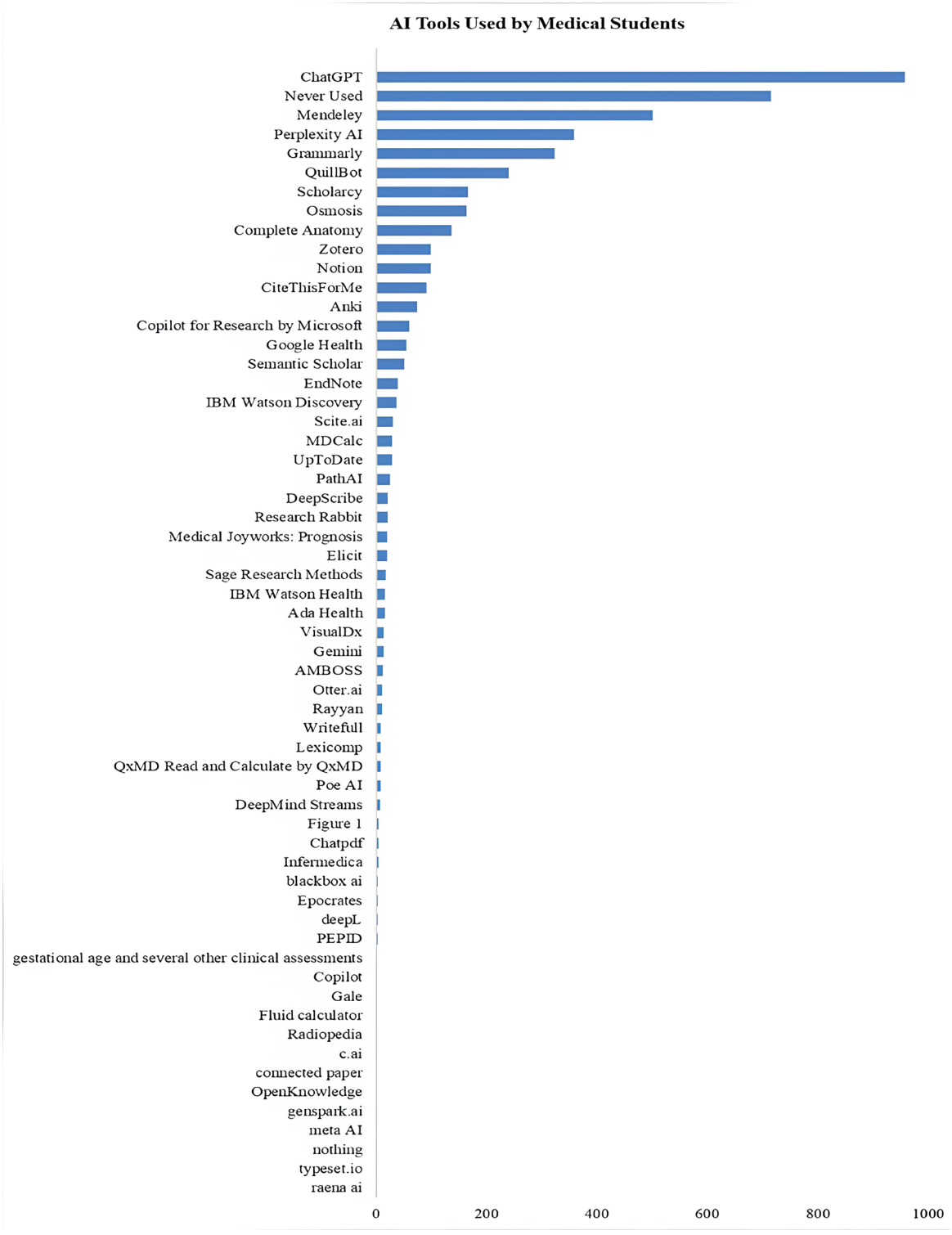

Figure 1. AI Usage by Medical Students
Note. AI: Artificial intelligence

Table 2. Distribution of Medical Student's Readiness Toward AI

Domain	Readiness Toward AI
Cognitive domain (mean ± SD)	24.48 (±5.920)
Ability domain (mean ± SD)	28.20 (±5.566)
Vision domain (mean ± SD)	10.72 (±2.489)
Ethical domain (mean ± SD)	10.96 (±2.463)
Overall respondents' readiness toward AI	74.36 (±14.028)

Note. AI: Artificial intelligence; SD: Standard deviation.

deeper engagement with AI.

