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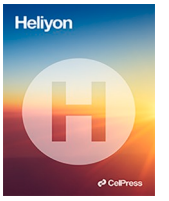

Research article

The trajectory and transition pattern of intention to practice medicine among medical students in China

Zehua Shi [a], Hongbin Wu [b,*]

[a] School of Management, Beijing University of Chinese Medicine, Beijing, 100029, China
[b] Institute of Medical Education/National Center for Health Professions Education Development, Peking University, Beijing, 100191, China

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ABSTRACT

There has been a growing concern about the career intentions (whether medical students have the intention to practice medicine) due to the increasingly serious problem of medical students attrition. Career intentions have the potential to promote medical students' career commitment and encourage them to stay in the medical profession. Moreover, a series of dynamic career intentions during medical education can be served as an early guide to the medical students' future career choices (whether medical students finally choose to practice medicine). However, few studies focus on the dynamics of career intentions among medical students. In this study, we utilized data from a large-scale national survey of medical students conducted in China from 2020 to 2022 to curve the trajectory of the intention to practice medicine among medical students during their undergraduate medical education by using multilevel growth model. Furthermore, we applied latent Markov model to estimate the transition matrix of the intention across each academic year during the undergraduate medical education. Our findings revealed a trajectory curve with a peak during the second year in the intention to practice medicine. In addition, we identified three latent states of career intention including "strong intention", "wavering" and "weak intention", and further found two distinct transition patterns between individuals with strong career intentions and those without strong career intentions. The transition patterns play a crucial role in understanding the changes in the trajectory of medical students' intentions and determining the optimal timing for interventions to prevent medical student attrition. Our study offers a comprehensive understanding for the dynamics of the career intention among medical students, which has practical implications for medical educators and institutions to address the issues of medical student attrition.

1. Introduction

The shortage of healthcare workers is a global problem. According to the World Health Organization (WHO), the gap between supply and demand in the labor market of healthcare industries has reached 17.4 million in 2013, a number predicted to remain at about 18 million by 2030 [1]. According to the estimation from the Association of American Medical Colleges (AAMC), the U.S. would see a shortage of up to nearly 122,000 physicians by 2032 [2]. Meanwhile, those economically underdeveloped countries are facing more severe shortages of health workers. This gap cannot be easily closed because of a high attrition rate in the medical field. O'Neill

* Corresponding author.
E-mail address: wuhongbin@pku.edu.cn (H. Wu).

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et al. reviewed studies of factors associated with dropping out of medical school and estimated an average of 9.1% attrition rate with a range between 2.7% and 20.1% across multiple countries worldwide, including the U.S., Australia, the UK, South Africa, the Netherlands, New Zealand, Canada, Israel, and India. Besides dropping out from medical schools, many countries saw a high proportion of students who choose to leave the medical profession upon graduation [3]. In 2021, a report published in the "Health Development Outlook" by China Health Development Research Center at Peking University estimated that China's medical graduate attrition rate was 20.7% between 2005 and 2018 using official data from the "China Health Statistics Yearbook" [4].

Due to the increasingly serious problem of medical students leaving the profession, there has been a growing concern about the career intentions among medical students [5–7]. Career intention refers to the attitude whether a medical student has the intention to practice medicine in his/her career. Most studies on career intention have used cross-sectional methods [7]. For example, Miranda et al. examined the career intention among medical students at the last two years of undergraduate medical education at four medical schools in the state of Minas Gerais, Brazil and found that only 79.3% of the participants indicated that they intend to work in this field after graduation [8]. Similarly, Kizito et al. conducted a cross-sectional study among 251 final-year medical students from four medical schools in Uganda. Of the 251 students enrolled in the study, 28 (11.2%) wanted to leave the health sector [6]. However, cross-sectional methods only capture a snapshot of career intentions at a single point in time. Career intentions change over time during medical education, and the final career choice to practice medicine is determined by a series of dynamic career intentions [9]. Thus, existing cross-sectional studies fail to examine a dynamic picture of how career intentions evolve over time. To reduce attrition rates before medical students making the final career choice, it is more important for medical educators and institutions to focus on career intentions and especially pay attention to the dynamics of the intentions.

To systematically study the dynamics of intention to practice medicine among medical students, this article has two research questions. First, we adopt a longitudinal perspective to curve the trajectory of medical students' intention to practice medicine during their undergraduate education stage. Second, we further examine the transition pattern of medical students' intention to practice medicine at each stage of undergraduate education. These two research questions will yield a comprehensive understanding for the dynamics of the intention, and provide a policy basis for interventions to reduce medical student attrition.

To address the research questions, we employed the repeated China Medical Student Survey (CMSS) which is a large-scale nationally representative survey targeting all grades of undergraduate medical students. Undergraduate Medical Education in China is a five-year formal medical training program that includes clinical rotation in the final year and widely adopted by medical schools in China.

This study has three contributions. First, we expand the literature on the dynamics of intention to practice medicine. Second, this study discovered transition patterns in the intention to practice medicine and provided practical implications for interventions. Finally, this study provides a reference for medical student attrition in China in a career intention sense.

