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Factors influencing hepatitis B vaccination intention and behavior among college students in Tibet: Insights from the expanded theory of planned behavior

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ABSTRACT

Hepatitis B (Hep B) remains a critical public health issue globally, particularly in Tibet, where vaccination rates and influencing factors among college students are yet understudied. This study applies a cross-sectional design to investigate the Hep B vaccination rate among 1,126 college students in Tibet and utilizes the expanded theory of planned behavior (ETPB) to identify vaccination behavior intention (BI) and vaccination behavior (VB). Stratified cluster sampling across three universities was used to assess behavioral attitudes (BA), subjective norms (SN), perceived behavioral control (PBC), past vaccination history (PVH) and vaccination knowledge (VK), and used structural equation modeling (SEM) for model validation and multi-group comparison. Results indicated that 16.3% of students had received the Hep B vaccine. VK notably improved BA toward vaccination ($\beta = 0.518$, $p < .001$). BA ($\beta = 0.232$, $p < .001$), PBC ($\beta = 0.239$, $p < .001$), SN ($\beta = 0.385$, $p < .001$) positively influenced BI. However, PVH failed to predict BI. BI ($\beta = 0.448$, $p < .001$) and PVH ($\beta = 0.127$, $p < .001$) were significant predictors of VB. Significant ethnic variations were noted. The positive effect of PVH on VB ($\beta = 0.151$, $p < .001$) and the mediating role of PBC in VB ($\beta = 0.076$, $p < .05$) were significant among Tibetan students. The effect of VK on BA was stronger among Tibetans ($\beta = 0.503$, $p < .05$),while the impact of attitude on BI was more pronounced among Han students ($\beta = 0.366$, $p < .05$). The vaccination rate for Hep B among college students in Tibet is relatively low, and the ETPB model effectively explains their vaccination intentions and behaviors. Tailored intervention strategies for Tibetan and Han students are recommended to boost vaccination rates effectively.

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Introduction

Hepatitis B (Hep B), caused by the hepatitis B virus (HBV), is a major global health issue, with 1.2 million new infections and 1.1 million deaths reported in 2022.[1–3] The World Health Organization (WHO) aims to eliminate the public health risks associated with viral hepatitis by 2030, recognizing vaccination as a cost-effective prevention strategy.[4] In China, the introduction of the Hep B vaccine into the National Immunization Program (NIP) for children has reduced HBsAg prevalence from high to moderate. Despite this progress, high HBsAg prevalence in adults and ongoing mother-to -child transmission challenges remain significant[5,6] Furthermore, the overall coverage of hepatitis B vaccination in adults remains low.[7] Tibet, the westernmost part of China, faces particularly severe economic and medical challenges, with higher rates of Hep B incidence and mortality compared to the national average and a high prevalence of non-immuno-protected adults at 43.8%.[8,9]

Given the immunological efficacy and cost-effectiveness of Hep B vaccination, existing research suggests promoting hepatitis B vaccination among young adults aged 20–39.[10,11] Since many college students fall within this age range, increasing their vaccination rate is essential to achieving greater cost-effectiveness. However, surveys conducted in the Xizang Autonomous Region in 2014 and 2020 revealed a full-course National Immunization Program (NIP) Hep B vaccination rate of 52.8% among university students, with an antibody positivity rate of only 37.7%.[8,9] Both figures are well below the other provinces,[12–14] highlighting that a significant portion of university students in Tibet missed the Hep B vaccination(NIP), creating a considerable immunity gap in this population. This low vaccination rate increases transmission risk, and insufficient antibody levels among female students pose additional challenges for preventing mother-to-child transmission. Understanding the adult Hep B vaccination rate in this population and implementing targeted strategies to improve their uptake is a valuable and impactful effort. Despite the importance of improving vaccination rates, there is a lack of comprehensive research in this field.[15]

The theory of planned behavior (TPB), proposed by Ajzen, provides a framework for understanding health behaviors through behavioral attitude (BA), subjective norms (SN), and perceived behavioral control (PBC).[16] These factors influence behavioral intention (BI) as well as actual behavior.[17] The TPB

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model has been widely adopted across various disciplines,[18–20] and has been successfully applied to predict vaccination intentions for various diseases, including COVID-19, influenza, and pertussis.[21–23]

BA refers to an individual's positive or negative evaluation of a specific behavior.[16] Empirical studies further highlight its role as a strong predictor of vaccination intentions for vaccines like COVID-19 and influenza.[24,25] These previous studies indicated that positive attitudes toward vaccines significantly increase the likelihood of vaccination, underscoring the critical role of behavioral attitude in shaping vaccination intentions and behaviors.

SN reflect an individual's perception of others' attitudes toward their behavior.[16] Empirical research consistently shows their influence on vaccine uptake, including HPV and hepatitis B vaccines. For example, research indicates that recommendations from healthcare professionals can increase individuals' motivation and intent to receive the hepatitis B vaccine,[26,27] and Yang et al. found that subjective norms significantly impact influenza vaccine hesitancy.[24] Thus, subjective norms are a crucial factor in shaping vaccination intentions and behaviors.