Figure 6 displays medical students' levels of readiness to use AI measured on a 5-point scale. The ethical domain recorded the highest average scores, ranging from approximately 3.5 to 3.7, particularly in areas related to acting ethically and complying with relevant regulations. The vision domain demonstrated moderate readiness levels, with scores between 3.0 and 3.4, reflecting an understanding of both the limitations and potential of AI.

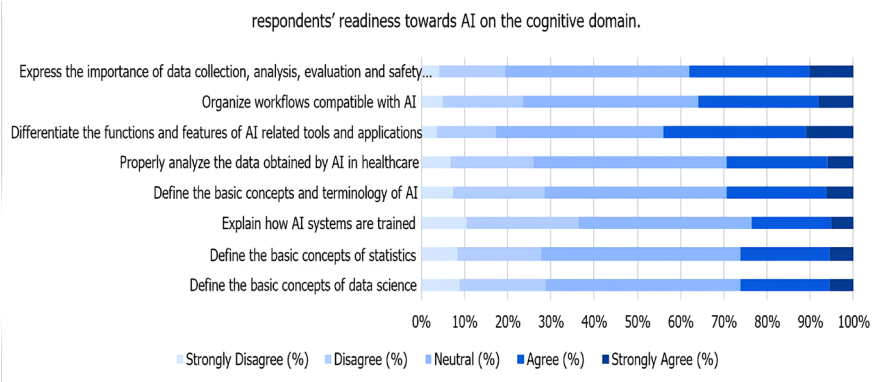

Figure 2. Respondents' Readiness Toward AI on the Cognitive Domain
Note. AI: Artificial intelligence

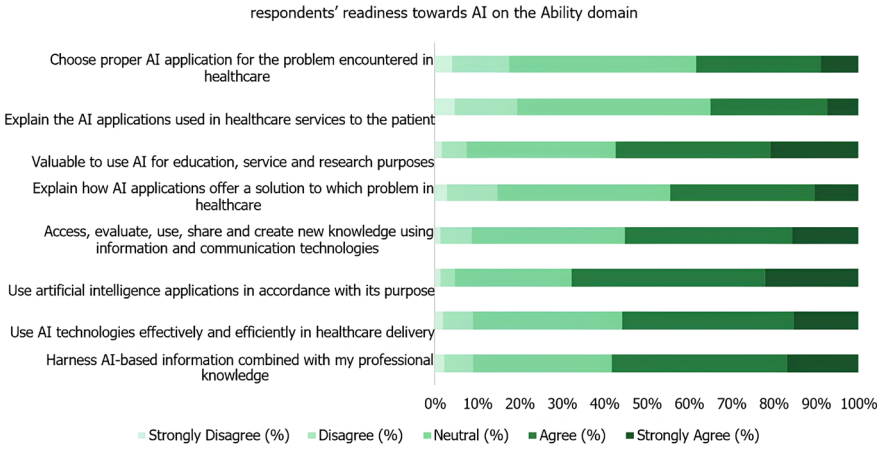

Figure 3. Respondents' Readiness Toward AI on the Ability Domain
Note. AI: Artificial intelligence

