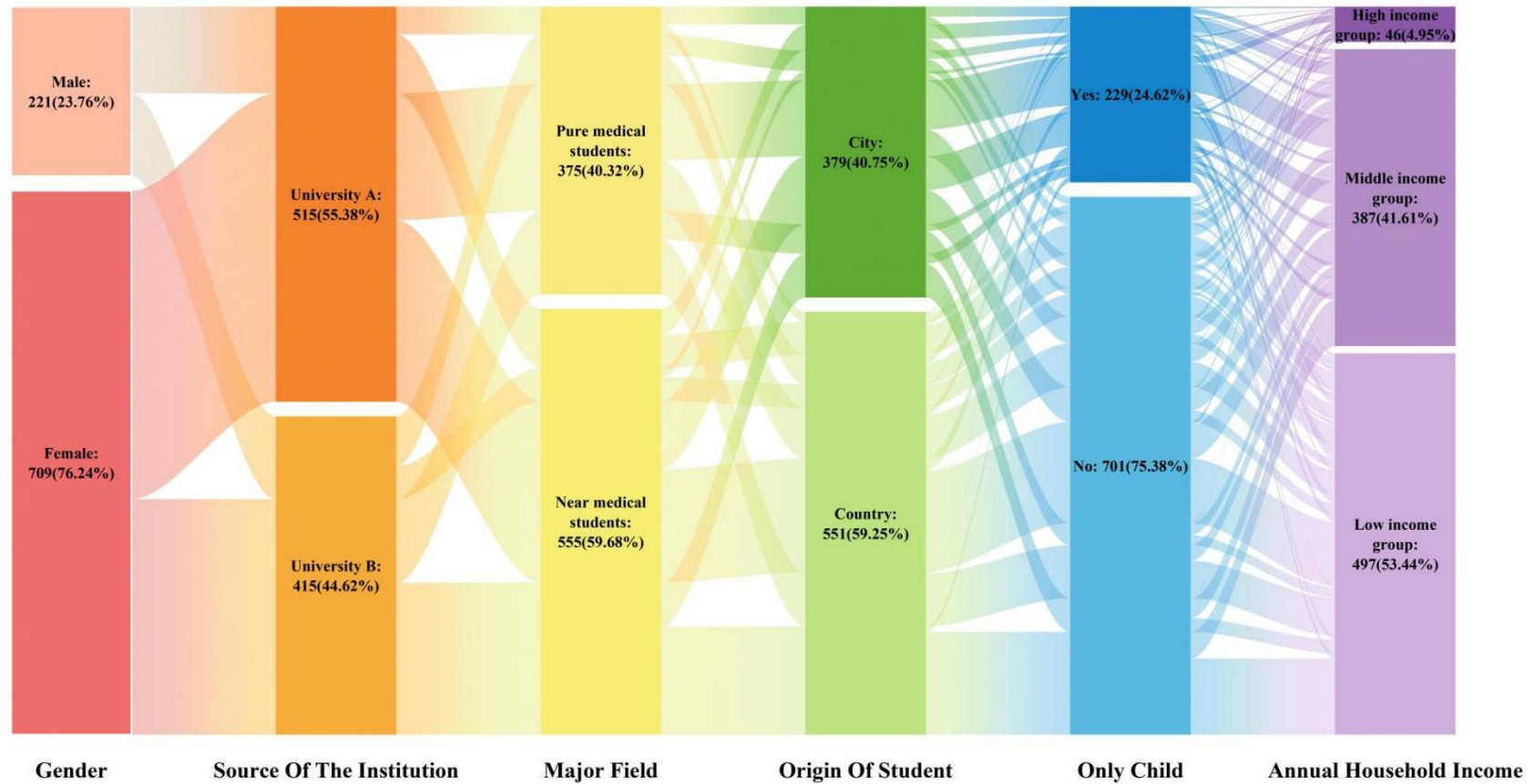


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Supplementary Figure 1 Quantitative and relational descriptions of different demographic characteristics (Unit: persons;Figure was created using Origin 2024[®] software)



Supplementary Table 1 Analysis of the Effect of GenAI Dependence on
Self-reported Academic Performance Based on the Ologit Model

Model Category		Model A (Subjective GenAI Dependence)		Model B (Objective GenAI Dependency Level)	
		β	P	β	P
Dependent Variable		0.197	0.115	-0.007	0.397
Gender		-0.531	<0.001	-0.513	<0.001
Origin Of Student		-0.025	0.864	-0.029	0.837
Control Variable	Only Child	0.275	0.075	0.280	0.070
	Annual Household Income	0.324	0.004	-0.323	0.004
	Major Field	0.115	0.361	0.127	0.310
	Prob > chi2	<0.001		<0.001	

Note: The independent variable of Model A is the Subjective GenAI Dependence, while that of Model B is the Objective GenAI Dependency Level. The dependent variable of both models is self-reported academic performance.