PBC refers to an individual's confidence in their ability to successfully perform a specific behavior.[17] In Yang et al.'s study on influenza, perceived behavioral control was shown to contribute to explaining vaccine hesitancy.[24] Similarly, Guidry et al. identified perceived behavioral control as one of the predictive factors for the intention to receive the COVID-19 vaccine.[28]

However, there is limited research on applying the TPB to Hep B vaccination intention and behavior among adults. Accordingly, we aimed to address the gap in the literature by utilizing the TPB model to explore the factors influencing Hep B vaccination intention and behavior among adults.

The flexibility of TPB allows for enhancements by incorporating additional variables to better predict specific behaviors.[16] Ajzen and Conner suggested that past behaviors could significantly influence future behavioral intention.[29,30] Prior influenza vaccination increases the likelihood of receiving a COVID-19 vaccine,[25] and individuals with previous preventive strategies are more inclined to continue such behavior.[31] These facts raise the question of whether prior vaccinations that are non- NIP vaccine can predict Hep B vaccination intention and behavior.

Knowledge, typically viewed as a foundational factor influencing attitude and behavior,[32] plays a crucial role in vaccination intention. Knowledge about the benefits of COVID-19 vaccination directly correlates with a positive attitude and indirectly influences vaccination intention.[25] A recent review highlighted that a lack of awareness about the benefits of Hep B vaccination contributes to high hesitancy rates.[33] A French study found that perceptions of vaccine benefits and effectiveness influence the acceptance of vaccines like varicella and HPV. Recognizing the benefits of a vaccine increases the likelihood of its acceptance.[34] Thus, this study integrates past vaccination history (PVH) and vaccination knowledge (VK) into the TPB model to assess their impact.

Additionally, previous research has underscored the role of racial and cultural factors in shaping vaccination intention and hesitancy.[35–37] In China, ethnic minorities' religious beliefs and traditional cultures have been linked to vaccine hesitancy.[38] To address this matter, we conducted a multi-group analysis to compare decision-making processes regarding Hep B vaccination among Tibetan and Han students for following reasons. Research has highlighted the unique challenges faced by ethnic minorities in accessing and understanding vaccine information due to socio-economic, cultural, and geographic factors, which can negatively influence vaccination attitudes and rates.[39,40] Lower education levels and limited trust in media sources make healthcare professionals the primary sources of vaccine information for these populations,[41] suggesting that subjective norms may have different effects on ethnic minorities compared to the Han population. Additionally, lower health literacy, often linked to reduced self-efficacy, is more prevalent among ethnic minorities, potentially impacting perceived behavioral control and vaccination behavior.[42] While ethnicity's role in vaccination behavior has been acknowledged, few studies have systematically examined its differential impacts across model pathways.

In summary, the overall objective of this study is to investigate the status of adult hepatitis B vaccination among students in Tibetan universities who have not received the NIP Hep B vaccine. Employing the expanded theory of planned behavior (ETPB) and structural equation modeling (SEM), we investigated the determinants of Hep B vaccination among college students in Tibet, and aimed to address this gap by conducting a multi-group analysis to compare decision-making processes regarding Hepatitis B vaccination between Tibetan and Han students, providing insights for targeted interventions to improve vaccination rates in minority communities.

Thus, based on the theoretical framework and empirical evidence outlined above, we propose the following ten hypotheses:

H1: BA toward Hep B vaccination is positively associated with BI

H2: SN are positively associated with BI.

H3: PBC is positively associated with BI.

H4: PBC is positively associated with VB.

H5: Hep B BI is positively associated with VB.

H6: VK concerning Hep B vaccination is positively associated with BA toward vaccination.

H7: PVH is positively associated with BI.

H8: PVH is positively associated with VB.

H9: BI mediates the relationship between SN (H9a), PBC (H9b), PVH (H9c), and VB; BA and BI mediate the relationship between VK (H9d) and VB.

H10: Path coefficients in the mediation model vary by ethnic identity.

Methods

Participants and recruitment procedure

We collected data from March to June 2024 using stratified cluster sampling at three comprehensive colleges under the jurisdiction of the Xizang Autonomous Region: Xizang Minzu University (located in Xianyang, Shaanxi), Tibet University (located in Lhasa, Xizang), and Xizang Agricultural and Animal Husbandry University (located in Nyingchi, Xizang). We categorized the participants by their school and major, with 3–4 classes randomly selected from each major.

The inclusion criteria for participants were (1) household registration in Tibet and (2) voluntary participation in the questionnaire survey. The exclusion criteria were (1) unable to read the questionnaire independently, (2) Hep B patient, and (3) individuals who had received the Hep B Vaccine through NIP or the Supplemental Immunization Program for NIP before the age of 15. We calculated the sample size estimation for the cross-sectional survey using the following formula:

$$N_{min} = deff \times \frac{Z^2{}_{1-\alpha/2} \times P \times (1-P)}{d^2}.$$

where d represents the permissible error, set at 0.03 based on expert experience; α is the type I error, set at 0.05 as per standard practice; and P is the adult Hep B vaccination rate in ethnic autonomous area, which is 13.9% according to Xu et al .[43] We set the design effect (deff) at 2, considering both international research practices and the specific context of China.