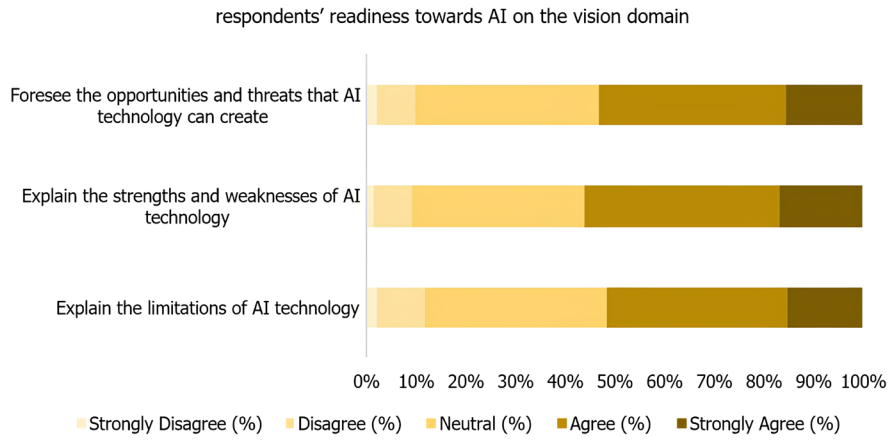

Figure 4. Respondents' Readiness Toward AI on the Vision Domain
Note. AI: Artificial intelligence

Likewise, the capability domain yielded an average score of around 3.0, especially in terms of integrating AI into clinical knowledge and practice. In contrast, the cognitive domain received the lowest scores, nearly 2.5–3.0, highlighting the need to strengthen foundational knowledge, especially in data science and statistics. These findings indicate that students' readiness tends to be higher in ethical and attitudinal aspects, while it remains lower in conceptual and technical competencies, representing the importance of early, structured, and skill-focused AI education within the medical curriculum.

Demographic Factors Related to Respondents' Readiness Toward Artificial Intelligence and the Perceptions of Structured Artificial Intelligence Training in Medical Education

Based on Tables S1 and S2 (Supplementary file), chi-square analysis indicated several demographic and experiential factors associated with medical students' readiness for AI. Cognitive readiness was primarily related to gender, prior exposure to AI blogs, and coding experience during high school, and previous AI training was most consistently associated with cognitive readiness. Ability readiness

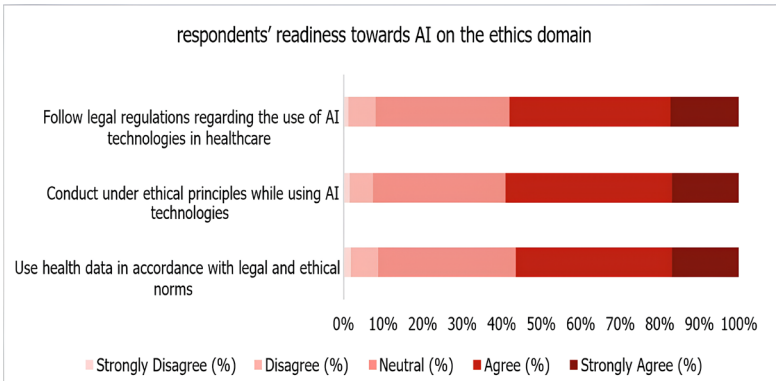

Figure 5. Respondents' Readiness Toward AI on the Ethics Domain
Note. AI: Artificial intelligence