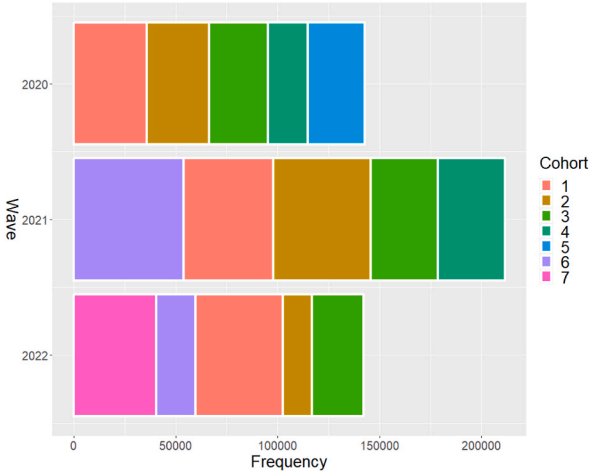

Fig. 1. Number of Respondents by Cohort at each Wave. Note: This figure shows the number of students in each cohort at each wave. Each wave from left to right represents first-year to fifth -year students, so the arrangement of each cohort is diagonal from top left to bottom right. For example, the leftmost cell in 2020 (first-year student) is defined as cohort 1, which will appear in the second cell of 2021 wave (second-year student) and the third cell of 2022 wave (third-year student). There is a noticeable fluctuation in the number of individuals within each cohort, indicating that the data are not balanced within each cohort. Notwithstanding, the missingness in this unbalanced data is ignorable under the assumption that the data are missing at random [10]. Under missing at random, missingness may be nonrandom, but the association between the probability of missingness and the missing value is explainable by the observed data [11].

2. Methods

2.1. Data

To study the trajectory of medical students' intention to practice medicine during their undergraduate stage, we utilized the China Medical Students Survey (CMSS) which is a large-scale nationally representative survey conducted by the National Center for Health Professions Education Development in China. CMSS is designed for five-year clinical undergraduate students and collected information about their basic demographic characteristics, pre-university experiences including retrospective intention to practice medicine when applying for medical schools, and academic performance in medical schools of clinical medical students from all five grades (first-year to fifth-year) including current intention to practice medicine. The survey is annually conducted at the end of every academic year in June in China. The first wave of the CMSS was conducted in 2020 and the most recent data was released in 2022, constituting a total of three survey waves (2020, 2021, 2022 waves).

In order to capture the trajectory of medical students' intention to practice medicine during their undergraduate program, we utilized all sample from the three waves of the CMSS. It should be noted that the CMSS is not designed to follow up individual medical students, but rather to comprehensively understand the quality of undergraduate medical education and the training status of enrolled medical students from the students' perspective each year. However, since the key identifiers of student IDs and college information are collected in each annual survey, we could match individuals across the three waves, which allows us to structure a dataset with the longitudinal feature.

After matching, our analytical sample consists of seven cohorts as shown in Fig. 1. As shown in Fig. 1, each wave from left to right represents the first-year to fifth-year students, so the arrangement of each cohort is diagonal from top left to bottom right. The seven cohorts, numbered 1 to 7, correspond to the first-year, second-year, third-year, fourth-year, fifth-year students at 2020 wave, the first-year students at 2021 wave, and the first-year students at 2022 wave. Each cohort provides corresponding information at different time points during the undergraduate program. For example, individuals in cohort 1 may provide information of their career intention at four time points: applying for medical school, and the end of their first, second, and third years of undergraduate study. Individuals in cohort 2 may provide information at four time points: when applying for medical school, and the end of their second, third, and fourth years of undergraduate study. While individuals in cohort 5 may only provide information at two time points: when applying for medical school and at the end of their fifth year, as they have graduated after the 2020 wave and are no longer included in subsequent surveys.

Our sample consists 143,449, 212,300, and 142,677 students in each respective wave. After matching the data among the three waves, a total of 367,397 students from 143 medical schools in China were included in the sample. After converting students into student-year observations, a total of 855,971 student-year observations were obtained.

2.2. Variables

When analyzing the trajectory of intention to practice medicine, the main dependent variable is a binary variable indicating whether the medical student intends to practice medicine or not. Our independent variable of interest is the time metric "Year", which is taken six values of {0, 1, 2, …, 5} representing the time points of one's applying for medical school (Year = 0), and the end of the first to the fifth (i.e., graduation) academic years of one's studying in medical school (Year = 1, 2, 3, 4, 5), respectively. We treat "Year" as a continuous variable in order to obtain a smooth trajectory curve. In addition, we also include demographic variables of medical students as covariates: Male (1 if the student is male and 0 otherwise), One Child (1 if the student was an only child in their family and 0 otherwise), and family background information: Parents' Education (parents' years of schooling) and Parents' Occupation (International Socio-Economic Index (ISEI) of occupational status for parents), Family Member (1 if the student had a family member who was a health professional and 0 otherwise), and Urban Area (1 if the student's hukou belonged to an urban area and 0 otherwise). For medical students who have missing data on demographic variables, we use the mean in their medical schools (and the median for dummy variables) to impute missing values. Note that we did not include any time-varying variables because the inclusion of these variables may affect the trajectory of the intention to practice medicine. Time-varying variables may act as mediating variables, which can separate the trends of these mediating variables from the overall fluctuation of the trajectory. Mechanism analysis of the trajectory of intention to practice medicine is beyond the scope of this study.

2.3. Empirical strategy

To study the first research question, fitting the trajectory of intention to practice medicine, we employed a multilevel growth model, which is straightforward to incorporate the repeated observations (medical students) nesting in clusters (medical schools) [12, 13].

Furthermore, multilevel growth models allow for the data structure that involves individuals who provide information at different occasions and different numbers of occasions, as long as the maximum number of possible occasions across the sample as a whole remains limited [14]. More specifically, as mentioned in the Data section, each cohort contributes data for a specific limited interval of time, while the six time points spanning the entire undergraduate period are observed across the sample as a whole.

It should be pointed out that there may be one potential issue using different cohorts to fit the trajectory. The existence of a common trajectory for all cohorts of medical students needs to be proven to ensure that the trajectories do not vary by cohort. A naive analysis is proposed that there will be no cohort differences if the (adjacent) cohorts means are fairly similar and their confidence intervals

overlap [11,15,16]. We present the results for this test in the Appendix.

