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Factors influencing HIV testing choices among Chinese undergraduates: insights from a discrete choice experiment

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Abstract

Introduction Globally, HIV infection rates continue to be a significant public health concern. In China, undergraduates are particularly vulnerable to HIV infection. Despite multiple prevention and control measures, HIV testing rates among undergraduates remain low. This study aims to elicit undergraduates' preferences for key characteristics of HIV testing options. Understanding their preference will help raise testing rates.

Methods A discrete choice experiment (DCE) was conducted among undergraduates in Wuhan, China. They were asked to make eight choices between two unlabeled alternatives that differed in five attributes (testing location, testing sample, additional services, testing cost, and minimum travel time). Data were analyzed using a mixed logit model.

Results A total of 461 undergraduates provided valid responses for analyses. Most undergraduates were heterosexual (78.5%) and non-medical majors (81.8%). Testing location was the most important non-monetary attribute, followed by testing sample and whether additional services were offered with the test. Undergraduates preferred qualified medical institutions for HIV testing than self-testing at home ($\beta = 1.640$, $P < 0.001$). They favored oral fluid as a method to obtain the sample, relative to urine samples ($\beta = 0.821$, $P < 0.001$). Free health checks offered at HIV testing was the most significant driving factor for their choice of HIV testing services ($\beta = 0.460$, $P < 0.001$). Undergraduates preferred free tests (β=-0.020, $P < 0.001$). Additionally, gender, years at the university and sexual orientation were statistically significant in the preference choices of HIV testing services for undergraduates.

Conclusions Understanding undergraduates' preferences for HIV testing services is the first step in designing future HIV prevention and control policies. Testing location was the most important non-monetary attribute in HIV testing services. Qualified medical institutions could regularly train campus doctors and establish partnerships to address undergraduates' needs and promote their participation in HIV testing.

Keywords Undergraduates, HIV testing, Discrete choice experiment, Preferences

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Introduction

According to the Joint United Nations Programme on HIV/AIDS (UNAIDS) global report, 9.3 million people living with HIV were still not receiving antiretroviral therapy (ART) and 1.3 million people newly acquired HIV in 2023 [1]. Although most countries in the world have taken a variety of measures to HIV, young people are still facing a considerable risk of infection. Globally, nearly 37.7 million individuals live with HIV, and 90% of whom are young adults [2]. In China, the annual newly reported HIV/AIDS cases among young students rose from 794 in 2010 to 3,422 in 2019, with undergraduates aged 18–22 accounting for 76.8% in 2019 [3]. The Chinese Center for Disease Control and Prevention (China CDC) reported a concerning recent surge in HIV infections among university students, with an annual growth rate of 30 to 50% in new diagnoses over the past few years [4].

Increasing uptake of HIV testing may be an effective way to reduce spread of HIV. Previous researchers have demonstrated that testing HIV could help prevent HIV among college students by enhancing their knowledge and awareness of HIV, which ultimately increases the chances of early detection, diagnosis, and treatment of individuals who have contracted HIV [5]. Some studies found advanced patients do not receive HIV test until symptoms appear, and late diagnosis increases the number of unaware patients and HIV-related deaths [6, 7]. Generally, early HIV testing and immediate treatment of HIV-infected individuals could dramatically reduce or even eliminate HIV transmission. HIV testing has been promoted as a primary prevention strategy and an entry point for HIV care, remaining the main strategy to dam the rising HIV infection [8].

HIV testing services could increase the probability of early diagnosis of HIV, which also had a substantial positive correlation with initiating the treatment of ART drugs [9]. Many university students in China have not received HIV testing; a recent study indicated that only 14.69% of those with sexual experience reported taking HIV testing in the preceding year [10]. A study in Henan noted that among university students who had engaged in sex, 37.3% reported having multiple sexual partners, and 35% had used condoms inconsistently in the past six months [11]. To increase HIV testing uptake in university students, the China CDC has also sponsored innovative options for testing [12]. From November 2018, vending machines for HIV test kits had been installed at 52 universities in 11 provinces, but the prevalence of HIV testing was relatively low [13]. The other research also indicated that HIV testing willingness among college students was 73.3%, the proportion of previous HIV testing was only 10.3% [14]. Further understanding of patterns of engagement with HIV prevention and testing was important to reducing HIV transmission.