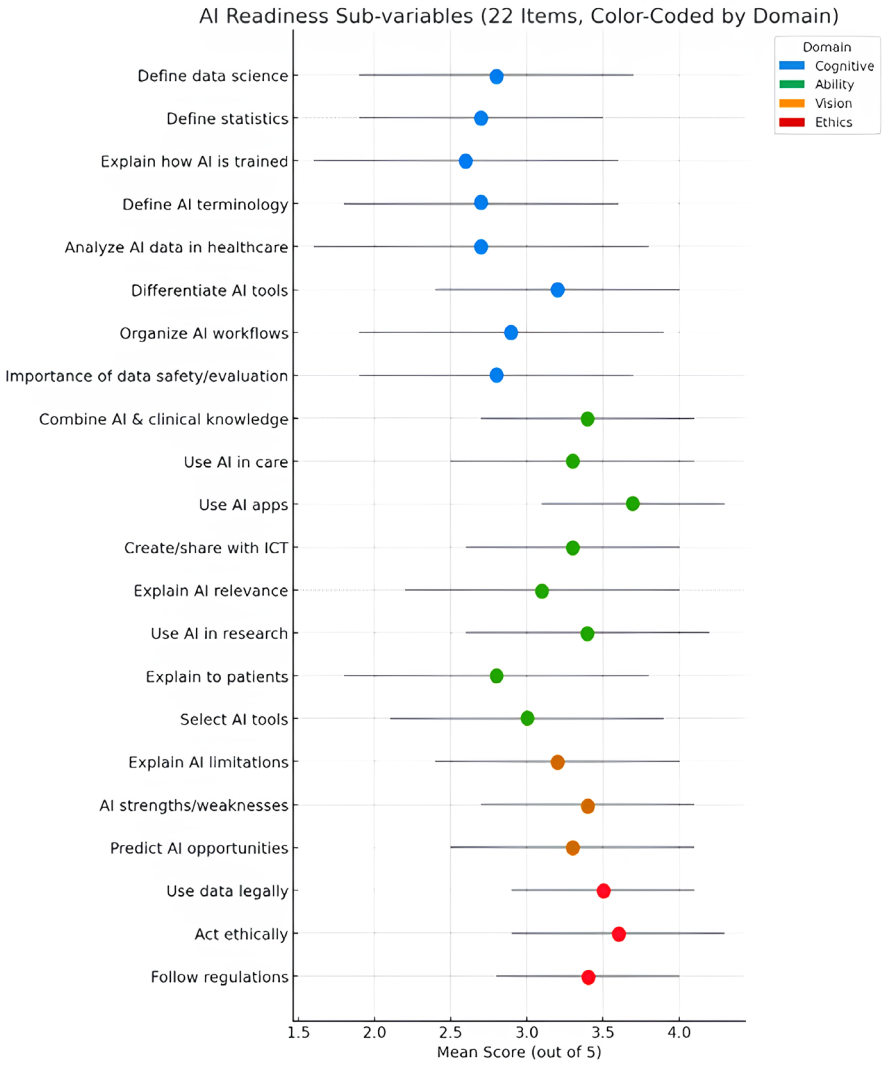

Figure 6. Level of Readiness in Using AI Among Medical Students
Note. AI: Artificial intelligence

varied significantly according to university type, year of study, and exposure to AI blogs, reflecting the links between institutional context and practical experience. Additionally, vision readiness was linked to gender, university type, regional background, academic level, and AI training, suggesting that a broader understanding of AI's potential develops through sociocultural and educational contexts. Based on the findings, ethical readiness increased with academic progression and was associated with region, father's education, and prior AI training, indicating the gradual development of ethical awareness over time. Overall, previous AI training consistently demonstrated the association across all domains, while active information-seeking behaviors, particularly via

AI blogs, were more frequently linked to readiness than passive sources. These findings confirm that medical students' readiness for AI is predominantly related to educational, experiential, and institutional factors rather than demographic characteristics alone.

Furthermore, in the multivariable logistic regression predictive model, prior participation in AI training was significantly related to readiness to use AI. Medical students who had previously received AI training were 1.9 times more likely to be ready to use AI compared with those without prior AI training (OR = 1.90; 95% CI = 1.44–2.61). Additionally, studying coding during high school was significantly associated with higher cognitive readiness, with students being 1.84 times more likely to display cognitive readiness (OR = 1.84; 95% CI = 1.33–2.54). Similarly, prior participation in AI training was significantly attributed to higher ability readiness, with students being 1.66 times more likely to have higher ability readiness (OR = 1.66; 95% CI = 1.24–2.22). Moreover, university type was noticeably associated with higher vision readiness, with students from certain university types being 2.20 times more likely to show higher vision readiness (OR = 2.20; 95% CI = 1.70–2.86), as well as higher ethics readiness, with students being 2.10 times more likely to demonstrate higher ethics readiness (OR = 2.10; 95% CI = 1.63–2.72). These results are presented in Tables S3–S7 (supplementary file).

Discussion

This study expanded previous research on medical students' readiness for AI by examining a regionally and institutionally diverse sample drawn from public and private medical schools across Sumatra. Unlike earlier studies conducted primarily in single institutions or regions with more uniform digital infrastructure, this study captured readiness patterns within a context characterized by substantial variations in institutional capacity, geographic development, and access to digital resources. This is essential to understanding AI readiness in such heterogeneous settings and supporting equitable and context-sensitive integration of AI into medical education.

