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The interplay between research expectations and perceived barriers: a mediation analysis among Chinese medical undergraduates

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Abstract

Background Scientific research activity is essential to drive undergraduate medical education innovation, but many barriers prevent students from participating in research activities. While many studies have identified these challenges, the psychological factors, such as research expectations and interest, influencing students' perceptions of these barriers have been less explored. This study intends to explore these barriers and how research expectations, through interest, influence student engagement in research.

Methods This cross-sectional study involved 322 medical students from Shandong University. The majority of participants were from the specialty of Clinical Medicine (72.36%), with other students from non-Clinical specialties (e.g. Public Health and Preventive Medicine, etc.). A structured questionnaire was used, measuring five key areas: demographics, scholarly characteristics, current research experience, attitudes toward research barriers, and research expectations. Statistical analyses, including Ordered logistic regression, Spearman's correlation, and Mediation analysis, were employed to assess research expectations' direct and indirect effects on perceived barriers through research interest.

Results The study found that the most significant barriers to research were lack of mentorship, heavy academic workload, lack of research skills, and insufficient funding. Students with higher research expectations reported greater perceived barriers, but their higher levels of research interest reduced the perceived impact of these barriers. Mediation analysis found that research interest acted as a mediator between expectations and barriers, with a significant indirect effect of expectations on barriers through interest. This study highlights the complex interaction between research expectations, interest, and perceived barriers in undergraduate medical education.

Conclusions The findings suggest that while high expectations may increase the awareness of challenges, strong intrinsic interest in research mitigates the impact of these barriers. Integrating more research-related courses into the training program, and providing adequate mentorship and resources to support students' research engagement will help cultivate a research-oriented mindset among medical undergraduates.

Keywords Medical research, Barriers, Expectations, Research interest, Mediator effect

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Background

China's medical education has been shifted from "discipline-centered" to "capacity-centered" [1], undergraduates need to develop creative thinking, cognition, and skills in medical science, especially research and innovation abilities, which benefit their academic performance during the undergraduate period. Thus, the pivotal challenge confronting contemporary medical education lies in devising strategies to enhance the scientific research proficiency and innovative capacity among medical undergraduates during this critical developmental phase [2].

Studies have shown that early exposure to research methodology training and participation in medical investigative practices strongly correlate with students' sustained academic commitment and professional development [3]. However, within the Chinese medical education context, undergraduate research engagement primarily emerges as spontaneous initiatives driven by personal interest or career aspirations, lacking systematic institutional support from mainstream educational frameworks [4].

Existing studies have consistently identified several barriers to undergraduate research engagement in medical education, for example, insufficient time due to curriculum overload [5–9], lack of knowledge and skills in experimental design and data analysis [5–7, 9], lack of structured mentorship [5, 6, 8–10], and lack of resources in terms of equipment and funding [5, 7, 10–12]. While the systemic barriers in undergraduate research engagement are well-documented within educational scholarship, current scholarship remains constrained by a fragmented analytical lens. Prevailing studies predominantly prioritize isolated barrier analyses yet critically overlook the psychological mediation mechanisms that dynamically shape students' perceptions. This compartmentalized methodology, which dissects barriers as static variables, fails to address how intrinsic motivation modulates perceived challenge thresholds or how research expectations recalibrate barrier significance.

To address this gap, our study uses mediation analysis to examine how research expectations influence perceived barriers through students' interest in research. By examining both direct and indirect effects, we aim to provide a deeper understanding of the factors that shape students' engagement in research, particularly how psychological mechanisms such as expectations and interest influence perceived barriers.

Table 1 Research questionnaire sections and items

Section Heading	Items	Measure
Your Demographics	1. Gender, age, major, previous degree	Boxes and free text
Your Scholarly Characteristics	1. Grade Point Average (GPA)	Box
	2. Any publications	Yes/no box
	3. Type of scientific research output	Five items. True/false options
Your Current State of Scientific Research	1. Whether participated in scientific research, Research training taken	Yes/no boxes
	2. Type of research involved in	Box
	3. Year started and time duration of the research	Boxes
	4. Perceived levels of interest in scientific research	5-point Likert scale
Your Attitude to Research Barrier	1. Perceived levels of barriers affect scientific research	Four items(ba1-ba4). 5-point Likert scales
Your Expectations for Participation in Research	1. Aiming to participate in research	Five items. True/false options
	2. Perceived levels of research gains	Four items(ex1-ex4). 5-point Likert scales

Methods

A cross-sectional study was carried out from March to July 2024. The participants were all from Shandong University, a leading research-intensive university in China. The study was approved by the Ethics Review Committee of Shandong University, School of Basic Medicine, and was undertaken according to the Helsinki Declaration. Participants were allowed to complete the questionnaire anonymously and at their discretion.