To study the second research question, which is to examine the transition pattern of the intention trajectories at different time periods, we use the Latent Markov Model (LMM). LMM has a main function of classification of units and studying the transition between these classes [17]. Through a suitably formulated LMM, we can aggregate subjects in different classes corresponding to the latent states, similar to a Latent Class Model (LCM). In contrast to the LCM, it is also possible to estimate a LMM with only one response variable per period [18,19] which is the binary variable to measure whether medical students intend to practice medicine at the end of each academic year in this study. Furthermore, the LMM has a higher degree of flexibility due to the possibility of subjects are allowed to move between the latent states during the period of observation. Specifically, we first identify the typical latent states for the intention to practice medicine based on the AIC and BIC values [17], which determines the optimal number of latent states with subjects in the same latent state having the same probability of practicing medicine. Second, we estimate the parameters of the LMM: conditional response probabilities given the latent state, initial probabilities, and the transition matrices of the latent states at each academic year.

3. Results

3.1. Descriptive statistics

Table 1 presents the distribution of the intention to practice medicine by each cohort at different academic year. We found that the various cohorts had roughly similar levels of intention to pursue a career in medicine at each specific year. Overall, the different proportion among students who intend to practice medicine by academic year indicated a non-linear trajectory of medical career intention over the undergraduate medical education. Specifically, there is a sharp increase in the early stage of undergraduate education, followed by a gradual decline with minor fluctuations. In the following analysis, we will employ a more stringent model to fit this trajectory.

4. The trajectory of intention to practice medicine

We applied multilevel growth model to fit the trajectory of medical students' intention to practice medicine over year. As presented in Table 2, we fitted linear, quadratic, and cubic models sequentially. All three goodness-of-fit indicators suggest that the cubic specification is the best for our data. Specifically, the difference in deviance between the quadratic (Column 2) and cubic (Column 3) models is significant in the chi-square test ($df = 1$, $p < 0.001$). Moreover, both AIC and BIC show a minimum value under the cubic model. In principle, we can estimate as high an order of polynomial function as can be identified by the number of repeated measurement occasions [20,21]. However, practically, given a minimum of five time points, researchers can estimate a third-order polynomial because higher-order polynomial trajectory models become increasingly difficult to interpret, especially when attempting to relate model results back to theory [21]. After running high order polynomial models, we found that they have little added value based on the goodness-of-fit indicators. Hence, we used the results from the cubic model to fit the trajectory curve and visually showed

Table 1
Descriptive Statistics for the intention to practice medicine, by Year and Cohort.

	Year					
Cohort	0	1	2	3	4	5
Cohort 1	70,953	35,718	44,014	42,944	—	—
Mean	0.562	0.913	0.856	0.852	—	—
SD	0.002	0.001	0.002	0.002	—	—
Cohort 2	62,173	—	30,772	47,939	14,233	—
Mean	0.542	—	0.912	0.850	0.814	—
SD	0.002	—	0.001	0.002	0.003	—
Cohort 3	55,453	—	—	28,760	32,717	25,399
Mean	0.533	—	—	0.876	0.800	0.830
SD	0.002	—	—	0.001	0.002	0.002
Cohort 4	43,232	—	—	—	19,544	32,971
Mean	0.531	—	—	—	0.810	0.809
SD	0.002	—	—	—	0.002	0.002
Cohort 5	27,991	—	—	—	—	27,991
Mean	0.529	—	—	—	—	0.860
SD	0.003	—	—	—	—	0.002
Cohort 6	59,106	53,863	19,125	—	—	—
Mean	0.550	0.873	0.902	—	—	—
SD	0.002	0.001	0.002	—	—	—
Cohort 7	40,480	40,480	—	—	—	—
Mean	0.579	0.904	—	—	—	—
SD	0.002	0.001	—	—	—	—

Notes: The first row for each cohort displays the number of observations in each academic year. Specifically, the count for year = 0 represents the total number of observations within that cohort, as each individual responds to their career intentions when applying for medical schools. Dashes indicate that data are not available at that academic year of cohort. The visualization is displayed in the Appendix (See Figure A1).

Table 2
Estimates of growth model for intention to practice medicine.

	Intention to practice medicine		
	(1)	(2)	(3)
Fixed effect			
Year	0.075*** (0.000)	0.230*** (0.001)	0.471*** (0.002)
Year squa		−0.036*** (0.000)	−0.182*** (0.001)
Year cubic			0.020*** (0.000)
Constant	0.576*** (0.005)	0.541*** (0.005)	0.527*** (0.009)
Random effect			
School-Level			
Random intercept	0.051	0.056	0.052
Random slope: year	0.012	0.036	0.024
Random slope: year square		0.006	0.004
Random slope: year cubic			0.0003
Student-Level			
Random intercept	0.199	0.203	0.120
Deviance	924,757	885,901	866,798
AIC	924,785	885,931	866,830
BIC	924,948	886,105	867,016
Number of schools	143	143	143
Number of students	367,397	367,397	367,397
student-year observation	855,971	855,971	855,971

Note: The values in the parentheses represent the standard errors of the fixed effect estimates. ***p < 0.001, **p < 0.01, and * p < 0.05. The demographic characteristics of the students were included in all regressions. It is evident that, overall, male individuals have lower career intentions. Those with urban household registration, mothers with higher levels of education and occupation, and individuals with a medical family background tend to have higher career intentions. At the student level, we included only random intercept terms, while at the school level, we introduced both random intercept and random slope terms. The standard deviations for each level are reported in the random effects. Due to the large sample size, this study used multilevel models where the response variable was treated as a continuous variable in the main results section. We also included the results of the logistic regression in the Appendix and found robust results.

in Fig. 2.

Note: This figure shows the regression results of the probability of intention to practice medicine against year, as presented in the column (3) of Table 2. "Year" is taken six values of {0, 1, 2, …, 5} representing the time points of one's applying for medical school (Year = 0), and the end of the first to the fifth (i.e., graduation) academic years of one's studying in medical school (Year = 1, 2, 3, 4, 5), respectively. We treat "Year" as a continuous variable in order to obtain a smooth trajectory curve. The y-axis represents the probability of intention to practice medicine. The covariates take the value of the mean of the sample for continuous variables and the median of the sample for dummy variables.