Artificial Intelligence Readiness in Sumatra: Comparative and Domain-Specific Insights

Overall, medical students in Sumatra exhibited a moderate level of overall AI readiness, with notable variations across cognitive, technical, vision, and ethical domains. Notably, their readiness levels were comparable to, or slightly exceeded, those reported in studies from Malaysia, Jordan, Saudi Arabia, and Iran (13, 17-19), despite Indonesia's uneven digital infrastructure. Their readiness was also slightly higher than that of students from Universitas Pelita Harapan in Java (12) and was comparable only to students in India. This suggests that informal exposure to digital technologies and general-purpose AI tools may partially offset the limited integration of formal AI education within medical curricula. Nevertheless, such exposure alone does not guarantee balanced competence across all domains of AI readiness.

Domain-specific analysis revealed that medical students in Sumatra obtained the highest score for technical ability and showed relatively strong vision regarding AI's role in healthcare. Likewise, Universitas Pelita Harapan students and Indian students received the highest scores in the ability domain and cognitive readiness, respectively. In contrast, students from Malaysia, Jordan, and Saudi Arabia generally displayed lower readiness across domains. In Saudi Arabia, despite the largest sample size, students demonstrated low levels of readiness across understanding, skills, and ethics (19).

Domain-specific patterns depicted a pronounced AI literacy paradox, wherein students showed strong technical ability and ethical awareness but consistently lower cognitive readiness. While students report confidence in using AI tools and indicate awareness of ethical and regulatory issues, many of them lack a foundational understanding of data science, statistics, and algorithmic principles (20, 21). This conceptual gap has important implications, as insufficient theoretical grounding may hinder critical evaluation of AI outputs, reduce perceived usefulness and ease of use, and ultimately constrain clinical adoption, as articulated in the Technology Acceptance Model (22, 23).

Despite these limitations, high technical proficiency, frequently developed through informal engagement with tools such as ChatGPT, supports personalized learning and rapid feedback (24, 25). Ethical readiness is likewise robust, reflecting awareness of professional, regulatory, and moral responsibilities (26, 27). Similarly, students express optimism regarding AI's future role in healthcare, although concerns persist regarding doctor–patient relationships, privacy, and accountability (28).

The high level of ethical awareness observed among medical students suggests that moral considerations are perceived as more critical than technological sophistication, aligning with the ethical principles of the World Health Organization for AI in healthcare (29). The deployment of AI without strong adherence to ethical responsibility and regulatory compliance poses risks, including misdiagnosis, privacy breaches, and cultural bias, which may all compromise patient safety. Consequently, ethical commitment plays a central role in preventing uncritical reliance on AI and ensuring that its clinical implementation prioritizes patient protection and professional accountability.

Moreover, Indonesia's uneven digital infrastructure does not appear to substantially constrain AI readiness among medical students in Sumatra. This pattern may be explained by relatively strong digital literacy, cultural familiarity with technology, and extensive informal exposure to AI tools. Based on provincial data, the average digital literacy score across Sumatra is approximately 49.53, indicating a moderate level of digital competence among the population, including university students,

which supports their ability to engage with and adapt to emerging digital and AI-based technologies (30). This is further confirmed by surveys showing widespread academic use of generative AI tools (e.g., ChatGPT) among Indonesian students (31-33).

In general, these findings indicate that AI readiness among medical students emerges from the interaction of informal engagement, technical confidence, ethical orientation, and contextual digital literacy. However, the persistence of the AI literacy paradox underscores the need for curriculum reform that integrates foundational AI knowledge, ethical reasoning, and clinical application in a balanced manner to ensure safe and effective use of AI in healthcare practices (18, 22, 29).

Adoption of General and Clinical Artificial Intelligence Tools in Medical Education

Medical students predominantly use general-purpose AI tools (e.g., ChatGPT, Mendeley, and Grammarly), while the adoption of clinically oriented platforms (e.g., Complete Anatomy, Osmosis, and UpToDate) remains limited. This pattern reflects students' preference for tools that are familiar, easy to use, and directly applicable to learning, which is consistent with the Technology Acceptance Model; this model emphasizes perceived usefulness, ease of use, and familiarity as key determinants of technology adoption (34, 35, 36).