Barriers to testing and contributors to delayed diagnoses include individual concerns relating to confidentiality and anonymity, as well as service-related factors such as not being offered a test, especially modern forms—such as self-testing [15]. Self-testing and self-sampling methods, alternatives to sexual health service clinics, can boost testing access by enhancing confidentiality, privacy, and convenience. They may also cut healthcare costs as they demand less time from healthcare professionals. One study showed that fear of HIV nosocomial infection may influence HIV test preferences among university students in Suzhou, China [16], which was an interesting finding, but the sample was small. Insufficient HIV/AIDS awareness may hinder the HIV testing uptake. University students with comprehensive sexual education and HIV/AIDS knowledge were more likely to test HIV [10, 17]. To enhance HIV/sexual health literacy, Chinese universities must implement standardized prevention education upon matriculation, as mandated by the Joint HIV Prevention Guidelines of the Ministry of Education and Ministry of Health [18]. However, an existing study indicates that low actual HIV testing rates [19], potentially due to the inconsistency between students' testing preferences and available services. Previous international research indicates that suboptimal HIV test uptake may be partially due to HIV testing service preferences that are misaligned with existing service options [20]. HIV testing services must be tailored to the preferences of those at risk, particularly underserved university students.

Discrete choice experiments (DCEs) allow systematic evaluation of attribute trade-offs and preference intensities, optimize resource allocation, and provide evidence-based policy insights [21]. In the field of HIV infection and sexual health, DCEs are becoming an important research method to obtain data on population preferences for HIV-related services, especially in HIV testing and prevention preference studies [22–24]. To investigate how undergraduates make trade-offs across various HIV-testing service attributes, we used DCEs to estimate the preferences and relative importance of the attributes of HIV testing.

Our study aims to assess undergraduates' preferences for HIV testing services in Wuhan, a city with the largest number of students and the third largest number of universities in China. We chose undergraduates as the respondents mainly for two reasons. First, compared with master's and doctoral students, undergraduates were more malleable in terms of attitudes and knowledge. Their less-developed cognitive frameworks made them more amenable to new knowledge, especially in the context of HIV prevention. Second, undergraduates accounted for a large proportion of the entire

university student population. Hence, their preferences for HIV testing services were highly representative and of great reference value for HIV prevention and control among the university student group. The results of this study can guide public health policies and HIV testing resource allocation based on Chinese university students' preferences.

Methods

Participants recruitment

In terms of sampling, we utilized a stratified cluster sampling approach. There are two categories of universities in China: national (funded by the central government) and provincial universities (funded by provincial governments) [25]. We chose three national universities and three provincial universities in Wuhan. This stratification framework guided our cluster sampling of universities in Wuhan. To ensure the sample's comprehensive representativeness, we ultimately recruited undergraduates from different majors in three national universities and three provincial universities in Wuhan. The inclusion criteria for respondents were as follows: (a) undergraduates enrolled in universities in Wuhan; (b) no severe physical diseases, mental illnesses, or cognitive impairments; (c) capacity to accurately understand questions, make appropriate choices and independently complete the questionnaire; (d) provision of informed consent and willingness to participate voluntarily.

In the initial phase of the survey, we reached out to ten universities across Wuhan. After concerted efforts, we secured the approval and collaboration of certain college-level leaders from six of those universities. We solicited the assistance of faculty members in charge of student affairs within the respective colleges. We posted recruitment notices and informed consent forms in college WeChat groups via WeChat, a Chinese multi-purpose messaging app. (In China, all students join online groups upon enrollment for better teacher-student communication and information dissemination). Undergraduates who volunteered to participate in this study were then added to a dedicated WeChat group, which was created specifically for the dissemination of information related to this research. Researchers of this study joined the WeChat group to later post questionnaire-filling guidelines and e-questionnaire QR codes. After giving informed consent and understanding the filling instructions, participants filled out the questionnaire by scanning the QR code. This survey had obtained ethical approval from the Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology(No. [2022] Lunshen Zi (S187)).

Purpose and rationale

Based on the random utility theory, DCEs have strong theoretical support. It enables participants to choose among hypothetical service scenarios, which vary according to defined attributes and their levels [26]. This method can figure out the preference trade-offs individuals make among the attributes of goods or services being described [27]. We utilized the DCE approach to understand undergraduates' preference for HIV-related options.