Participants

In light of the review by Amgad [13], a classification system was established for the students participating in the present questionnaire survey. The majority of participants were medical undergraduates majoring in Clinical Medicine and a minority from non-Clinical Medical specialties including Public Health and Preventive Medicine, Pharmaceutical Science, Nursing, and Biomedical Sciences.

Data collection

The questionnaire was primarily based on the questionnaire designed by Burgoyne [12], as well as other questionnaires used in related studies [14, 15]. The questionnaire was designed to cover five dimensions: demographics, scholarly characteristics, current research situation, attitudes toward research barriers, and expectations for scientific research. Each dimension was composed of multiple relevant items. For more detailed information on the questionnaire design, please refer to Table 1. The following section presents the content of the specific question items of the five-point Likert scale

Table 2 Measurement items of the 5-point likert scale form construct

Construct	Items	Reference
Perceived expectations		
ex1	How important do you think participating in research activities is for your future development?	[4, 16–18]
ex2	How important do you think research activities are for improving research skills?	[4, 5, 17]
ex3	How important do you think research activities are for building resilience?	[19]
ex4	How important do you think research activities are for developing critical thinking?	[5, 17]
Perceived barriers		
ba1	How significant is the lack of mentorship in undergraduate research?	[17, 18, 20]
ba2	How significant is the heavy academic workload in affecting undergraduate research?	[18, 21, 22]
ba3	How significant is the lack of relevant knowledge and skills in undergraduate research?	[4, 17, 23]
ba4	How significant is the lack of funding and laboratory space in undergraduate research?	[4, 20, 24]
Research Interest	What is your interest in scientific research?	[18, 23, 24]

that was designed about research expectations, research interests, and barriers to research (Table 2).

We distributed the questionnaire via the Wenjuanxing platform, allowing medical undergraduates to respond by clicking on our link. Upon completion of all questions by the participants, the data was automatically aggregated, and we exported all the information in tabular format. At the beginning of the survey page, we clarified key details such as the target participants and the purpose of the study, ensuring informed consent from each participant. We informed the participants about the principle of anonymous data collection and emphasized that they could withdraw from the survey at any time without any detriment to their interests, the questionnaires of those who withdrew midway were not included in this analysis. A total of 437 individuals clicked on the survey link to respond, of which 322 completed the questionnaire, giving a response rate of 73.68%. Based on the criteria established by Babbie [25], a response rate exceeding 70% qualifies the study as "very good".

Statistical analysis

This study employed Spearman's correlation test to analyze and visualize the correlations among various variables. Ordered logistic regression was performed to investigate the key influencing factors of each barrier. The confirmatory factor analysis was conducted to demonstrate the structural validity and goodness-of-fit of the model. A constructed mediation effect model was used to further explore the mediating role of research interest between research expectations and research barriers, untangling the specific relationships among these factors in the research process of medical undergraduates.

In this study, P-values less than 0.05 were considered to indicate statistical significance. The majority of the data analysis was performed using IBM SPSS software (version 27.0.1.0), while several figures were created using Origin Pro 2025 software (version 10.2.0.196). Both the confirmatory factor analysis and the mediation effect analysis were based on IBM AMOS software (version 24.0.0). The Bollen-Stine Bootstrap P correction method [26] was selected to adjust the goodness-of-fit based on the characteristics of the data.

Results

Demographic and scholarly characteristics

A total of 322 students participated in this study. The sample was predominantly male (53.42%), with the majority in their 3rd year of study (54.97%), aged between 20 and 21 years old (69.88%), and majoring in Clinical Medicine (72.36%). In terms of academic performance, the majority of participants had a Grade Point Average (GPA) ranging from 3.0 to 4.0 (62.42%), scored on a scale of 0 to 5, and over half were involved in basic medical research (56.52%). It is worth noting that 54.35% of students actively participating in research activities. However, only 29.50% of students had received formal research training. (Table 3)

Factors influencing research barriers faced by undergraduates

Given the ordinal nature of the barrier assessments, an ordered logistic regression approach was selected to preserve the hierarchical structure of the dependent variables while quantifying the cumulative odds of perceiving higher-level barriers. The result showed significant associations between predictors (research training, research interest, and research start year) and perceived barriers to undergraduate research participation (Table 4). Students without prior research training exhibited 2.96 times higher odds of reporting a lack of mentorship as a critical barrier (ba1: OR = 2.96, 95% CI = 1.52–5.76, $p < 0.001$) and 1.87 times higher odds of identifying insufficient funding or laboratory space (ba4: OR = 1.87, 95% CI = 1.05–3.34, $p < 0.05$) compared to their trained counterparts, suggesting that structured training programs may mitigate these challenges by integrating mentorship and resource allocation.