As depicted in Fig. 2, the probability of intention to pursue a medical career is 54.5% at the stage of applying for medical schools (Year = 0). It increases significantly in the early stage of medical education, with a peak of 92.3% during the second year, followed by a relatively gradual decline with minor fluctuations, hovering around 85%. Finally, at the time of graduation in the fifth year, the probability of pursuing a medical career is 87.6%.

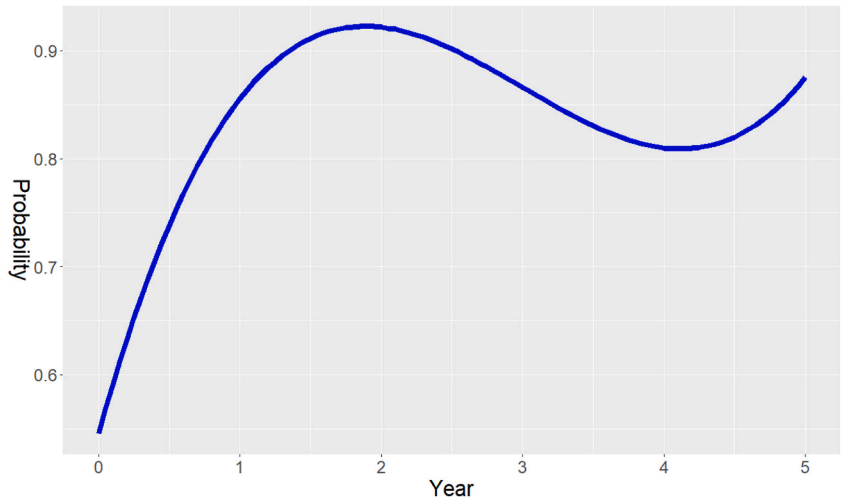

Fig. 2. Trajectory of medical students' intention to practice medicine.

In addition, we observe that the heterogeneity in career intentions is mostly derived from the student level, with relatively small variations between schools. Referring to the standard deviation of the random intercept for school-level in the third column in Table 2, we find that the heterogeneity in initial career intentions among schools is not substantial. The standard deviation of random intercepts between school is 0.052. While the intercept in fixed effect is 0.527, which means that the variation around the mean within one standard deviation is (encompassing approximately 68% of the samples from all medical schools) approximately between 0.475 and 0.579. Furthermore, we observed that the variations of career intentions among schools have decreased even further when the undergraduate study starts. The standard deviation of school-level random effects for "year" is 0.024, while the coefficient for year in fixed effect is 0.471. The standard deviation of school-level random effects for "year square" is 0.004, while the coefficient for "year square" term in fixed effect is −0.182. The standard deviation of school-level random effects for "year cubic" is 0.0003, while the coefficient for "year cubic" in fixed effect is 0.020. Overall, the coefficients for the year, year square, and year cubic terms in fixed effects are much larger than the standard deviations of random slopes among schools. Therefore, the heterogeneity among medical schools is relatively small and the trajectory of career intention we presented in Fig. 2 is applicable to the majority of schools in our sample.

4.1. Transition matrix among the latent states of intention to practice medicine

Based on the obtained trajectory of medical students' career intentions, we further investigated the transition patterns of the intention during different periods of the undergraduate stage. First, we determined the optimal number of latent states for medical students' intention based on the AIC and BIC values for the Latent Markov Model (LMM). We tested the number of latent states from 1 to 4, and found that the values of both information criterion reached the minimum when the number equals to 3, as illustrated in Panel A of Table 3. Therefore, dividing medical students' intention into three latent states is the most appropriate according to our dataset. Second, we presented the conditional response probabilities estimated by the LMM for the three latent states, which indicates the probabilities of intention to practice medicine given their latent states, as shown in Panel B of Table 3. According to the conditional response probabilities, we found that the probability of the intention to practice medicine is 2.4% given the first latent state (row). Therefore, we name this latent state as the "weak intention" state. The probability of the intention to practice medicine increases to 68.5% given the second latent state (row) and thereby we name this state as the "wavering" state. The probability of the intention to practice medicine given the third latent state (row) continues to increase to 97.7%, which is named as the "strong intention" state.

After classifying the latent states with substantial meanings, we presented the estimated initial probabilities and transition matrix based on the LMM in Table 4.

At Year 0, indicating the time point of one's applying for medical school, we found that the majority of subjects belong to the "weak intention" latent state (42.0%) and the "strong intention" latent state (46.1%) as shown in Panel A of Table 4. In addition, only 11.9% students are unsure about whether to pursue a career in medicine or not at the medical school application stage. The numbers of subjects in the "weak intention" and "strong intention" states are roughly equal, resulting a polarization in state distribution at the initial time.

As medical education begins, demonstrated in Panel B of Table 4, there is a high persistence in the "strong intention" state from entrance to exit of medical school, meaning that subjects having the strongest tendency to practice medicine very rarely move to states with a lower tendency of practicing medicine. The probability of remaining in this state is at around 94.5%–100% throughout the undergraduate stage.

Interestingly, for those in the "weak intention" state, their intentions are relatively malleable during the first year (Year 0 to Year 1). 47.4% of them move to the "wavering" state, 48.2% move to the "strong intention" state, and only the remaining 4.4% still stay in the "weak intention" state. However, starting from the second year, there is a relatively high persistence in the "weak intention" state. The probability of staying in the weak intention state fluctuates between 67.1% and 93.8% during their second to fifth year. Except for staying in this state during the second to fifth year, the majority of the remaining subjects move to the "wavering" state (6.2%, 7.0%, 15.3%, and 11.6%), and very few subjects choose to move to the "strong intention" state (0%, 0.3%, and 5.8%), except in the last year (21.3%). During the last year, among those in the "weak intention" state in the fourth year, the proportion of subjects who choose to

Table 3
Information criterion and estimates of the conditional response probabilities.