The estimated minimum sample size was 1,022 individuals. After accounting for factors such as the rate of lost visits and refusal of visits, an additional 10%-20% was added to the estimated sample size, and the final sample size was around 1,200 individuals.

To ensure the quality of the questionnaire and prevent missing data, the questionnaire was administered on-site via an online e-questionnaire link and completed class by class, under the supervision of a teacher. At least one member of the research team was present to handle any questions from participants. Counselors and classroom teachers provided support and assistance to ensure the smooth execution of the project. Additionally, the project received ethical approval from the Ethics Committee of the Faculty of Medicine at Xizang Minzu University (No. 23MDY04). Prior to the survey, participants were given a comprehensive explanation of the study, with assurances of voluntary participation and confidentiality.

Measures

We adapted the measures used in this study from the basic framework of TPB, incorporating additional dimensions for VK and PVH. The questionnaire items were based on Franceis' scale and included questions from other scholars' surveys to develop a suitable set of questions.[24,25,44] (show in Appendix A)

Behavior measure

We defined Hep B VB as receiving the Hep B vaccine after reaching the age of 16. We measured it using a dichotomous entry: "Did you receive the non-NIP Hep B vaccine?" (yes/no).

Behavior attitude measure

We assessed BA toward the TPB using a scale with four items using the prompt "I think that the Hep B vaccine is . . . " The participants could choose from the following answers, we used five-point Likert scale: *useless/risky/unnecessary/has serious side effects* was score as 1 and *useful/not risky/necessary/has no side effects* was score as 5. Participants were instructed to score from 1–5 according to their personal views.

Subjective norms measure

We assessed SN using four items on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*): "The attitudes of (1) online media or netizens/(2) parents and family members/(3) classmates and friends/(4) doctors influenced my decision to receive the non-NIP Hep B vaccine."

Perceived behavioral control measure

We assessed PBC using four items ranging from 1 (*strongly disagree*) to 5 (*strongly agree*): "I think I am able to follow through with the plan and put it into action, if I decide to get the non-NIP Hep B vaccine." "I think the decision to get the non-NIP Hep B vaccine or not was an easy decision to make," "I think I made the right decision." and "I think I can make an independent decision about whether to get the non-NIP Hep B vaccine or not."

Behavior intention measure

We measured BI using three items scale: "After reaching the age for the non-NIP Hep B vaccine (16 years and older), I think I would (1) considering to get/(2) trying to get/(3) actually getting the non-NIP Hep B vaccine." We assessed this using a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Vaccination knowledge measure

We assessed the knowledge dimension using four items ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), focusing on the participants' understanding of the benefits of Hep B vaccination: "I am highly aware of how the Hep B vaccine protects me from Hep B," "I am highly aware of the Hep B vaccine's role in reducing the serious consequences of the disease," "I am highly aware of the Hep B vaccine's role in creating an immune barrier for the population." and "I am highly aware of the importance of Hep B vaccine for social activities (e.g.: travel, job hunting, learning) provides convenience ."

Past vaccination history measure

Participants were asked whether they had received the influenza vaccine, rabies vaccine, HPV vaccine, hemorrhagic fever vaccine, and an open-ended question was included to allow participants to list any additional non-NIP vaccines they had received beyond those mentioned above. If participants had received the non-NIP Hep B vaccine, we ensure that these non-NIP vaccines were administered prior to the Hep B vaccination. The results were recorded as follows: "never received" for those with no vaccinations, and "received" for those who had received at least once vaccination.

We also collected data on socio-demographic traits such as sex, age, ethnicity, place of residence, school, grade, profession, and parents' education level.

Data analysis

We analyzed the data descriptively using SPSS 26.0 software. We assessed the reliability of the questionnaire by calculating the Cronbach's alpha coefficient. Additionally, we evaluated the component reliability and convergent validity of the scales using composite reliability (CR) and average variance extracted (AVE) tests, calculated with AMOS 24.0 software.[45] The analysis involved comparing the root value of AVE with Pearson correlation coefficients between latent variables to determine their validity. We estimated the structural equation models using the maximum likelihood method, with model fit assessed using the minimum discrepancy of confirmatory factor analysis/degrees of freedom (CMIN/df), the goodness-of-fit index (GFI), the adjusted GFI (AGFI), the comparative fit index (CFI), and the root mean square of error of approximation (RMSEA).[46] We employed a bias-corrected percentile Bootstrap test with 5,000 replicate extractions to calculate 95% confidence intervals (CIs) to validate the mediating effects of the models,[47] with the test level set at 0.05.