Interestingly, a non-linear relationship emerged between research interest levels and perceived

Table 3 The Socio-demographic and scholarly characteristics of the participants ($N = 322$)

Demographic and scholarly characteristics		Number (%)
Gender	Male	172 (53.42%)
	Female	150 (46.58%)
Grade	1	12 (3.73%)
	2	92 (28.57%)
	3	177 (54.97%)
	4–5	41 (12.73%)
Age	18–19	42(13.04%)
	20–21	225 (69.88%)
	≥ 22	55(17.08%)
Majors	Clinical Medicine	233 (72.36%)
	Other Medical Specialties	89 (27.64%)
GPA	< 3.0	66 (20.50%)
	3.0–4.0	201 (62.42%)
	> 4.0	55 (17.08%)
Participated in scientific research	Yes	175 (54.35%)
	No	147 (45.65%)
Research training	Yes	95 (29.50%)
	No	227 (70.50%)
Started time	Grade 1	25 (7.76%)
	Grade 2–3	181 (56.21%)
	Grade 4–5	15(4.66%)
Duration of the research	< 6 months	140 (43.48%)
	6–12 months	47 (14.60%)
	> 12 months	63 (19.57%)
Research type	Basic medical research	182 (56.52%)
	Clinical medical research	93 (28.88%)
	Public health research	23 (7.14%)
	Medical education research	24 (7.45%)

barriers. Students with moderate research interest (level 4) reported 1.90 times higher odds of emphasizing academic workload as a barrier (ba2: OR = 1.90, 95% CI = 1.02–3.53, $p < 0.05$) relative to those with the highest interest (level 5). This finding implies that students with strong intrinsic motivation (level 5) may reframe academic workload as a manageable challenge rather than a barrier, potentially through enhanced self-efficacy and active engagement with mentors or peers. In contrast, moderate interest (level 4) students likely experience conflicting priorities between coursework and research commitments, exacerbating perceived stress. This aligns with studies [27] showing that high research interest fosters resilience and problem-solving strategies, such as optimizing time management or seeking support.

The timing of research initiation also significantly influenced barrier perceptions. Students who began research in Grade 4 demonstrated markedly reduced odds of mentorship-related concerns (ba1: OR = 0.02, 95% CI = 0.001–0.31, $p < 0.01$) compared to those starting in Grade 5, likely due to accumulated academic knowledge over time. Conversely, non-involved students and those initiating research in Grades 3–4 showed diminished workload-related barriers (ba2: OR = 0.07–0.10, $p < 0.05$), suggesting that delayed research engagement in senior years (Grade 5) exacerbates perceived academic strain.

Expectations and barriers to medical student participation in research

In this questionnaire, we assessed undergraduates' perceived goals and benefits of research participation. This assessment aimed to understand students' motivations

Table 4 Impact of different predictors on the barriers experienced by participants ($N = 322$)

Variables	barrier 1		barrier 2		barrier 3		barrier 4	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Research training								
No	2.96***	1.52–5.76	0.85	0.46–1.58	1.70	0.95–3.03	1.87*	1.05–3.34
Yes	1	Reference	1	Reference	1	Reference	1	Reference
Research Interest								
1	0.25	0.05–1.38	2.90	0.48–17.36	1.59	0.30–8.51	1.38	0.28–6.84
2	0.33	0.09–1.27	0.91	0.25–3.31	0.84	0.24–2.94	2.52	0.68–9.28
3	0.51	0.22–1.18	1.78	0.85–3.73	1.43	0.69–2.96	0.85	0.42–1.73
4	0.55	0.26–1.15	1.90*	1.02–3.53	0.86	0.47–1.55	0.80	0.45–1.45
5	1	Reference	1	Reference	1	Reference	1	Reference
Research start year								
No involvement in research	0.18	0.02–1.79	0.10*	0.01–0.90	0.72	0.17–3.08	0.85	0.22–3.33
Grade 1	0.48	0.04–6.48	0.13	0.01–1.52	0.93	0.16–5.60	0.80	0.15–4.42
Grade 2	0.34	0.03–3.86	0.11	0.01–1.13	0.72	0.14–3.62	0.69	0.15–3.16
Grade 3	0.15	0.01–1.61	0.07*	0.01–0.65	0.52	0.11–2.52	0.41	0.09–1.82
Grade 4	0.02**	0.001–0.31	0.05*	0.004–0.75	0.42	0.05–3.58	0.17	0.02–1.27
Grade 5	1	Reference	1	Reference	1	Reference	1	Reference