Defining attributes and attribute levels

Qualitative methods were employed to identify attributes and their corresponding levels in the study. Initially, these were derived from a literature review and relevant Chinese HIV prevention and control policy documents. Subsequently, two rounds of expert consultation (Supplementary Material 1) and a pre-survey were carried out to refine them. After reviewing literature [28–35] and considering existing policy support, five initial attribute levels were identified: testing location, testing sample, additional services, testing cost and travel time. Subsequently, two HIV policy experts, four health policy experts, and one scholar engaged in other social work were invited to evaluate these attributes. They also provided suggestions for modifying the corresponding attribute levels. Through expert consultation and further literature review, the "travel time" attribute was changed to "minimum travel time", as the impact of different means of transportation on travel time needed to be considered. Considering that HIV self-testing didn't involve travel time to a fixed testing location, "0 min" was added to the level options of the " minimum travel time" attribute. Experts suggested adding the "testing convenience" attribute. However, after literature research and team discussions, we found that testing convenience was overly broad, overlapping with other attributes and hard to distinguish. Thus, it was not incorporated into this study. Table 1 showed final attributes & levels.

Experimental design

In this study, an unlabeled discrete choice experiment was used. It enabled participants to be unaffected by the psychological cues of technical labels, thus better reflecting their true decisions [36]. Our study named choice sets generically as HIV testing service A and B. The generation of choice sets in the discrete choice experiment included full factorial design and partial factorial design. The full factorial design combined all attribute levels to generate all possible service combinations. Full factorial design would generate $4^2*3^3=432$ possible combinations, overloading respondents and reducing compliance. So, we chose partial factorial design to select representative and non-repetitive choice sets.

Table 1 Attribute and level Settings in the DCE

Attributes & definitions	Levels	Level interpretations
Testing location (the place where HIV testing services are provided)	①China CDC	/
	②Qualified medical institutions	Get an HIV test at qualified medical institutions, such as hospitals and community health service centers.
	③Qualified social organizations	Get an HIV test at qualified social organizations, such as NGOs and social groups.
	④Self-testing	Get an HIV testing at home
Testing sample (samples need for initial HIV screening)	①Blood	/
	②Oral fluid	/
	③Urine	/
Additional services (supportive service provided by the HIV testing location)	①Free heath checks	Including screening for other STDs and general health checks.
	②Free distribution of HIV prevention products	Including HIV publicity materials, condoms, etc.
	③Free HIV counseling	Including pre-test, in-test, post- test consults & HIV prevention tips.
	④No additional services	Don't offer extra services
Testing cost (the fee payable for HIV testing services)	①Free	/
	②50CNY	/
	③100CNY	/
Minimum travel time (the shortest time required to reach the testing location)	①0 min	/
	②30 min	/
	③60 min	/

Abbreviation: China CDC: Chinese Center for Disease Control and Prevention; STDs: sexually transmitted diseases

Table 2 Choice set sample

Attribute	HIV Testing Service A	HIV Testing Service B
Testing location	Qualified medical institutions	Qualified medical institutions
Testing sample	Blood	Urine
Additional services	No additional services	Free HIV counseling
Testing cost	50CNY	100CNY
Minimum travel time	60 min	30 min
I choose	◎	◎

Imagine you were offered two HIV testing services back then: HIV Testing Service A and HIV Testing Service B. These services differed in testing location, cost, sample, additional services and minimum travel time. For the following choices, pick the service you'd prefer based on your personal preference. When making your decision, assume that other aspects of the two services were identical, except for the five factors listed

Table 3 Demographic characteristics of the undergraduates ($n=461$)

Characteristics	*n*(%)
Gender	
Male	173(37.5)
Female	288(62.5)
University years	
Freshmen and Sophomores	231(50.1)
Juniors and Seniors	230(49.9)
Place of residence	
Urban	231(50.1)
Rural	230(49.9)
University classification	
National universities	266(57.7)
Provincial universities	195(42.3)
Discipline	
Medical	84(18.2)
Non-medical	377(81.8)
Sexual orientation	
Heterosexuality	362(78.5)
Non-heterosexuality	99(21.5)