Panel A: AIC and BIC for determining the optimal number of latent states		
Number of latent states	AIC	BIC
1	2,656,848	2,656,859
2	867,342	867,483
3	859,489	859,868
4	859,546	860,270
Panel B: Estimates of the conditional response probabilities Response variable		
Latent states	Do not intend to be a doctor	Intend to be a doctor
Weak intention	0.976	0.024
Wavering	0.315	0.685
Strong intention	0.023	0.977

Table 4
Estimates of initial probabilities and transition matrices.

Panel A: Initial Probability			
Year 0	Initial probability		
Weak intention	0.420		
Wavering	0.119		
Strong intention	0.461		
Panel B: Transition Matrix			
Year 1			
Year 0	Weak intention	Wavering	Strong intention
Weak intention	0.044	0.474	0.482
Wavering	0.000	0.165	0.835
Strong intention	0.000	0.000	1.000
	Year 2		
Year 1	Weak intention	Wavering	Strong intention
Weak intention	0.938	0.062	0.000
Wavering	0.071	0.918	0.011
Strong intention	0.003	0.037	0.960
	Year 3		
Year 2	Weak intention	Wavering	Strong intention
Weak intention	0.927	0.070	0.003
Wavering	0.056	0.935	0.009
Strong intention	0.000	0.055	0.945
	Year 4		
Year 3	Weak intention	Wavering	Strong intention
Weak intention	0.789	0.153	0.058
Wavering	0.096	0.877	0.027
Strong intention	0.001	0.025	0.974
	Year 5		
Year 4	Weak intention	Wavering	Strong intention
Weak intention	0.671	0.116	0.213
Wavering	0.072	0.811	0.117
Strong intention	0.001	0.017	0.982

move to the "strong intention" state is 21.3%, which is nearly twice as many as those (11.6%) who move to the "wavering" state.

Transition patterns among subjects who are in the "wavering" state are similar to those in the "weak intention" state. The majority of subjects (83.5%) move to the "strong intention" state during the first year while a small proportion (16.5%) choose to stay in their initial state, and almost none of subjects (0%) choose to transfer to the "weak intention" state. In the subsequent years, the wavering group also maintain a relatively high level of stability, the transition probabilities of remaining in this state range from 81.1% to 93.5% during their second to fifth years. Apart from staying in this state during the second to fifth year, the majority of the remaining subjects move to the "weak intention" state (7.1%, 5.6%, 9.6%, and 7.2%). Those who select to move to the "strong intention" could be considered negligible (1.1%, 0.9%, and 2.7%), except in the last year (11.7%). During the last year, the proportion of subjects (11.7%) who choose to move to the "strong intention" state slightly exceeds those (7.2%) who moved to the "weak intention" state.

5. Discussion

This study explored the trajectory of the career intention of medical students and discovered a curve with a peak during the second year. Our findings implicate that medical educators should pay particular attention to career intention and its dynamics among medical students. Taking longitudinal perspective to study the intention is a growing consensus and one of the key objectives in future's medical education research [22]. However, there is little knowledge about the dynamics in the intention to practice medicine. A closely related study investigated the later trend in the intention to practice primary care among medical students from their third (end of pre-clinical curriculum) to their sixth (before graduation) academic year and found that the proportion of students intending to practice primary care increased over time, from 13% in the third year to 24% in the sixth year [7].

We also found that only 54.5% of medical students have the career intention of being a doctor when they applied for medical schools, consistent with the findings in Ref. [23]. The lower pre-admission intention to pursue a medical career may be related to the medical education system in China. The selection of medical students begins when they apply for medical schools right after high school graduation in China, and there are no medical-related courses or counseling provided in high school. Therefore, the intention to pursue a medical career among Chinese high school students may not stem from their intrinsic motivation but rather from the encouragement or persuasion from their parents and teachers, resulting in a lower intention before admission to medical school. In contrast, the medical education system in the U.S. requires students' completion of a four-year undergraduate degree, completion of pre-medical coursework, and passing of the Medical College Admission Test before applying for medical school [24]. Medical school admission in the U.S. is highly competitive and selective. According to USnews, in 2010, 121 medical schools in the U.S. received 521, 876 applications, of which only 46,447 of the most outstanding applicants were admitted, resulting in an average admission rate of

only 8.9%. Therefore, the medical education system in the U.S. could select applicants with higher intentions to pursue a medical career at the very beginning.

According to our estimation, the intention to practice medicine at the graduation of the fifth year is 87.6%, indicating an attrition rate of approximately 12.4% in a career intention sense. This probability of intention to practice medicine at graduation provides a reference for medical student attrition in China. While there is no consensus on the specific attrition rates of medical students in China, it is an indisputable fact that the attrition rate of medical students in China is high. As mentioned in the introduction, a report published by China Health Development Research Center at Peking University states that China's medical graduate attrition rate was 20.7% between 2005 and 2018 [4]. Related studies have also reported high attrition rates among Chinese medical students [25,26]. Although some Chinese medical education experts have pointed out that existing studies on medical students attrition have controversial conclusions and tend to overestimate the attrition rate in China [27].

Additionally, the relatively low heterogeneity in career intentions among medical schools may be attributed to the characteristic nature of medical education, where the need for standardized quality in cultivating medical talents prevails. The fundamental objective of medical education is to furnish society with high-quality healthcare professionals across various levels of healthcare facilities, ensuring that patients at different levels of healthcare facilities can benefit from the expertise of outstanding doctors, offering accurate diagnoses and precise treatments to meet their diverse healthcare needs. Consequently, all medical schools in China are mandated to adhere to the "Standards for Undergraduate Medical Education in China (Clinical Medicine)" to ensure homogeneity in talent cultivation. This encompasses standardized academic management, uniform teaching content and standards, consistent teaching processes, and uniform faculty development. These measures collectively aim to achieve homogeneity in developing professional skills and professionalism among medical schools [28].