Data were analyzed using AMOS 24.0 software to conduct a multi-group analysis. This analysis aims to examine differences in the structural model across groups by using nested models with constraints to test for structural invariance.[48,49] The primary objective of this multi-group analysis was to assess whether ethnic factors moderate the model and to explore the mechanisms influencing vaccination intentions and behaviors in different ethnic groups. The process involves several steps:

(1) Measurement Invariance: A measurement weight equality constraint was applied to the baseline model to assess whether the measurement structure is consistent across groups. If the test was passed, it indicated that the measurement model is invariant and suitable for both groups.
(2) Structural Invariance: Next, based on the previous step, we further imposed equality constraints on the structural weights to assess whether differences exist in the structural models (i.e., path coefficients) between the groups. This step evaluated whether the relationships between variables are consistent across the Tibetan and Han groups. The main goal is to evaluate whether ethnic factors moderate the model and if further exploration is needed to understand the mechanisms influencing vaccination intentions and behaviors in different groups.

Results

Characteristics of the participants

We included a total of 1,126 participants (92.0% response rate) in the study after excluding questionnaires that were completed in under 4 minutes, did not meet the inclusion criteria, or exhibited highly patterned responses. The sample comprised 66.4% female (747) and 33.7% male (379) students. Over half of the students were Tibetan, accounting for 77.3% of the total. Additionally, 74.8% of the students came from rural areas, while 9.4% were involved in the medical profession. Most respondents were sophomores (41.7%) and juniors (31.2%). Furthermore, 12.2% reported having a family member employed in a medical-related occupation, such as in the Department of Health, hospitals, or the Center for Disease Control and Prevention (CDC). Most participants' parents had an education level of elementary school or lower, at 55.6% and 69.5% for fathers and mothers respectively. Family incomes were either below ¥10,000 per year (33.0%) or between ¥10,000 and ¥50,000 per year (35.7%) (Table 1).

The survey indicated that 16.3% (184/1126) of the respondents had received the Hep B vaccine. Univariate analysis identified a significant association between VB and factors such as locality, parents' education level, and the presence of relatives studying medicine ($p<0.05$). However, these demographic factors did not significantly predict Hep B VB when included in the logistic regression model. Consequently, we excluded demographic variables from the SEM analysis.

Measurement model reliability and fit

We removed items from the scale based on their factor loadings, excluding those having loadings below 0.6.[50] The CR and Cronbach's alpha coefficients for all dimensions exceeded 0.7, while the AVE surpassed 0.5. These findings indicate that the scales demonstrated strong internal consistency and solid convergent validity (Table 2). In terms of discriminant validity, the square roots of the AVE values for each construct were greater than the correlations between the latent variables, except for the correlation between SN and VK, which was slightly higher. Despite this result, the discriminant validity was generally acceptable (Appendix B). Furthermore, the measurement model showed satisfactory fit indices: $\chi^2/df = 2.983$, RMSEA = 0.042, GFI = 0.968, AGFI = 0.954, CFI = 0.978, all of which met the recommended criteria.[46] These results suggest that the data fit the model well (Appendix C).

Table 1. Participants' information and univariate analysis.

Variable		N (%)	Hep B vaccination Yes ($n = 184$)	No ($n = 942$)	Univariate analysis x^2	*P* value
Sex	Male	379 (33.7%)	61	318	0.025	0.874
	Female	747 (66.3%)	123	624		
Ethnicity	Tibetan	870 (77.3%)	135	735	1.900	0.168
	Han	256 (22.7%)	49	207		
Locality	Rural	916 (81.3%)	140	776	4.015	0.045
	Urban	210 (18.7%)	44	166		
Medical professional	Yes	106 (9.4%)	24	82	3.398	0.065
	No	1020 (90.6%)	160	860		
College	Xizang Minzu University	351 (31.2%)	50	301	1.641	0.440
	Xizang Agricultural and Animal Husbandry University	525 (46.6%)	91	434		
	Tibet University	250 (22.2%)	43	207		
Grade	Freshman	158 (14.0%)	23	135	5.841	0.120
	Sophomore	470 (41.7%)	74	396		
	Junior	351 (31.2%)	53	298		
	Senior	147 (13.1%)	34	113		
Family with a medical background	Yes	137 (12.2%)	24	113	0.158	0.691
	No/Unknown	989 (87.8%)	160	829		
Father's education level	Primary	626 (55.6%)	87	539	12.925	0.012
	Secondary	276 (24.5%)	45	231		
	High school	95 (8.4%)	24	71		
	College	79 (7.0%)	20	59		
	Unknown	50 (4.4%)	8	42		
Mother's education level	Primary	783 (69.5%)	114	669	11.180	0.025
	Secondary	186 (16.5%)	31	155		
	High school	71 (6.3%)	20	51		
	College	36 (3.2%)	8	28		
	Unknown	50 (4.4%)	11	39		
Annual household income	<10,000	372 (33.0%)	59	313	3.260	0.515
	10,000–50,000	402 (35.7%)	58	344		
	50,000–100,000	131 (11.6%)	26	105		
	>100,000	86 (7.6%)	17	69		
	Unknown	135 (12.0%)	24	111		