In this study, Ngene1.3 software was used for D-efficient design, ultimately generating 16 choice sets. Given that respondents' stress increased with the growth in the number of choice sets, attributes, and attribute levels, reducing response reliability [27]. Thus, we adopted the block design [37]. Sixteen choice sets were randomly and evenly distributed into two questionnaire versions, with each choice set presenting two unlabeled scenarios: HIV Testing Service A and HIV Testing Service B. We also set up a consistency check. After the eight choice sets in each version of the questionnaire, an additional choice set was added, which was identical to the sixth choice set in each version. If a participant's choices for the two choice sets were the same, they passed the consistency check. If different, there was a risk that the participant was answering randomly or didn't understand the discrete choice experiment, thus failing the consistency check. Questionnaires of this kind were eliminated. We applied a forced choice set. When no clear advantage existed, forced choice under uncertainty made the selected option more justifiable, reducing the risk of error and regret [38]. Also, our study did not consider an opt-out option because reducing the burden on participants was crucial in survey research [39]. Although forced choice set without an opt-out option may introduce bias [40], an empirical study showed that minimal divergence between the forced and unforced choice model in DCE outcomes [41]. Table 2 presented an example of a choice set.

Survey design

The questionnaire in this study consisted of three modules. The first part included explanations of the research, its attributes and levels. The second part involved a basic demographic survey (such as gender, major, sexual orientation, etc.). The third part was the DCE section, which included various scenario simulations of undergraduates' preferences for HIV testing. The survey participants were asked to make decisions that maximized utility between

the two options in each choice set under the given situations.

This research determined the sample size based on the Johnson & Orme principle [42].

$$\frac{nta}{c} \geq 500 \quad (1)$$

Where "n" was the recommended minimum sample size, "t" was the number of choice sets, "a" was the number of options in each choice set, and "c" was the maximum number of attribute levels. According to the above formula, the minimum acceptable sample size for this discrete choice experiment (with t = 8, a = 2, c = 4) was 125 people.

Data collection

To ensure the reliability and validity of the survey, we conducted a pre-survey before the formal investigation. Prior to this, all project investigators underwent a day of offline training. We also posted questionnaire filling notes in the relevant WeChat group. Data from this phase wasn't included in the final analysis. During this stage, we mainly addressed cognitive ambiguity issues from participants about filling out the questionnaire. To further verify their understanding of DCE attributes, levels, and filling requirements, we conducted face-to-face interviews with 35 students from a national university (Supplementary Material 2). Meanwhile, we made slight adjustments to some wordings to improve clarity without altering the defined attributes or levels. In the formal survey, we released the improved and more understandable filling instructions for the DCE questionnaire. The instructions contained a hypothetical scenario and explanations of each attribute level's meaning. We also provided the QR code for the e-questionnaire. This ensured that respondents accurately understood the survey content before the DCE, allowing them to make choices in line with their own ideas.

Regarding data management, the data were collected online between March 1st, 2024 and April 30th, 2024 through Wenjuanxing (www.sojump.com), a professional Chinese survey website. All participants accessed the questionnaire by scanning the WeChat QR code. They were able to submit the questionnaire only after finishing all options. All questionnaires were filled out anonymously. Students could complete the questionnaire during their spare study time, which was expected to take about 10 ~ 15 min. Each student received a 5 CNY reward upon finishing the survey as a token of appreciation for their time. After all students had filled it out, the researcher exported all the data for processing and analyses. To avoid duplicates, questionnaires with the same IP address as those previously submitted were not accepted. Those failing the consistency check or having an abnormal completion time (under 5 min or over 30 min) were excluded.

Economic analyses

The data analysis of the DCE was based on the random utility maximization theory [43]. We used Stata 8.0 (Stata Corp, College Station, TX, USA), adopted dummy coding, and constructed a mixed logit model to measure the preference of undergraduates for HIV testing services. The mixed logit model allows parameter values to vary across respondents [44]. For calculation and interpretation ease, we assumed a fixed effect for testing cost [45]. Additionally, we conducted interaction regression to further evaluate the preference heterogeneity, with $P < 0.05$ set as the threshold for assessing significance. In this study, a utility function for undergraduates' selection of HIV testing services was constructed. The dependent variable represented the choice utility of each undergraduate for HIV testing services, while the independent variables represented undergraduates' preferences for each attribute characteristic of HIV testing services. The utility equation was as follows:

$$\begin{aligned} U_i = V_i + \varepsilon_i = \beta_0 + (\beta_{Testing\,location} + \sigma_{1i})\,X_1 \\ + (\beta_{Testing\,cost} + \sigma_{2i})\,X_2 + (\beta_{Testing\,sample} + \sigma_{3i})\,X_3 \\ + (\beta_{Additional\,service} + \sigma_{4i})X_4 + (\beta_{Minimum\,travel\,time} \\ + \sigma_{5i})X_5 + \varepsilon_i \end{aligned} \quad (2)$$