We identified three latent states of intention to practice medicine among medical students by LMM. Besides the two opposing latent states, strong and weak intention states, there is a wavering state with moderate probability of intention to practice to medicine. According to the transition matrix further estimated by the LMM, two distinct transition patterns were observed between individuals in the "strong intention" state and those in the other two states. Individuals in the "strong intention" state demonstrated a high degree of stability, remaining steadfast in their commitment. Even those who entered the "strong intention" state at a later stage also demonstrated the same high degree of stability. In contrast, individuals in the other two states showed a high likelihood of transitioning to a different state in the first year, and although they demonstrated a moderate towards high stability in subsequent years, some still transitioned to other states, particularly in the final year. These different transition patterns may be related to the career decision-making process among different students. Specifically, students who are strongly committed to a career tend to make decisions based on their long-term goals and preferences, while students who are more undecided or hesitant demonstrate a variety of behaviors, including active (such as exploring options) and passive ones (such as letting things unfold naturally or waiting for opportunities to emerge) [29]. Therefore, the former group is more likely to stick to their initial career plans, while the latter is more inclined to change their career paths and explore different options.

In addition, the changes in the trajectory of intention to practice medicine are mainly driven by the students in the "weak intention" and "wavering" states rather than those in the "strong intention" state, as the latter state maintains an extremely high stability rate once students enter this state. Specifically, the initial increase in the trajectory of intention to practice medicine during medical education state follows the pattern that a large number of students from the "weak intention" and "wavering" states move to the "wavering" and "strong intention" states. Similarly, the gradual decline with minor fluctuations in the trajectory in the later stages of undergraduate education can be attributed mainly to the difficult-to-reverse negative attitude of students in the "weak intention" state and the neutral or negative attitude towards practicing medicine of students in the "wavering" state.

Finally, it is important to note that the state dependence observed in the "weak intention" and "wavering" states starting from the second year of medical education highlights the essentials of early intervention in addressing medical student attrition issue. Although a considerable number of individuals in the "weak intention" and "wavering" states transitioned to the "strong intention" state in the first year, there were still a significant percentage of individuals remained in these two states by the end of the first year. Specifically, 51.8% (1-0.482) of students in the "weak intention" state and 16.5% (1-0.835) of the "wavering" state choose to stay in the "weak intention" or "wavering" states at the end of the first year. Therefore, it is necessary to intervene with first-year medical students to enhance their transition from the "weak intention" and "wavering" states to the "strong intention" state due to their malleability of the intention. Ye et al. also support our findings in their research on the intention to practice medicine among Chinese medical students as well. Their research found that nudge information interventions have a stronger effect on students in their early college years, reducing the dropout rate of low-grade medical students by an additional 0.8% [30].

In this sense, collecting the information about the intention to practice medicine from medical students at the time of admission is crucial for the intervention in the first year of medical education. Currently, the CMSS is conducted at the end of each academic year, by which time first-year students have already completed their first year of the study. Future research could add survey for new incoming students to obtain their intention to practice medicine before the academic year begins. This would provide medical school educators with sufficient time and information to intervene with those students that respond with no intention to practice, who are most likely in the "weak intention" and "wavering" states.

This study has some limitations. First, the information about medical students' career intention at application stage was retrospective, which means that respondents had to recall their intention at application when they answered the survey, introducing the possibility of measurement bias at application. However, we found that this recall appeared to be stable across different waves, so we believe using retrospective data is not a big concern. Specifically, for individuals who recalled their career intention at application stage multiple times across two or more waves, we examined the stability of their responses over time. For instance, we first selected individuals who recalled the career intention information in both 2020 and 2021 waves, and then calculated the proportion of

individuals with the same intention at application across both waves. Following the same method, we calculated the proportions across the 2020 and 2022 waves, as well as across the 2021 and 2022 waves. We found that the proportions ranged from 97.88% to 99.87%, meaning that most students' cross time recall were consistent. For individuals who answered the career intention at application twice or more, we used their earliest reported intention as the measurement for the intention at application. In summary, we believe that with the stable reported career intention at application, the measurement at application effectively reflects each individual's career intention before enrollment and provides a reasonable baseline for the subsequent development of career intention.

Second, this paper does not further explore the mechanisms of the dynamic trajectory of medical students' career intentions, neither discussing time-invariant nor time-varying variables. Regarding the association between time-invariant variables and career intentions, a large body of literature focuses on sociodemographic characteristics [3,31–34], but the existing studies have not found any specific pattern of sociodemographic variables that is particularly important in relation to career intention or dropout. We only add these time-invariant variables as covariates in the regression. On the other hand, we are unable to discuss the relationship between time-varying variables and career intentions due to data limitations, and what factors dynamically contribute to this uncovered trajectory remains unclear. Mechanism exploration is beyond the scope of this study. Future research may focus more on the impact of time-varying variables on the changes in career intentions.

Finally, this study did not take into account the impact of COVID-19 on medical career intentions. It should be noted that the data we used spanned from 2020 to 2022, which coincided with the COVID-19 pandemic in China, a period marked by the outbreak and subsequent mitigation of the pandemic. The influence of the pandemic on the career intentions of medical students cannot be ignored. For example, there was a noticeable increase in the number of Chinese medical undergraduates expressing a desire to pursue clinical medicine and public health careers following the pandemic [35]. However, it's also worth noting that a minority of healthcare professionals and medical students in China expressed regret regarding their career choices during the COVID-19 outbreak [36]. Thus, the impact of the pandemic might vary among individuals. In our data analysis, different cohorts provided career intentions for different academic years. If the pandemic, on average, had uniformly affected the career intentions of each cohort, the overall trend in the career intentions trajectory we analyzed would likely remain consistent, with only vertical shifts. Nevertheless, it's important to consider that future research can utilize data from normal years to analyze the career intention trajectories under normal circumstances.