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **OR** Odds Ratio,**95% CI** 95% Confidence Interval

and expectations regarding research participation. Specifically, we found that 63.35% of respondents believed that participation in research provided a foundation for pursuing a postgraduate degree, and 62.11% indicated a desire to acquire experimental skills through such participation. In addition, 52.80%, 44.10%, and 34.16% of students aspired to publish, were interested in scientific research, and wanted to apply for student innovation projects respectively.

In terms of students' expectations of research, our findings revealed a relatively consistent view. Students recognized the positive impact of research on future development (86.96%), improving experimental skills (87.27%), building resilience (86.34%) and developing critical thinking skills (85.09%). These results, shown in Fig. 1, indicate that the majority of students had a positive attitude toward the benefits of research.

Similarly, we analyzed barriers faced by undergraduates during the research process. Among them, lack of mentorship was identified as the greatest barrier (86.96%), followed by heavy study load or lack of time (82.30%), lack of knowledge and skills (75.47%), and lack of funding or equipment (71.43%).

Spearman correlation analysis of factors related to barriers and expectations

To identify the specific factors associated with the barriers or expectations perceived by medical undergraduates in research participation, we conducted a Spearman correlation analysis. The results are shown in the heatmap (Fig. 2), with correlation coefficients for specific barrier and expectation items. Several important correlations have been appreciable in our analysis. It was evident from the correlation among the various items that certain barriers were perceived in the same breath. For example, the lack of research skills was positively correlated with the lack of research opportunities, suggesting that students who felt inadequately skilled were also more likely to perceive limited opportunities for research involvement.

Also, in the correlation analyses, we found a high correlation between undergraduate students' expectations and perceived barriers. For instance, students with