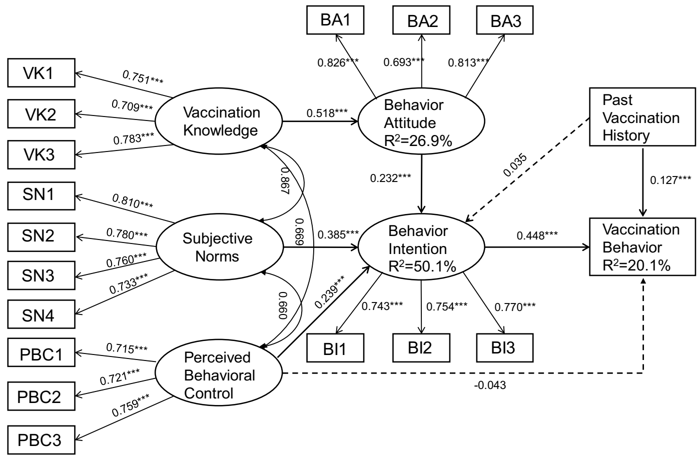
Table 2. Unstandardized coefficients (unstd), standard errors (SE), test of significant deviation from zero (Z, p-value), standard deviations (std) of items, reliability (Cronbach's α), composite reliability (CR), and average variance extracted (AVE) for the measurement scales.

Dimension	Question	Unstandardized coefficients (Unstd.)	Standard error (SE)	Z-value	P-value	standard deviation (Std.)	Cronbach alpha (α)	Composite Reliability (CR)	Average Variance Extracted (AVE)
BA	BA1	1.000				0.824	0.818	0.822	0.607
	BA2	0.910	0.040	22.699	<0.001	0.694			
	BA3	0.987	0.039	25.569	<0.001	0.813			
SN	SN1	1.000				0.809	0.853	0.854	0.594
	SN2	0.968	0.034	28.120	<0.001	0.780			
	SN3	0.932	0.034	27.190	<0.001	0.759			
	SN4	0.930	0.036	26.058	<0.001	0.733			
PBC	PBC1	1.000				0.714	0.774	0.775	0.535
	PBC2	1.030	0.051	20.301	<0.001	0.721			
	PBC3	1.116	0.053	20.949	<0.001	0.759			
VK	VK1	1.000				0.755	0.795	0.798	0.569
	VK2	1.007	0.045	22.594	<0.001	0.710			
	VK3	1.127	0.045	25.157	<0.001	0.795			
BI	BI1	1.000				0.744	0.800	0.802	0.574
	BI2	1.021	0.045	22.526	<0.001	0.756			
	BI3	1.037	0.045	22.851	<0.001	0.772			

AVE = average variance extracted, BA = behavioral attitude, BI = behavioral intention, CR = composite reliability, PBC = perceived behavioral control, SE = standard error, SN = subjective norms, Std. = standard deviation, Unstd. = unstandardized coefficients, VK = vaccination knowledge, α = Cronbach's alpha reliability coefficient.

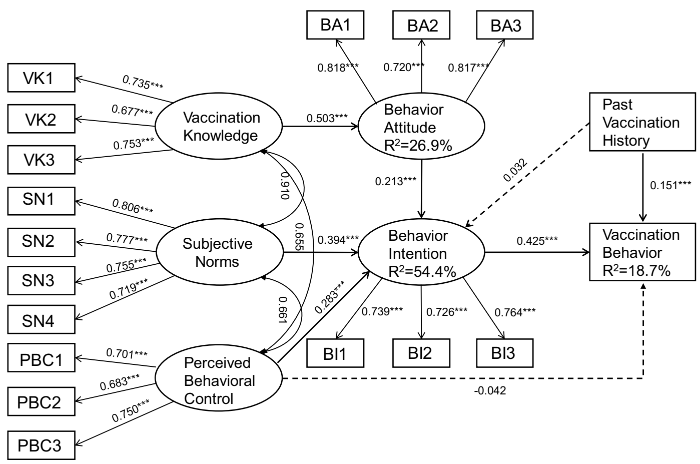
Analysis of SEM

The fit of the structural model was tested before the path analysis and the model fit indices of the structural model indicated a good fit(χ^2/df = 2.634, RMSEA = 0.038, GFI = 0.976, AGFI = 0.955, CFI = 0.976), as show in Appendix C. For the entire sample, the results (Appendix D) showed that most hypothesized paths were significant, except for the paths between PBC and VB (p=0.300) and between PVH and BI (p=0.184). The comprehensive model accounted for 50.1% of the variance in BI and 20.1% of the variance in VB. Specifically, VK was positively associated with BA (β=0.518, p< 0.001). BA (β=0.232, p<0.001), SN (β=0.385, p<0.001), and PBC (β=0.239, p<0.001) were positively correlated with BI. Additionally, BI (β=0.448, p<0.001) and PVH (β=0.127, p<0.001) were positively associated with VB (Figure 1a).