Supplementary Table 2 Variable Definitions and Measurements

Category	Variable	Assignment
Control Variable	Gender	Female=0; Male=1
	Origin Of Student	Country=0; City=1
	Only Child	No=0; Yes=1
	Annual household level	Low income group（Less than 80,000 RMB）=0
		Middle income group（80,000–300,000 RMB）=1
		High income group（300,000 RMB or more）=2
	Major Field	Near medical students=0
		Pure medical students=1
		Poor（Bottom 20%）=0
	Self-rated Academic Performance	Average（50%-80%）=1
Good（20%-50%）=2		
Excellent（Top 20%）=3		
Independent Variable	Performance Expectancy	Original value
	Effort Expectancy	Original value
	Self-Efficacy	Original value
	Critical Thinking	Original value
	Academic Pressure	Original value
	Facilitating Conditions	Original value
	Social Influence	Original value
Dependent Variable	GenAI Dependency Level	Original value

Supplementary Table 3 Analysis of Variance (ANOVA) of GenAI Dependency
Level Across Different Demographic Characteristics

	Variable	Mean ± SD	t/F	P
	Total	21.914±6.746		
Gender	Male	21.394±7.880	1.314	0.189
	Female	22.076±6.349		
Origin Of Student	City	21.509±6.920	1.519	0.129
	Country	22.192±6.615		
Only Child	Yes	21.734±7.235	0.466	0.641
	No	21.973±6.582		
Annual Household Income	Low income group	21.873±6.793	0.860	0.422
	Middle income group	22.106±6.487		
	High income group	20.739±8.250		
Source Of The Institution	A College	22.680±7.115	3.885	<0.001***
	B College	20.964±6.134		
Major Field	Pure medical students	21.405±7.346	1.893	0.059
	Near medical students	22.258±6.291		
Self-rated Academic Performance	Excellent	22.174±7.299	1.600	0.188
	Good	21.511±6.766		
	Average	21.934±6.345		
	Poor	23.459±6.811		
*** <i>p</i> <0.001, ** <i>p</i> <0.01, * <i>p</i> <0.05				

Supplementary Table 4 Reliability Analysis

Variable	Cronbach's Alpha	Number of Items
GenAI Dependency Level	0.908	8
Performance Expectancy	0.811	3
Effort Expectancy	0.850	3
Self-Efficacy	0.858	3
Critical Thinking	0.877	3
Academic Pressure	0.723	3
Facilitating Conditions	0.810	3
Social Influence	0.733	3
Total Factor	0.909	29

Supplementary Table 5 Kaiser-Meyer-Olkin and Bartlett's Test

Test		Result
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.917
Bartlett's Test of Sphericity	Approx. Chi-Square (χ^2)	9919.476
	df	210.000
	Sig.	<0.001

Supplementary Table 6 Factor Loadings Based on a Principal Component Analysis

Extraction with Varimax Rotation

Variable	Item	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Communality
Performance Expectancy	PE1	0.756							0.767
	PE2	0.774							0.777
	PE3	0.762							0.724
Effort Expectancy	EE1		0.760						0.730
	EE2		0.818						0.820
	EE3		0.791						0.795
Self-Efficacy	SE1			0.783					0.819
	SE2			0.756					0.799
	SE3			0.694					0.770
Critical Thinking	CT1				0.763				0.748
	CT2				0.798				0.816
	CT3				0.822				0.846
Academic Pressure	AP1					0.637			0.830
	AP2					0.839			0.752
	AP3					0.805			0.773
Facilitating Conditions	FC1						0.754		0.726
	FC2						0.781		0.780
	FC3						0.715		0.711
Social Influence	SI1							0.739	0.774
	SI2							0.757	0.705
	SI3							0.805	0.794
Cumulative % of Variance		12.452	23.791	34.537	45.077	55.392	65.273	74.588	

Supplementary Note 1 A Survey on Medical Students' Dependence on Generative Artificial Intelligence

Dear Student,

We are conducting a survey investigating the dependence of medical students on generative artificial intelligence (e.g., ChatGPT®). This study aims to evaluate your current usage patterns, degree of dependence, and associated influencing factors regarding GenAI in medical education and clinical practice. The findings will provide a critical reference for guiding and standardizing the integration of GenAI within medical education.