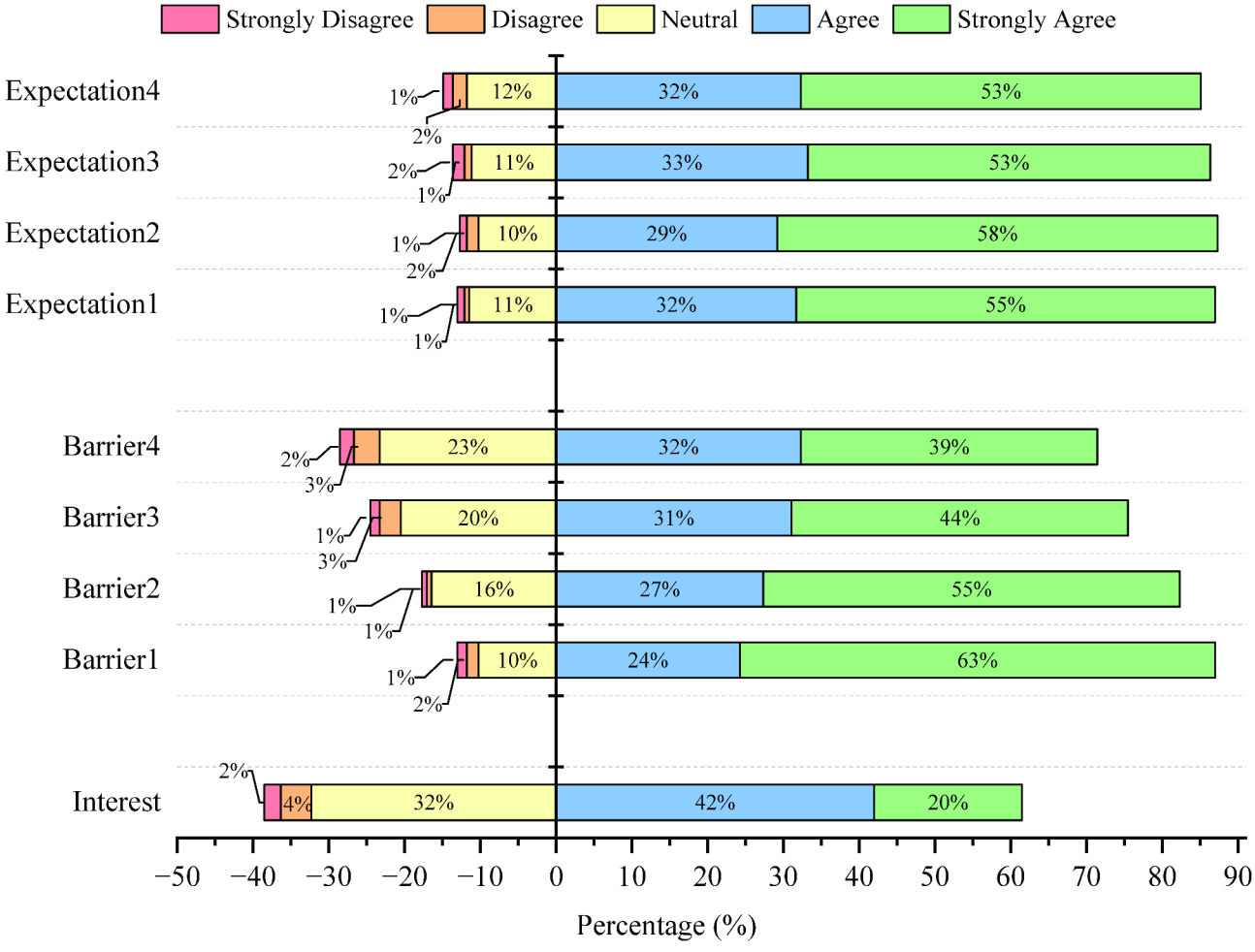

Fig. 1 Distribution of responses to Likert-scale items on research expectations, barriers, and interest among participated medical undergraduates