U_i represented the overall utility of a specific HIV testing service for undergraduates i. V_i represented the measurable utility of a particular HIV testing service method described by the attributes included in the DCE. β_0 was the constant. $\beta_{Testing\,location}$, $\beta_{Testing\,cost}$, $\beta_{Testing\,sample}$ $\beta_{Additional\,service}$, $\beta_{Minimum\,travel\,time}$ were regression coefficients. σ_i denoted the random parameter for each service attribute of undergraduate i. ε_i represented the random component of utility, which captured the unobserved variation in service attributes and individual preferences. The selected alternative had a higher total utility than the other alternatives in one set. The distribution simulation was based on 500 iterations of Halton random sampling. Based on effects coding, a positive coefficient indicated undergraduates preferred that attribute level over the mean effect, while a negative coefficient indicated they preferred it less [46]. Meanwhile, we compared the impacts of different attributes on undergraduates' preference for HIV testing services by calculating the relative importance (RI) of non-economic service attributes [47]. The RI of each attribute was derived from its overall utility value (i.e., the differences between the highest and lowest coefficients) divided by the sum of all attributes' utilities [48].

Results

Participants characteristics

A total of 552 undergraduates agreed to participate in this study. However, 91 of them were excluded due to failing the consistency check, having abnormal answering times, or lacking comprehension. Ultimately, 461 questionnaires available for analysis were obtained, with an effective rate of 83.5%. Among the 461 respondents, there were slightly more female undergraduates (62.5%). Most undergraduates were heterosexual (78.5%) and non-medical majors (81.8%). Further demographic characteristics of the undergraduates were presented in Table 3.

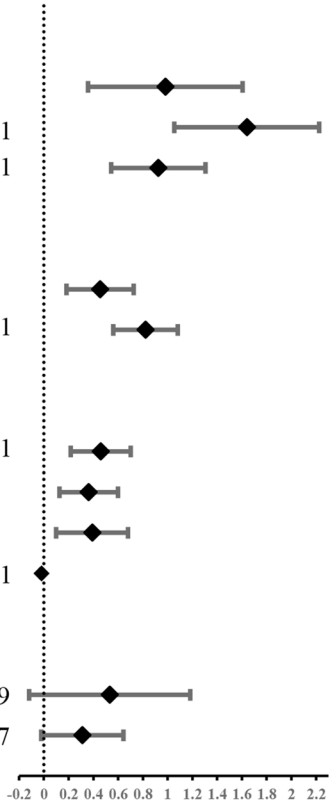
HIV testing preference

Mixed Logit model analysis revealed that among the five HIV testing service attributes in the study, all but the minimum travel time significantly influenced undergraduates' choices of HIV testing services (Table 4). Regarding HIV testing location, undergraduates preferred qualified medical institutions ($\beta = 1.640$, $P < 0.001$), followed by the China CDC ($\beta = 0.982$, $P = 0.002$) and qualified social organizations ($\beta = 0.925$, $P < 0.001$). In terms of testing sample, compared with urine testing, undergraduates exhibited strong preferences for blood testing ($\beta = 0.455$, $P = 0.001$) and oral fluid testing ($\beta = 0.821$, $P < 0.001$). When compared with simple testing without additional services, free health checks emerged as the most significant driving factor for their choice of HIV testing services ($\beta = 0.460$, $P < 0.001$), followed by free HIV counseling ($\beta = 0.390$, $P = 0.009$) and free distribution of HIV prevention products ($\beta = 0.362$, $P = 0.003$). In terms of testing cost, undergraduates were more inclined to free HIV testing services (β=-0.020, $P < 0.001$).

We incorporated service attributes with significant impacts to calculate relative importance coefficients. Among non-monetary service attributes of HIV testing services, undergraduates placed the greatest emphasis on the testing location (58.77%), followed by the testing samples (21.14%) and the additional services (20.09%) (Fig. 1).