Data will be collected anonymously. All information will be utilized strictly for academic research, and your personal privacy will be protected. The questionnaire will take approximately 5 to 8 minutes to complete. Please respond based on your actual experiences. Completing this questionnaire indicates your informed consent to participate in this study.

Thank you for your support and cooperation!

Part I: Socio-demographic Characteristics

1. Please indicate your gender :

- ☐ Male
- ☐ Female
- ☐ Other

2. Where is your place of origin?

- ☐ City
- ☐ Country

3. Are you the only child in your family?

- ☐ Yes
- ☐ No

4. Annual household level:

- ☐ Low income group (< 80,000 RMB)
- ☐ Middle income group (80,000 - 300,000 RMB)
- ☐ High income group ($\geq$ 300,000 RMB)

5. What is your major field of study?

- ☐ Pure medical student (programs conferring a Bachelor of Medicine degree upon graduation, including clinical medicine, preventive medicine, nursing, etc.)
- ☐ Near medical student (non-clinical majors in medical institutions, e.g., pharmacy, medical law, medical English, health administration, etc.)

6. Please self-evaluate your academic performance over the past academic year:

- ☐ Excellent (Top 20%)

- ☐ Good (20% - 50%)
- ☐ Average (50% - 80%)
- ☐ Poor (Bottom 20%)

Part II: Current Status and Self-Evaluation of GenAI Usage

7. Have you ever used generative artificial intelligence tools (e.g., ChatGPT®, ERNIE Bot®, DeepSeek®, Doubao®, etc.)?

- ☐ Yes
- ☐ No (If not, the survey is complete.)

8. How often do you use generative artificial intelligence (GenAI) in your daily life?

- ☐ At least once a day
- ☐ 3-5 times a week
- ☐ Once or twice a week
- ☐ 1 to 3 times per month
- ☐ Rarely used

9. Which generative AI tools do you typically use? (Multiple selections allowed)

- ☐ ChatGPT®
- ☐ DEEPSEEK®
- ☐ Doubao®
- ☐ Kimi®
- ☐ ERNIE Bot®
- ☐ iFLYTEK Spark®
- ☐ Claude®
- ☐ Gemini®
- ☐ Qwen®
- ☐ Med-PaLM® (Medical-specific)
- ☐ Other (please specify): _____

10. For what specific clinical or academic scenarios do you typically use GenAI?
(Multiple selections allowed)

- ☐ Assist with course learning (e.g., explaining concepts, solving post-class exercises)
- ☐ Search for medical materials and literature
- ☐ Write theses, reports, and other written works
- ☐ Cross-cultural language translation or interpretation
- ☐ Analyze simulated cases and practice assisted diagnosis
- ☐ Assist with the processing and writing of medical documents
- ☐ Simulate medical Q&A and patient consultations
- ☐ Write code for software operation
- ☐ Develop personalized study plans
- ☐ Other (please specify): _____

11. Do you think using generative AI could help you improve your academic performance?

- ☐ Yes
- ☐ No

12. Do you consider yourself dependent on GenAI?

- ☐ Dependent
- ☐ Independent

13. What negative impacts do you associate with GenAI dependence? (Multiple answers allowed)

- ☐ Diminished critical thinking ability
- ☐ Decreased ability in independent literature retrieval
- ☐ Basic errors caused by GenAI dependence
- ☐ Difficulty in completing a complete diagnosis and treatment thinking without GenAI prompts
- ☐ Being questioned about academic integrity due to direct copying of GenAI answers
- ☐ Decreased frequency of discussions with mentors/peers

- ☐ Prominent issues regarding data security and privacy breaches
- ☐ Prone to intellectual property issues
- ☐ Other negative impacts (please specify): _____

Part III: Survey on GenAI Dependence Level¹

Please recall your learning scenarios over the past year and check the corresponding option for each item.

1 = Strongly Disagree, 2 = Disagree, 3 =Uncertain, 4 = Agree, 5 = Strongly Agree

No.	Measurement Item	1	2	3	4	5
D1	I would feel anxious or uncomfortable if I couldn't use GenAI.	☐	☐	☐	☐	☐
D2	Before I can start a job or task, I have to launch my GenAI tools.	☐	☐	☐	☐	☐
D3	Without the use of GenAI, I would find it difficult to accomplish professional-related tasks.	☐	☐	☐	☐	☐
D4	Even for jobs or tasks that I can easily do myself, I tend to let GenAI help.	☐	☐	☐	☐	☐
D5	I would rather spend my time on GenAI than other teachers or textbooks.	☐	☐	☐	☐	☐
D6	Even without using GenAI, I want to keep it logged in/started in the background.	☐	☐	☐	☐	☐
D7	I'm spending more and more time on GenAI.	☐	☐	☐	☐	☐
D8	For me, life without GenAI is inconvenient.	☐	☐	☐	☐	☐

Part IV: Survey on Factors Associated with GenAI Dependence

Please recall your learning scenarios over the past year and check the corresponding option for each item.