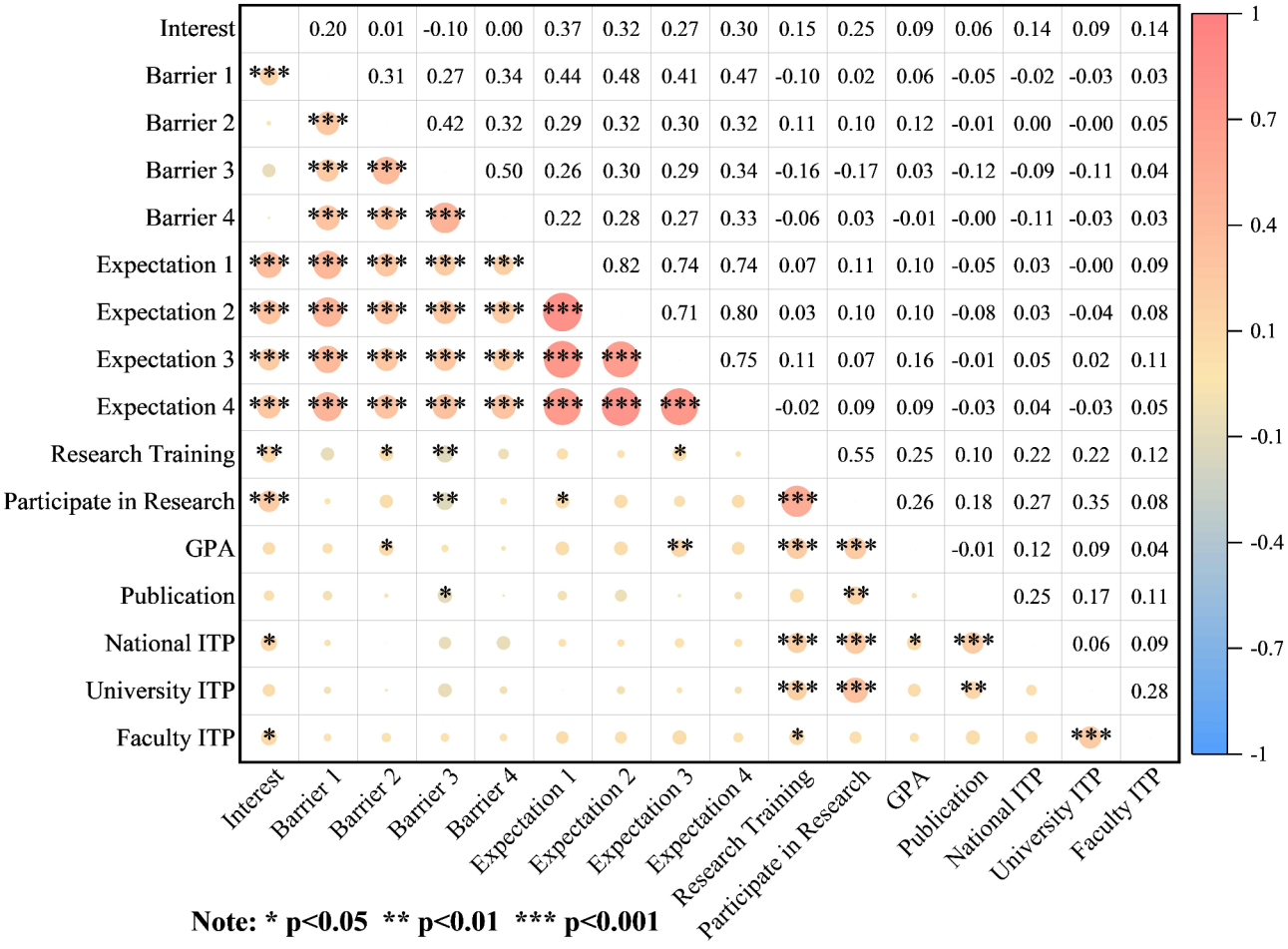

Fig. 2 Spearman correlation analysis of factors related to barriers and expectations in undergraduate research participation. (ITP: Undergraduate Innovative Test Program)

Table 5 Reflective constructs assessment

Construct	Unstandardized Regression Coefficients	Factor loading	Cronbach's Alpha Coefficient	S.E.	*P*	AVE	CR
ba1	1	0.566	0.706			0.381	0.7101
ba2	1.026	0.592		0.141	***		
ba3	1.329	0.68		0.171	***		
ba4	1.275	0.625		0.17	***		
ex1	1	0.882	0.92			0.7441	0.9206
ex2	1.067	0.916		0.045	***		
ex3	0.94	0.783		0.053	***		
ex4	1.057	0.864		0.05	***		

Note: *** $p < 0.001$, **S.E.** Standard Error, **AVE** Average Variance Extracted, **CR** Composite Reliability

higher expectations may tend to perceive certain barriers as more important, potentially because their motivation drives them to actively seek out novel research approaches. In doing so, they may encounter more challenges, thus heightening their awareness of existing barriers.

Reliability, validity, and confirmatory factor analysis

To ensure the quality of the measurement instrument, we conducted reliability and validity tests. Reliability was evaluated using Cronbach's alpha to confirm internal consistency among items. Structural validity was assessed via confirmatory factor analysis (CFA), verifying the hypothesized construct alignment through model fit indices and standardized factor loadings. This dual

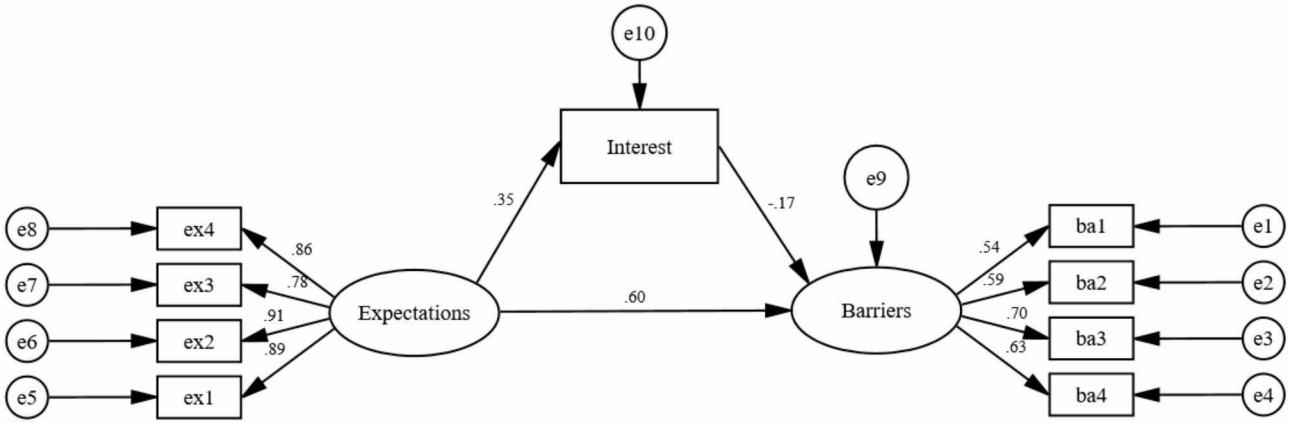

Fig. 3 Mediation Effects of Research Interest on Expectations and Barriers. (Values in the graph are normalized regression coefficients)

Table 6 Path analysis results of expectations, interest, and barriers

Pathways			Standardized Estimate	S.E.	C.R.	P
Interest	<---	Expectations	0.345	0.071	6.227	***
Barriers	<---	Interest	-0.174	0.033	-2.688	0.007
Barriers	<---	Expectations	0.6	0.058	6.776	***

Note: *** $p < 0.001$, **S.E.** Standard Error, **C.R.** Critical Ratio

approach ensures the scale's consistency and accuracy in capturing intended constructs.