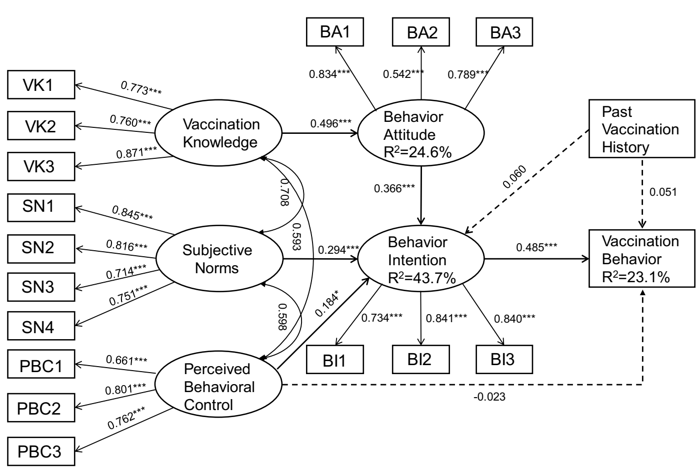
*P<0.05, **P<0.01, ***P<0.001

a. Standardized solution of the structural model for the entire sample



*P<0.05, **P<0.01, ***P<0.001

b. Standardized solution of the structural model for the Tibetan group



*P<0.05, **P<0.01, ***P<0.001

c. Standardized solution of the structural model for the Han group

Figure 1. Standardized solution of the structural model.

Table 3. Results of the mediation effect in the proposed model.

Pathway	Point estimate (Unstd.)	Standard error (SE)	Z-value	Bootstrapping 95% Bias-corrected Lower	Bias-corrected Upper	Percentile Lower	Percentile Upper	P-value
The mediation effect test of the entire sample								
SN → BI → VB (1)	0.096	0.017	5.647	0.066	0.133	0.065	0.131	<0.01
PBC → BI → VB (2)	0.066	0.018	3.667	0.036	0.106	0.035	0.103	<0.01
PVH → BI → VB (3)	0.012	0.009	1.333	−0.005	0.030	−0.006	0.030	>0.05
VK → BA → BI → VB (4)	0.032	0.006	5.333	0.022	0.045	0.021	0.044	<0.01
Comparison of the mediation effect								
1 vs 2	0.030	0.028	1.071	−0.025	0.085	−0.025	0.084	>0.05
1 vs 4	0.065	0.017	3.824	0.034	0.101	0.033	0.101	<0.01
2 vs 4	0.035	0.018	1.944	0.002	0.074	0.001	0.073	<0.05
Mediation effect test of the Tibetan group								
SN → BI → VB	0.092	0.019	4.842	0.059	0.135	0.057	0.131	<0.001
PBC → BI → VB	0.076	0.023	3.304	0.039	0.133	0.038	0.129	<0.001
PVH → BI → VB	0.010	0.009	1.111	−0.008	0.030	−0.008	0.029	>0.05
VK → BA → BI → VB	0.028	0.006	4.667	0.018	0.041	0.017	0.040	<0.001
Mediation effect test of the Han group								
SN → BI → VB	0.080	0.031	2.581	0.030	0.153	0.027	0.149	<0.01
PBC → BI → VB	0.068	0.038	1.789	0.000	0.155	−0.005	0.146	>0.05
PVH → BI → VB	0.023	0.022	1.045	−0.018	0.072	−0.020	0.069	>0.05
VK→ BA → BI → VB	0.050	0.019	2.632	0.022	0.103	0.021	0.099	<0.001

BA = behavioral attitude, BI = behavioral intention, PBC = perceived behavioral control, PVH = past vaccination history, SE = standard error, SN = subjective norms, Unstd. = unstandardized coefficients, VB = vaccination behavior, VK = vaccination knowledge.

Table 4. The critical ratio of path coefficients between the Tibetan and han groups.

Hypothesis	Pathway	Path coefficient Tibetan group	Path coefficient Han group	Critical ratio
H1	BA → BI	0.213***	0.366***	2.942**
H2	SN → BI	0.394***	0.294***	−0.603
H3	PBC → BI	0.283***	0.184*	−0.340
H4	PBC → VB	−0.042	−0.023	0.135
H5	BI → VB	0.425***	0.485***	0.217
H6	VK → BA	0.503***	0.496***	−2.432**
H7	PVH → BI	0.032	0.060	0.545
H8	PVH→VB	0.151***	0.051	−1.399

BA = behavioral attitude, BI = behavioral intention, CI = confidence interval, PBC = perceived behavioral control, PVH = past vaccination history, SE = standard error, SN = subjective norms, VB = vaccination behavior, VK = vaccination knowledge.
*P<0.05, **P<0.01, ***P<0.001.

Among the four proposed pathways to explain the mediating effects, the results from the SEM supported the mediating effects for H9a, H9b, and H9d, except for the pathway involving PVH → BI → VB. Specifically, the relationships between SN, PBC, and VB were mediated by BI. The effect sizes were as follows: SN (β=0.096, 95% *CI*: [0.066,0.133]) and PBC (β=0.066, 95% *CI*: [0.036,0.106]). Additionally, BA and BI served as chain mediators between VK (β=0.032, 95% *CI*: [0.022,0.045]) and VB.

A comparative analysis of the mediating effects for different pathways revealed no statistically significant difference between the mediating effects of the two paths: SN→BI→VB and PBC→BI→VB ($p > 0.05$). However, the mediating effects of both paths were higher than the pathway from VK→BA→BI→VB ($B_{\text{pathway 1}}$=0.065, $B_{\text{pathway 2}}$=0.035, p<0.05), as shown in Table 3.