1 = Strongly Disagree, 2 = Disagree, 3 =Uncertain, 4 = Agree, 5 = Strongly Agree

Dimension	No.	Measurement Item	1	2	3	4	5
Performance expectancy ^{2,3}	PE1	I believe GenAI is highly useful for my academic and professional life.	☐	☐	☐	☐	☐
	PE2	I believe GenAI can help me achieve something very important.	☐	☐	☐	☐	☐
	PE3	I believe GenAI significantly enhances my learning efficiency.	☐	☐	☐	☐	☐
Effort Expectancy ^{2,3}	EE1	I find learning to use GenAI to be effortless.	☐	☐	☐	☐	☐
	EE2	I find GenAI operations simple, intuitive, and user-friendly.	☐	☐	☐	☐	☐
	EE3	Achieving proficiency in using GenAI is an easy task for me.	☐	☐	☐	☐	☐
Self-Efficacy ⁴	SE1	I am highly confident in my ability to utilize GenAI effectively.	☐	☐	☐	☐	☐
	SE2	I possess clear learning objectives, which I persistently pursue and	☐	☐	☐	☐	☐

		ultimately achieve.					
	SE3	I am confident that I can overcome most difficulties if I exert the necessary effort.	☐	☐	☐	☐	☐
Critical Thinking ⁵	CT1	I routinely question and verify the answers generated by GenAI.	☐	☐	☐	☐	☐
	CT2	I am adept at identifying the critical information within GenAI outputs.	☐	☐	☐	☐	☐
	CT3	I proactively evaluate whether GenAI-generated content aligns with practical clinical and real-world scenarios.	☐	☐	☐	☐	☐
Academic Pressure ^{6,7}	AP1	Due to the complexity of medical knowledge and the uncertainty of clinical scenarios, I face a massive volume of material that requires learning.	☐	☐	☐	☐	☐
	AP2	I frequently experience distress arising from an intense desire to achieve excellent academic results.	☐	☐	☐	☐	☐
	AP3	I often struggle to keep pace with coursework, exams, internships, or mentor assignments, necessitating external tools to maintain progress.	☐	☐	☐	☐	☐
Quality Control	QC	Please select "Strongly Disagree" for this item.	☐	☐	☐	☐	☐

Facilitating Conditions ²	FC1	I possess the necessary resources (e.g., campus network support, device compatibility) required to utilize GenAI tools.	☐	☐	☐	☐	☐
	FC2	GenAI is highly compatible with the other professional applications I utilize.	☐	☐	☐	☐	☐
	FC3	I have access to assistance when encountering professional issues while using GenAI.	☐	☐	☐	☐	☐
Social Influence ^{2,8}	SI1	Individuals who influence my behavior (e.g., attending physicians, mentors) advocate for the use of GenAI in medical learning.	☐	☐	☐	☐	☐
	SI2	Positive evaluations of GenAI within medical education on social media strongly influence my willingness to adopt it.	☐	☐	☐	☐	☐
	SI3	Within my social network, individuals who proficiently use GenAI command more prestige than those who do not.	☐	☐	☐	☐	☐

This concludes the questionnaire. Thank you once again for your participation!

References

1. Zhang, X., Yin, M., Zhang, M., Li, Z. & Li, H. The Development and Validation of an Artificial Intelligence Chatbot Dependence Scale. *Cyberpsychology, Behavior, and Social Networking* <https://doi.org/10.1089/cyber.2024.0240> (2025)
2. Venkatesh, V., Thong, J. Y. L. & Xu, X. Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly* 36, 157–178 (2012).
3. Cabrera-Sánchez, J.-P., Villarejo-Ramos, Á. F., Liébana-Cabanillas, F. & Shaikh, A. A. Identifying relevant segments of AI applications adopters – Expanding the UTAUT2’s variables. *Telematics and Informatics* 58, 101529 (2021).
4. Zhang, J. & Schwarzer, R. Measuring optimistic self-beliefs: A Chinese adaptation of the General Self-Efficacy Scale. *Psychologia: An International Journal of Psychology in the Orient* 38, 174–181 (1995).
5. Kember, D. & Leung, Y. P. Development of a questionnaire for assessing students’ perceptions of the teaching and learning environment and its use in quality assurance. *Learning Environments Research* 12, 15–29 (2009).
6. Yusoff, M. S. B., Fuad, A. & Yaacob, M. J. The Development and Validity of the Medical Student Stressor Questionnaire (MSSQ). *ASEAN Journal of Psychiatry* 11, (2010).
7. Solberg, V. S., Hale, J. B., Villarreal, P. & Kavanagh, J. Development of the College Stress Inventory for Use with Hispanic Populations: A Confirmatory Analytic Approach. *Hispanic Journal of Behavioral Sciences* 15, 490–497 (628877088000000000).
8. Lu, L., Cai, R. & Gursoy, D. Developing and validating a service robot integration willingness scale. *International Journal of Hospitality Management* 80, 36–51 (2019).