Evaluation of the measurement model showed satisfactory reliability and validity across the constructs, with notable variations in convergent validity between the latent variables (Table 5). For the barrier perception constructs (ba1-ba4), all factor loadings ranged from 0.566 to 0.680 ($P < 0.001$), confirming their statistical significance in measuring the intended latent variable. Composite reliability (CR = 0.710) exceeded the recommended threshold of 0.70, while Cronbach's alpha (α = 0.706) indicated acceptable internal consistency.

In contrast, the external environment constructs (ex1-ex4) exhibited excellent psychometric properties, with exceptionally high factor loadings (0.783–0.916, $p < 0.001$) and robust reliability indices (α = 0.920, CR = 0.921). The AVE value of 0.744 was well above the 0.50 benchmark, confirming strong convergent validity. These results indicate that the items ex1-ex4 together explain 74.4% of the variance of the construct, demonstrating an accurate measurement of the latent variable.

We then also tested the model fit of the CFA, and the results indicated that the model fit after correction was excellent($x^2 = 30.70$, $df = 19$, $x^2/df = 1.62$, RMSEA = 0.04, NFI = 0.98, CFI = 0.99, IFI = 0.99), suggesting that the fit was good. Taken together, we have reason to believe that the structural validity and data fit of the measurement model meet the appropriate criteria, and the robustness of parameter estimation passes the test, based on which we can explore in depth the mechanism of direct and indirect mediating effects between variables.

Mediation analysis within structural equation modeling

To more flexibly analyze the potential relationships between research expectations, interest, and perceived barriers, we conducted a mediation analysis using structural equation modeling (SEM). The model fit indices were excellent ($x^2 = 37.83$, $df = 25$, $x^2/df = 1.51$, RMSEA = 0.04, NFI = 0.97, CFI = 0.99, IFI = 0.99), indicating a good fit of the SEM (shown in Fig. 3).

Path analysis discovered that expectations significantly and positively predicted interest (β = 0.345, $p < 0.001$), suggesting that higher expectations are associated with greater research interest. Interestingly, in turn, was negatively related to perceived barriers (β = -0.174, $p = 0.007$), suggesting that increased interest is associated with lower perceived barriers. In addition, expectations had a direct positive effect on barriers (β = 0.6, $p < 0.001$), meaning that higher expectations were associated with more perceived barriers, more details were shown in Table 6.

The mediation analysis showed a significant indirect effect of expectations on barriers through interest (β = -0.039, 95% CI [-0.078, -0.010], $p = 0.021$), accounting for − 11% of the total effect. This indicates expectations reduce perceived barriers indirectly via increased interest. The direct effect remained significant (β = 0.391, 95% CI [0.172, 0.654], $p = 0.001$), contributing 111% to the total effect. The total effect (β = 0.352, 95% CI [0.133, 0.626], $p = 0.002$) was also significant (Table 7), suggesting an incomplete mediation model where expectations influence barriers both directly and indirectly through interest.

Table 7 Results of mediation effect test

Parameter	Bootstrap SE	Estimate	Lower	Upper	*P*	Effect proportion
Indirect Effect	0.017	-0.039	-0.078	-0.010	0.021	-11%
Direct Effect	0.125	0.391	0.172	0.654	0.001	111%
Total Effect	0.128	0.352	0.133	0.626	0.002	

Discussion

This study advances our understanding of the barriers to research engagement among medical students in China, highlighting the psychological factors that shape their perceptions of these barriers. By exploring the interplay between research expectations and intrinsic interest, the study introduces a dual-pathways model, suggesting that while high expectations may increase awareness of challenges, intrinsic interest acts as a protective factor, enabling students to view barriers as manageable rather than insurmountable. These findings have significant implications for medical education, urging educational institutions not only to increase research participation but also to create an environment that fosters students' research expectations and intrinsic motivation. This approach will help students to perceive research challenges as opportunities for growth rather than deterrents. In addition, the study advocates a more comprehensive approach to mentoring, curriculum design, and resource allocation to ensure that students are provided with the necessary tools and support to succeed. Ultimately, the findings provide a framework for shaping the next generation of healthcare professionals who are not only clinically competent but also well-prepared to contribute to the advancement of medical science through research and innovation.