This usage pattern may also be influenced by the composition of the study population, as most respondents were undergraduate (preclinical) medical students. At this stage, learning activities primarily focus on theoretical understanding and academic performance, which likely explains the preference for general-purpose AI tools over clinically oriented applications with limited immediate relevance. Accordingly, the lower adoption of clinical AI tools appears driven more by structural and educational barriers (e.g., limited curricular integration, restricted access, and insufficient formal instruction) than by a lack of student interest.

Although most respondents reported no prior formal AI training, engagement in informal or alternative learning activities indicates growing awareness of AI competencies for future clinical practice (12). Without structured curricular integration, students may excel in academic AI applications yet remain underprepared for ethical and effective clinical use. Therefore, integrating AI education into medical curricula is essential to support clinical reasoning and patient care, which is in line with the recommendations of the American Medical Association (37).

Factors Associated With Medical Students' Artificial Intelligence Readiness

Our findings revealed that AI readiness among medical students is not merely an individual-level competency but is fundamentally shaped by structural and social inequities embedded within educational systems. Differences observed across gender, institutional type, geographic region, parental education, and prior exposure to AI or programming reflect unequal opportunities to develop the cognitive, technical, and ethical capacities required to meaningfully engage with AI in medical practices. These findings conform to prior evidence, indicating that technological readiness in medical education is strongly influenced by institutional and sociocultural contexts rather than individual aptitude alone (18, 19, 38).

Institutional context emerged as a critical determinant of AI readiness. Students from public universities consistently demonstrated higher readiness, particularly in the domains of technical ability, ethical awareness, and future-oriented vision, which corroborates the findings of studies highlighting the role of curriculum quality, faculty expertise, and digital infrastructure in shaping AI competencies (39, 40). Multivariate analysis further indicated that university type specifically influences vision and ethical readiness, underscoring the unique contribution of institutional factors beyond simple bivariate associations. In the Indonesian context, public institutions typically benefit from government-supported funding, standardized curricula, and more stable digital infrastructure, enabling more consistent integration of AI-related competencies. In contrast, private universities, especially those outside the Java region, frequently face greater resource constraints and variability in curricular priorities. These findings suggest that AI readiness is shaped less by public–private status alone than by institutional vision, investment, and commitment to technological integration. This highlights the role of institutional governance and policy in either mitigating or reproducing readiness gaps.

Additionally, gender-based disparities were evident, with male students reporting higher readiness across cognitive, ability, and vision domains. These patterns align with global evidence implying that gendered technology socialization, differential self-efficacy, and AI-related anxiety affect engagement with digital technologies (41). Such disparities often emerge early in educational trajectories and persist across schooling levels, thereby reflecting broader sociocultural norms that frame AI and advanced technologies as male-dominated fields (12). In many Asian contexts, patriarchal expectations and unequal access to digital resources may further constrain women's opportunities to develop AI competencies (42). Without gender-responsive educational strategies, these disparities may persist into AI-enabled clinical practice, indicating the need for targeted interventions to promote equity.

Access to AI-related training and early programming experience played a substantial role in shaping students' readiness. Those who had participated in formal AI training or had prior exposure to coding demonstrated higher readiness across cognitive, technical, and ethical domains (17, 19). In addition, multivariate logistic regression identified AI training and coding experience as independent predictors of domain-specific

readiness. AI training enhanced overall readiness and ability, while coding experience specifically improved cognitive readiness, highlighting the unique impact of these educational interventions. These findings reveal the importance of structured educational programs in fostering not only competence but also confidence and trust in AI technologies. Consistent with the Technology Acceptance Model (Davis, 1989), hands-on experience appears to strengthen perceived usefulness and ease of use (43), which are essential precursors to meaningful adoption. Moreover, these results suggest that AI readiness cannot be improved solely through individual motivation, emphasizing the need for systematic and targeted educational strategies to mitigate readiness gaps and promote equitable competence development.

In this study, the year of study was significantly associated with readiness in the ability and ethical domains. Students from later year groups, particularly the 2022 intake, demonstrated higher perceived skills and ethical awareness in applying AI, likely reflecting learning experiences shaped by the post–coronavirus disease 2019 acceleration of digital transformation, including online learning, increased use of digital tools, and exposure to AI-related content emphasizing responsible practice (19, 44, 45). These findings suggest that AI readiness dynamically develops as students progress academically, rather than linearly, underscoring the need for longitudinal, developmentally structured educational strategies to support both technical competence and ethical awareness. Unequal exposure to digital and AI-related experiences may contribute to variability in readiness, emphasizing the importance of providing structured opportunities to ensure equitable skill and ethical development across all years of study (46).