Supplementary Note 2 Interview Guide for Medical School Teachers on Student Dependence on Generative Artificial Intelligence

Dear Professor/Instructor,

Thank you for taking the time out of your busy teaching schedule to participate in this interview. Generative Artificial Intelligence (GenAI) is becoming increasingly integrated into higher medical education settings. While it offers substantial efficiency gains in students' learning processes, it simultaneously introduces potential risks associated with over-reliance. As practitioners in medical education, your observations regarding students' usage and dependency behaviors concerning GenAI, alongside any pedagogical countermeasures you have explored. These firsthand experiences will not only illuminate pedagogical nuances that student-level surveys may fail to capture, but also provide practical references for the rational application of GenAI in medical education.

This interview will take a semi-structured format and focus on topics related to students' dependence on AI. We encourage you to share your insights freely based on your specific teaching contexts. The session will last approximately 25 to 30 minutes. We assure you that your personal information and interview responses will be strictly anonymized. All collected data will be utilized exclusively for academic research purposes and will remain strictly confidential.

Thank you once again for your support! Your contributions will directly assist in optimizing the application pathways of GenAI in medical education.

Part I: Demographic Information

1. How many years of teaching experience do you have?

- ☐ $\leq$ 5 years
- ☐ 6 – 10 years
- ☐ 11 – 15 years
- ☐ $\geq$ 16 years

2. What is your area of instructional specialization?

☐ Pure medical student (programs conferring a Bachelor of Medicine degree upon graduation, including clinical medicine, preventive medicine, nursing, etc.)

☐ Near medical student (non-clinical majors in medical institutions, e.g., pharmacy, medical law, medical English, health administration, etc.)

3. What is your primary teaching modality?

☐ Theoretical lectures

☐ Laboratory courses

☐ Clinical practicums (e.g., clerkships, clinical mentoring)

☐ Mixed modality

4. Have you received any training related to the pedagogical application of GenAI?

☐ Yes

☐ No

Part II: Observations and Perceptions of GenAI Usage and Dependence

Behaviors

1. In your teaching practice, have you observed students utilizing GenAI to assist their learning? In which specific medical learning scenarios is this behavior most concentrated?

2. What behaviors do you think indicate that students are dependent on GenAI? Please illustrate your answer with examples from your teaching experience.

3. Based on your observations, what are the primary drivers behind these dependency behaviors?

4. Have you observed any differences in students with different characteristics regarding their level of dependence on GenAI or the contexts in which they depend on it? If so, please briefly explain.

Part III: The Impact of Dependence on GenAI on Medical Education

1. In terms of teaching effectiveness, has students' dependence on GenAI had a positive impact on your teaching?

2. Does students' dependence on GenAI pose challenges for your teaching? Please focus on issues specific to medical education.

3. Have you encountered instances where GenAI "hallucinations" led students to form cognitive misconceptions? How do you address such issues?
4. Do you believe that medical students' dependence on GenAI will affect the development of their core medical competencies? Please provide examples that take into account the characteristics of medical education.

Part IV: Teaching Strategies That Depend on GenAI

1. Have you adjusted your teaching methodologies or assignment designs in response to students' dependence on GenAI?
2. Following these adjustments, what changes have you observed in students' responses or learning outcomes?
3. Have you established or implemented any guidelines or policies regarding GenAI usage in your teaching?
4. In your opinion, how should intervention strategies differ for students exhibiting varying levels of GenAI use (e.g., light utilitarian use vs. heavy dependence)?

Part V: Future Perspectives on GenAI

1. To better manage students' dependence on GenAI, do you require specific training or resource support?
2. In what areas should the university or faculty strengthen the guidance and management of students' GenAI usage?
3. What do you consider to be the appropriate role of GenAI in medical education? How should educators balance its "instrumental" and "substitutive" aspects?
4. What are your perspectives on the future trajectory of GenAI within medical educational practice?