This study examines the barriers to research engagement among undergraduate medical students, with a particular focus on the complex relationships between research expectations, interest, and perceptions of barriers. The findings reinforce previous findings on common barriers to research participation, including lack of mentoring, heavy academic workload, inadequate research skills, and lack of funding [5, 27, 28]. These barriers are consistent with global trends, where mentorship and resources remain critical challenges.

This study represents a significant shift in the understanding of barriers to research participation through the innovative use of mediation analysis, a method not traditionally applied in the context of medical education research. Previous studies have largely focused on isolated barriers such as mentorship, workload, and resource constraints [29, 30]. However, these studies often fail to consider the psychological mechanisms, such as motivation, expectations, and interests, that shape how students experience and interpret these barriers.

Therefore, our study extends the existing literature by highlighting the significant role of intrinsic interest in mediating the effect of research expectations on perceived barriers. Specifically, the mediation analysis revealed a dual-pathway effect: research expectations influenced perceived barriers both directly and indirectly, with the indirect influence mediated by students' interest in research. This finding aligns with the work of recent studies, such as those by Abusamak et al. (2024) [17] and Kyaw Soe et al. (2018) [9], which also emphasize the psychological impacts of overcoming research barriers. This is also consistent with theories of motivation and self-determination that emphasize the role of intrinsic interest in overcoming external constraints [31, 32]. It suggests that students with higher levels of intrinsic motivation are better able to cope with the challenges posed by time constraints and academic workload. Conversely, students with moderate levels of research interest were more likely to perceive these barriers as insurmountable, further highlighting the role of intrinsic interest in mitigating the impact of perceived barriers.

By integrating psychological factors into the analysis, this study provides a deeper, multidimensional view of research participation. Our findings provide a more complex and dynamic picture of how students interact with their research environment and show new insights into how educators and policymakers can better support students in overcoming barriers. This conceptual shift calls for a more nuanced approach to structuring research opportunities in medical education, emphasizing the need to foster both the motivation and support structures that enable students to overcome these challenges effectively [19, 20, 33].

In light of these findings, we argue that educational institutions, particularly in China, need to adopt a more holistic approach to promoting research engagement. In addition to addressing traditional barriers such as mentorship and resources, medical schools need to cultivate a mindset that encourages students to view research as an integral part of their education [33]. Schools should invest in developing strategies that raise students' expectations of research while fostering their intrinsic motivation. This can be achieved through curriculum changes, mentoring programmers, and research opportunities that foster a supportive and resource-rich research environment [34].

Limitations and future study

Although the current study provides insights into the mechanisms linking research expectations, interests,

and barriers, the current study still has several limitations. Firstly, the sample was from a single university and mainly Clinical specialty, limiting the generalizability of the results. Secondly, the cross-sectional design captures only the current state, not changes over time. Lastly, this study focused on individual and institutional factors but did not account for external factors like national research trends or policy changes, which could provide a more comprehensive understanding.

Future studies should further explore the long-term effects of research expectations and interest on students' actual research participation. It would be beneficial to adopt a longitudinal design to track how students' expectations and interests evolve, and how these factors influence their engagement in research across different academic stages. In addition, exploring how external factors - such as national research policy, funding availability, and trends in health innovation - interact with institutional factors to shape students' research experiences could provide a more comprehensive understanding of the barriers to research participation.

Conclusion

Our study represents an important shift in the understanding of barriers to research participation. It calls for a more nuanced approach that considers not only the usual single factor but also the psychological factors that influence how students perceive and deal with these challenges. The conclusions of our study are based on the characteristics of the participants, predominantly medical students from Clinical Medicine and other related specialties at Shandong University. By fostering both high research interest and intrinsic motivation, medical education institutions can create a research-oriented culture that empowers students to overcome perceived barriers and contribute meaningfully to the advancement of medical science.

Abbreviations

GPA	Grade Point Average
ITP	Undergraduate Innovative Test Program
CFA	Confirmatory factor analysis
SEM	Structural equation modeling
RMSEA	Root Mean Square Error of Approximation
NFI	Normed Fit Index
CFI	Comparative Fit Index
IFI	Incremental Fit Index

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Author contributions

HWM contributed to the conception and design of the study and the revision of the article. HC contributed to the conception and design of the study and revision of the article. RQ contributed to the data collection, analysis interpretation, and the drafting of the article. QLZ and RS contributed to the conception and design of the study. All the authors approved the final manuscript.

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Data availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Shandong University. All the students voluntarily participated in the study in response to the official invitation. The participants were informed of their optional and anonymous survey. The research would not affect individual privacy rights and welfare. Data confidentiality was protected.

Consent for publication

All authors have read and given consent for the publication of this manuscript.

Competing interests

The authors declare no competing interests.

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