Comparison of the Tibetan and Han groups

The comparison between the two-group constraint models yielded the following findings: After imposing the equality constraint on the measurement weights of the baseline model, no significant difference was observed between the two groups (χ^2 =13.958, df=11, $p > 0.05$). The small absolute increment in the fit indices further supported the conclusion that the measurement model is invariant across the two groups. However, when we further applied equality constraints on the structural weights of the model based on this foundation, significant differences between the two groups were identified (χ^2 =18.137, df =8, P<0.05). This suggests that ethnicity may moderate the structural influence on vaccination behavior. These findings warrant further exploration of the differences in path coefficients between the two group models, as detailed in Appendix E. For the Tibetan group, the model explained 18.7% of the variance in VB and 54.4% in BI. VK positively influenced BA (β=0.503, p<0.001), and BA, SN, and PBC were positively correlated with BI. However, no statistically significant relationship between PBC and VB was observed.

In the Han group, the model explained 23.1% of the variance in VB and 43.7% in BI. We noted similarly positive relationships between VK, BA, and BI, but unlike the Tibetan group, PVH was not significantly linked to VB. The mediation effect of PBC on VB was also non-significant (β=0.068, p>0.05), as shown in Table 3.

We analyzed the paths of the Tibetan and Han groups to assess potential differences between the models. By comparing the critical ratios of the path coefficients, a significant difference was indicated if the absolute value of the critical ratio was exceeded 1.96 ($p < 0.05$). The analysis revealed two significantly different paths: BA → BI (critical ratio=2.942) and VK→BA (critical ratio=-2.432). Although we observed no significant difference between PVH and VB, the direction of the path coefficients differed between the groups, suggesting possible variability in this relationship. These findings support Hypothesis 10 (see Table 4).

Discussion

Our study found that among university students in Tibet, only 16.3% of students who missed the NIP Hep B vaccine received the adult Hep B vaccine. This rate aligns with findings from other ethnic minority regions in China but is notably lower than vaccination rates in economically developed areas.[7,43] This result underscores the urgent need for public health initiatives to enhance vaccination rates in this region.

The primary aim of this study was to develop an ETPB model to assess its efficacy in explaining Hep B vaccination intention and behavior among unvaccinated university students in Tibet, considering ethnic differences. Our results support the hypotheses that VK (H6) positively influences BA, and that BA (H1), SN (H2), and PBC (H3) positively impact BI. Additionally, PVH (H8) and BI (H5) were found to positively impact VB. Nevertheless, PVH (H7) did not substantially impact BI, and PBC (H4) did not significantly influence VB. Furthermore, the model was able to differentiate between different ethnic identities through multi-group analysis, suggesting that the ETPB extension model can be utilized to shed light on BI and subsequent VB.

ETPB model analysis

We found that Tibetan university students with positive attitudes toward Hep B vaccination were more likely to intend to get vaccinated. Additionally, higher levels of positive attitudes were associated with stronger intentions to vaccinate. The perceptions of vaccine-related knowledge of participants had an indirect effect on VB, mediated by BA and BI. These findings align with those of previous studies.[25,51,52] When individuals understand the efficacy and advantages of the Hep B vaccine, their favorable attitudes toward the vaccine are enhanced, leading to increased intention to get vaccinated and ultimately promoting VB.[27] Hep B vaccination efforts should prioritize highlighting the necessity and advantages of vaccination to potentially enhance vaccination rates.

The participants' intention to get vaccinated against Hep B was more strongly influenced by SN compared to other factors. Additionally, our findings provide evidence that BI mediates the promotion of VB. This result suggests that students are more susceptible to the influence of expectations surrounding their social relationships on their intention and choice to get vaccinated. This finding aligns with previous research,[24,26] Indicating that students prefer to receive recommendations for Hep B vaccination from individuals. For instance, a study conducted by Afolabi et al. revealed that health worker recommendations effectively motivated participants to receive the Hep B vaccine.[27]

Certain studies examining COVID-19 vaccination intention imply that SN do not play a significant role in predicting BI. This finding appears to contradicts our results.[25,53] However, whether this discrepancy is directly comparable is worth further investigation. A study by Emily et al. suggested that the empirical relationship between the COVID-19 vaccine and the Hep B vaccine lacks peer-reviewed evidence.[54] On one hand, this difference may stem from the distinct characteristics of the COVID-19 vaccine and disease compared to Hep B, which may render direct comparisons inappropriate. On the other hand, it suggests that different vaccines may raise different concerns, and applying the same reasoning from COVID-19 to Hep B could lead to flawed conclusions. This suggests the need for solid empirical research to verify the relationship between these two vaccines and confirm their comparability

Moreover, the influence of online communication (as opposed to traditional social relationships) is a matter of greater concern than the influence of doctors, parents, or classmates. The emergence of "online communities" transcends conventional geographic constraints. The vast amount and quick spread of information online facilitate the development of vaccine hesitancy among students through negative public opinion on social media, more so than in traditional face-to-face interactions. It is crucial not to overlook the impact of social media on vaccination intention and behaviors[41,55,56]

We found that PBC positively influenced BI. However, PBC did not directly predict behavior but rather influenced it through the intention to vaccinate. This finding aligns with the discoveries found by O'Neal et al.,[31] though it contradicts the initial framework proposed by Ajzen et al.[16] This phenomenon may be attributed to the fact that while some university students perceive vaccination decisions as individually autonomous, the practical execution of VB is not exempt from the impact and restrictions imposed by the family model. Parental involvement curtails students' autonomy in making decisions regarding healthcare. This pattern may also influence the relationship between PVH and both vaccination intention and behavior.