Family background, particularly parental education, further shaped students' digital readiness. Higher parental educational attainment, especially paternal education, was related to greater AI readiness, supporting prior evidence that familial social capital and digital mediation practices at home influence students' technological engagement (47, 48). This issue highlights how inequities external to formal education systems can indirectly shape professional readiness, thereby reinforcing the need for compensatory institutional strategies to support students from less advantaged backgrounds.

Conceptual Typology of Artificial Intelligence Readiness

Collectively, the domain-specific patterns observed in this study suggest the existence of distinct conceptual profiles of AI readiness among medical students. One profile is characterized by strong practical ability and ethical awareness but limited conceptual understanding, representing confident users of AI tools who may lack foundational knowledge. In addition, the other profile demonstrates balanced competence across domains, reflecting students with high potential to critically engage with AI in clinical contexts. Furthermore, the third profile exhibits uniformly low readiness, indicating that students are at risk of exclusion from AI-enabled medical practice. These profiles illustrate how unequal access to education, training, and institutional support translates into divergent readiness trajectories, emphasizing the equity dimension of AI readiness.

Implications for Medical Education

Understanding AI readiness as a product of systemic educational and social conditions has important implications for curriculum design and policy. Medical schools should adopt equity-oriented strategies that integrate AI literacy longitudinally, ensure inclusive access to training, and address gendered and socioeconomic disparities in technological engagement. Without such systemic interventions, the rapid integration of AI into healthcare risks exacerbating existing inequities rather than enhancing educational and clinical outcomes.

Strengths and Limitations of the Study

This study provided a comprehensive assessment of AI readiness among medical students in Sumatra and was strengthened by its large, regionally diverse sample. To our knowledge, it represents the largest multi-institutional dataset examining AI readiness among medical students in Indonesia, including participants from multiple provinces and both public and private universities. This breadth enhances the robustness of subgroup comparisons and improves contextual relevance compared with prior single-institution studies. Moreover, the use of the MAIRS-MS instrument allowed multidimensional evaluations across cognitive, technical, vision, and ethical domains, offering a nuanced understanding of students' preparedness and highlighting both strengths and gaps in AI readiness.

However, several limitations should be acknowledged. The cross-sectional design limited causal inference and did not capture changes in AI readiness over time. In addition, the use of self-reported measures may have introduced response bias, particularly in domains related to technical competence and ethical awareness. Further, the non-random sampling approach and uneven participation across institutions may have affected representativeness at the university level. Furthermore, the MAIRS-MS measured perceived readiness rather than objectively assessed skills, and, therefore, actual competencies in data science or clinical AI application were not evaluated in this study. Finally, faculty readiness and institutional implementation capacity, as important contextual factors for AI integration, were not assessed in this study. Consequently, the findings should be interpreted as reflecting AI readiness among participating students rather than providing population-level estimates for all medical students in Indonesia.

Conclusion

Medical students in Sumatra demonstrated moderate-to-high readiness for AI, particularly in technical skills, vision of AI's role in healthcare, and ethical awareness,

while cognitive readiness remains limited. It was revealed that hands-on experience, active engagement with AI platforms, and early programming exposure are key factors associated with higher readiness.

To support equitable AI integration, curricula should begin with foundational AI literacy, progress to clinical applications, and include practical workshops and supervised exercises. It is noteworthy that collaborative strategies between public and private universities can address disparities in instructors, equipment, and funding, while equity-oriented and longitudinal approaches ensure inclusive development of competence and ethical awareness across all student groups.

Authors' Contribution

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Competing Interests

The authors declare that they have no conflict of interests.

Ethical Approval

This study was approved by the Ethics Committee of the Faculty of Public Health, Universitas Sriwijaya (343/UN9.FKM/TU.KKE/2024).

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Supplementary File

Supplementary file contains Table S1-S7.

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