6. Conclusion

This study offers a comprehensive understanding of the dynamics of career intentions among medical students in China. First, we found that the trajectory of intention to practice medicine among medical students exhibits a peak during the second year. Second, the optimal number of latent states for the intention was identified to be three, which can be defined as "strong intention", "wavering", and "weak intention". Finally, there are different transition patterns between individuals in the strong intention state and those in the other two states. Individuals who are in the "strong intention" state at any time from enrollment to graduation maintain extremely high stability of the intention, while individuals in the other two states showed a high likelihood of transitioning to a different state in the first year, and then demonstrated a moderate to high stability in subsequent years. These findings suggest that the changes in intention to practice medicine are primarily driven by the students in "weak intention" and "wavering" states rather than those in "strong intention" state. More importantly, medical educators and institutions should pay attention to and intervene with students who do not have a strong intention to practice medicine as early as their first year of medical school.

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Data availability

Data will be made available on request.

CRediT authorship contribution statement

Zehua Shi: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation. **Hongbin Wu:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Robustness check by using multilevel Logit model to examine the trajectory of intention to practice in medicine.

We employed a multilevel Logit model for robustness check as the response variable was a binary variable, and the results are shown in Table A1. Consistent with the main findings, the intention to practice medicine demonstrated similar curves.

Table A1
Results of the Main Regression Using Logit

Fixed effect	Intention to practice medicine		
	(1)	(2)	(3)
Year	0.530*** (0.002)	1.695*** (0.007)	3.469*** (0.017)
Year square		−0.269*** (0.001)	−1.360*** (0.009)
Year cubic			0.151*** (0.001)
Random effect			
School-Level			
Random intercept	0.102	0.053	0.119
Student-Level			
Random intercept	1.355	1.625	1.710
Deviance	892,760	857,654	841,789
AIC	892,786	857,682	841,819
BIC	892,938	857,845	841,994
Number of schools	143	143	143
Number of students	367,397	367,397	367,397
student-year observation	855,971	855,971	855,971

Note: The values in the parentheses represent the standard errors of the fixed effect estimates. ***p < 0.001, **p < 0.01, and * p < 0.05. The demographic characteristics of the students were included in all regressions. To enable the model to identify the parameters effectively, we only included random intercept in the random effects part.

Common trajectory among different cohorts

We utilized data from seven distinct cohorts and each cohort provides data on intention to practice medicine at different time points during their undergraduate stage. Therefore, it is necessary to test whether there is a common trajectory of the intention developing among different cohorts. We followed the method of Miyazaki & Raudenbush (2000). Specifically, we plotted the mean and 99.5% confidence interval of the intention to practice medicine for different cohorts at each time point. If the confidence intervals overlap at each time point, it indicates no significant difference in the intention to practice medicine among cohorts. As shown in Figure A1, the intention to practice medicine generally shows no significant difference among different cohorts across each time point. Therefore, we have reason to believe in the validity of the common trajectory for all cohorts.

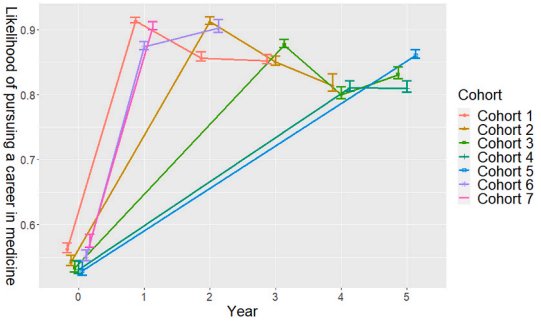

Fig. A1. Test for common trajectory among different cohorts..

References

[1] WHO, Global Strategy on Human Resources for Health, Workforce 2030, 2016.
[2] T. Dall, R. Reynolds, K. Jones, R. Charkrabarti, W. Iacobucci, The Complexities of Physician Supply and Demand: Projections from 2017 to 2032, Association of American Medical Colleges, Washington, DC, 2019.
[3] L.D. O'Neill, B. Wallstedt, B. Eika, J. Hartvigsen, Factors associated with dropout in medical education: a literature review, Med. Educ. 45 (2011) 440–454.
[4] H. Wang, X. Liu, Analysis of Medical Student Attrition in China from 2005 to 2018, China Health Development Research Center, Peking University, 2021.
[5] I. Huntington, S. Shrestha, N.G. Reich, A. Hagopian, Career intentions of medical students in the setting of Nepal's rapidly expanding private medical education system, Health Policy Plan 27 (2012) 417–428.
[6] S. Kizito, D. Mukunya, J. Nakitende, S. Nambasa, A. Nampogo, R. Kalyesubula, A. Katamba, N. Sewankambo, Career intentions of final year medical students in Uganda after graduating: the burden of brain drain Career choice, professional education and development, BMC Med. Educ. 15 (2015) 1–7.
[7] E. Pfarrwaller, L. Voirol, G. Piumatti, M. Karemera, J. Sommer, M.W. Gerbase, S. Guerrier, A. Baroffio, Students' intentions to practice primary care are associated with their motives to become doctors: a longitudinal study, BMC Med. Educ. 22 (2022) 1–10.