While past vaccination experiences can serve as a reference for students' future vaccination experiences, these past behaviors may have been decided upon by the students' parents rather than by the students. As a result, the influence of PVH on their current choices may be diminished. This situation may clarify our findings, wherein PVH did not emerge as a significant predictor of BI and exhibited a relatively weak association with VB. These results are comparable to the outcomes of a study on flu vaccination.[24]

Multi-group analysis

The path correlation results of the structural model in the analysis of multi-group effects showed distinct patterns in the Tibetan and Han groups, partially supporting the conclusion that the attributes of ethnic group have a moderating effect on the model. Specially, the analysis, found that PVH did not significantly impact VB in the Han group, which differed from the Tibetan group.

We have argued that past VB is likely influenced by surrogate parental decision-making due to parental and family model in the vaccination process for students. This influence leads to a difference between individuals' perceptions of the situation and their sense of control over their own behavior. Parents of Chinese minority students are influenced by factors such as culture, educational level, ethnic religion, and cultural disparities, leading to a limited pattern of parental involvement in their children's health choices.[38,57] Consequently, Han individuals may be more likely to be influenced by family patterns compared to Tibetan students. Additionally, the correlation between PVH and VB was no longer significant in the Han group. Moreover, the influence of PBC on VB through BI is not significant in the Han group, possibly due to the presence of this phenomenon. Hence, the impact of PVH on VB and the underlying process by which PBC affects VB through BI may not be suitable for this specific subgroup of the study's population.

Our analysis of the variations in path coefficients indicates that the impact of BA on BI is more evident in the Han group. When Han participants held favorable views toward the vaccine, their inclination to get vaccinated increased significantly. In contrast, the ability of Tibetan group to promote positive attitudes was stronger when they believed they had a greater understanding of the Hep B vaccine and held more favorable opinions about it. Previous studies have reached similar conclusions.[39,40] These variations may stem from the impact of diverse traditional cultures and religious beliefs on the decision-making process regarding healthcare options among different ethnic groups.[57] Medical anthropology asserts that the delivery of healthcare should not solely rely on modern medicine but should also consider social, cultural, psychological, spiritual, and other variables. This assertion implies that it is important to consider ethnic-cultural disparities when striving to encourage adult VB among Tibetan college students. Enhancing cultural caregiving competence and improving the ability to handle cultural differences are crucial steps in this direction.[58,59] This phenomenon suggests that further research could be conducted to validate the impact of ethnic differences on decision-making processes and behaviors within a more balanced sample size.

Limitations

This study has several limitations. First, the cross-sectional design limits the ability to establish causal relationship, although the findings offer valuable directions for future research. Second, vaccination behavior (VB) was self-reported through retrospective recall, which may introduce recall bias.

However, a preliminary survey was conducted to refine the questionnaire, and in the subsequent community-based trial, a subset of participants underwent serological testing, which demonstrated high accuracy and good quality in self-reports. Additionally, we assessed students' understanding of Hep B vaccination based on subjective perceptions rather than objective knowledge. The sample was also limited to three universities in Tibet, excluding junior colleges. Future studies should consider expanding the sample size to improve representativeness and generalizability. Finally, the sample was imbalanced, with 77.3% ($N = 870$) from the Tibetan group and 22.7% ($N = 256$) from the Han group. In addition, 81.3% of participants were from rural areas ($N = 916$), while only 18.7% were from urban areas ($N = 210$); 87.8% of participants came from families without a medical background ($N = 989$), and 12.2% came from families with a medical background ($N = 137$). This imbalance, resulting from random sampling, suggests the need for future research to ensure more balanced representation, possibly using matching techniques to better explore the factors influencing Hepatitis B vaccination in these populations and account for potential socio-demographic differences.

Conclusion

This study offers valuable insights and strategies for Hep B prevention, vaccine promotion, and health education and promotion, particularly in universities with ethnic minority students. In general, the Hep B vaccination rate of college students is low. The model analysis results suggest that we need for tailored interventions based on cultural background. For Tibetan students, the focus was on improving practical knowledge of the Hep B vaccine to encourage vaccination uptake rather than merely promoting the vaccine. In contrast, Han students benefited from strategies aimed at enhancing positive attitudes through educational campaigns, leading to increased VB. By leveraging medical advice and positive online public sentiment, societal expectations and perceived control over VB were strengthened, particularly among Tibetan university students.

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Data availability

Data available on request due to restrictions (e.g., privacy, legal or ethical reasons).

Institutional review board statement

Our study protocol was approved by the Ethics Committee of the Faculty of Medicine at Xizang Minzu University (No. 2023–25; data 26 June 2023).

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