[8] Santos FF dos Miranda Cz de, K.C. Pertile, S. de M. Costa, A.P. Caldeira, M.S. Barbosa, Factors associated with career intention in primary health care among medical students, Rev. Bras. Educ. Méd. (2021), https://doi.org/10.1590/1981-5271v45.3-20200439.ing.
[9] A. Singh, H. Alberti, Why UK medical students change career preferences: an interview study, Perspect Med Educ 10 (2021) 41–49.
[10] R.J. Little, N. Schenker, Missing data, in: Handb. Stat. Model. Soc. Behav. Sci, . Springer, 1995, pp. 39–75.
[11] Y. Miyazaki, S.W. Raudenbush, Tests for linkage of multiple cohorts in an accelerated longitudinal design, Psychol. Methods 5 (2000) 44–63.
[12] P.J. Curran, K. Obeidat, D. Losardo, Twelve frequently asked questions about growth curve modeling, J Cogn Dev (2010), https://doi.org/10.1080/15248371003699969.
[13] S.W. Raudenbush, A.S. Bryk, Hierarchical Linear Models: Applications and Data Analysis Methods, sage, 2002.
[14] S.K. Sterba, Fitting nonlinear latent growth curve models with individually varying time points, Struct. Equ. Model. 21 (2014) 630–647.
[15] Chan Randenbush, Growth curve analysis in accelerated longitudinal designs, Pap Knowl Towar a Media Hist Doc (1992) 12–26.
[16] C. Mathur, D.J. Erickson, M.H. Stigler, J.L. Forster, J.R. Finnegan, Individual and neighborhood socioeconomic status effects on adolescent smoking: a multilevel cohort-sequential latent growth analysis, Am. J. Publ. Health 103 (2013) 543–548.
[17] F. Bartolucci, A. Farcomeni, F. Pennoni, Latent Markov Models: A Review of a General Framework for the Analysis of Longitudinal Data with Covariates, 2014, https://doi.org/10.1007/s11749-014-0381-7. Test.
[18] F. Bartolucci, A. Farcomeni, F. Pennoni, Latent Markov Models for Longitudinal Data Statistics in the Social and Behavioral Sciences Series, 2012.
[19] J.K. Vermunt, R. Langeheine, U. Bockenholt, Discrete-time discrete-state latent Markov models with time-constant and time- varying covariates author (s): jeroen K . Vermunt , rolf langeheine and ulf bockenholt source, Journal of Educational and Behavioral Statistics , Summer 24 (24) (1999) 179–207.
[20] P.M. Bentler, Number of factors in growth curve modeling, Struct. Equ. Model. 25 (2018) 961–964.
[21] K.A. Bollen, P.J. Curran, A Structural Equation Perspective, 2006.
[22] K. Hood, R. Cant, J. Baulch, A. Gilbee, M. Leech, A. Anderson, K. Davies, Prior experience of interprofessional learning enhances undergraduate nursing and healthcare students' professional identity and attitudes to teamwork, Nurse Educ. Pract. 14 (2014) 117–122.
[23] D. Wang, X. Ye, H. Wu, Prosocial modelling matters: the association between parent and faculty involvement in fighting COVID-19 with medical students' career commitment, Ann. Med. 54 (2022) 3146–3156.
[24] K.J. Dezee, A.R. Artino, D.M. Elnicki, P.A. Hemmer, S.J. Durning, Medical education in the United States of America, Med. Teach. 34 (2012) 521–525.
[25] S.S. Lien, R.O. Kosik, A.P. Fan, L. Huang, X. Zhao, X. Chang, Y. Wang, Q. Chen, 10-year trends in the production and attrition of Chinese medical graduates: an analysis of nationwide data, Lancet (2016), https://doi.org/10.1016/s0140-6736(16)31938-9.
[26] J. Zeng, X.X. Zeng, Q. Tu, A gloomy future for medical students in China, Lancet 382 (2013) 1878.
[27] CNR News, CMG: 600,000 Medical Students Do Not Want to Wear the "White Coat" Is a Misinterpretation, 2021. https://baijiahao.baidu.com/%0As?id=1616527589865654981&wfr=spider&for=pc. (Accessed 11 January 2021).
[28] J. Wang, L. Zhao, F. Xian, Research and practice of clinical teaching homogeneity in medical education, Med Educ Manag 6 (2020) 251–255.
[29] B. Cuesta-Briand, M. Coleman, R. Ledingham, S. Moore, H. Wright, D. Oldham, D. Playford, Extending a conceptual framework for junior doctors' career decision making and rural careers: explorers versus planners and finding the 'right fit, ' Int J Environ Res Public Health (2020), https://doi.org/10.3390/ijerph17041352.
[30] X. Ye, M. Zhai, L. Feng, A. Xie, W. Wang, H. Wu, Still want to be a doctor? Medical student dropout in the era of COVID-19, J. Econ. Behav. Organ. 195 (2022) 122–139.
[31] M.K. Grace, Parting ways: sex-based differences in premedical attrition, Soc. Sci. Med. 230 (2019) 222–233.
[32] M. Ibrahim, A. Fanshawe, V. Patel, K. Goswami, G. Chilvers, M. Ting, Y. Pilavakis, C. Rao, T. Athanasiou, What factors influence British medical students' career intentions? Med. Teach. 36 (2014) 1064–1072.
[33] L.V. Monrouxe, A. Bullock, H.M. Tseng, S.E. Wells, Association of professional identity, gender, team understanding, anxiety and workplace learning alignment with burnout in junior doctors: a longitudinal cohort study, BMJ Open 7 (2017) 1–12.
[34] S. Wainipitapong, M. Chiddaycha, Assessment of dropout rates in the preclinical years and contributing factors: a study on one Thai medical school, BMC Med. Educ. 22 (2022) 1–8.
[35] Z. Gong, W. Li, H. Bu, M. He, H. Hou, T. Ma, X. Hu, L. Fu, J. Adu-Amankwaah, H. Sun, Impact of COVID-19 pandemic on the professional intention of medical and related students, BMC Med. Educ. 21 (2021) 1–7.
[36] G. Yang, L. Wang, J. Wang, Z. Geng, H. Liu, T. Xu, Career choice regret during COVID-19 among healthcare students and professionals in mainland China: a cross-sectional study, BMC Med. Educ. 21 (2021) 1–10.