Table 4 Estimation of preferences from the mixed logit model

Attribute	*β*	*SE*	*P*	*95%CI*
Testing location				
Self-testing(ref)				
China CDC	0.982	0.319	0.002	0.357~1.606
Qualified medical institutions	1.640	0.299	<0.001	1.054~2.225
Qualified social organizations	0.925	0.194	<0.001	0.544~1.306
Testing sample				
Urine(ref)				
Blood	0.455	0.138	0.001	0.183~0.726
Oral fluid	0.821	0.133	<0.001	0.561~1.082
Additional services				
No additional services (ref)				
Free heath checks	0.460	0.124	<0.001	0.217~0.702
Free distribution of HIV prevention products	0.362	0.121	0.003	0.126~0.599
Free HIV counseling	0.390	0.148	0.009	0.099~0.680
Testing cost	-0.020	0.002	<0.001	-0.024~-0.016
Minimum travel time				
60min(ref)				
0min	0.532	0.332	0.109	-0.119~1.183
30min	0.311	0.170	0.067	-0.021~0.643
Observations		7376		
AIC		4163.308		
BIC		4239.271		
Log likelihood		-2070.654		
LR chi-square value		309.680		



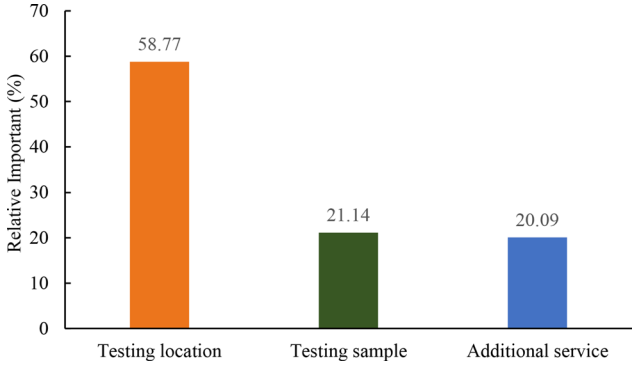


Fig. 1 Relative importance of service attributes

Heterogeneity analyses

Table 5 constructed an interaction effect model between characteristic variables and attributes. Compared with male, female undergraduates valued additional services of free health checks more ($\beta = 0.860$, $P < 0.001$) (Table 5 Model 1). Relative to juniors and seniors, freshmen and sophomore preferred qualified social organizations for HIV testing ($\beta = 0.746$, $P = 0.004$) and valued the access of the additional service of free HIV counseling ($\beta = 0.700$, $P = 0.005$) (Table 5 Model 2). Compared to heterosexual undergraduates, non-heterosexual (such as homosexual and bisexual) undergraduates were more predisposed to receiving the additional services of free health checks ($\beta = 0.583$, $P = 0.022$) (Table 5 Model 3).

Discussion

As the backbone of future social development, the health condition of undergraduates is of utmost importance. In recent years, university students have gradually become a high-risk group for HIV infection. To enhance university students' HIV prevention knowledge, China mandated HIV prevention education in all universities in 2015 [18]. However, their HIV testing rates remain relatively low [49]. Understanding undergraduates' preferences for HIV testing and optimizing services to align with these preferences can help increase their HIV testing rates. This study aims to identify undergraduates' HIV-testing preferences. We found that, apart from minimum travel time, testing location, testing sample, additional services, and testing cost all influenced undergraduates' preferences for HIV testing. They preferred qualified medical institutions for HIV testing, favored oral fluid for sample collection, and regarded free health checks provided with HIV testing as the key driver of their choice. Additionally, they strongly preferred free testing. These findings provide valuable insights for universities, hospitals and the China CDC to allocate resources precisely and efficiently.

Overall, our findings demonstrated both consistencies and discrepancies with prior research in certain aspects. Regarding testing locations, undergraduates preferred qualified medical institutions for HIV testing, like the findings of a study in Yunnan Province, China, which may reflect the undergraduates' perceptions that hospitals have more professionals and better medical resources [50]. In contrast, a study conducted in South Africa

Table 5 Preference heterogeneity of different demographic characteristics

Interaction terms	Model 1 Gender: female (ref: male)		Model 2 University years: Freshmen and sophomores (ref: juniors and seniors)		Model 3 Sexual orientation: Non-heterosexuality (ref: Heterosexuality)	
	Mean	SE	Mean	SE	Mean	SE
Testing location						
China CDC	-0.078	0.327	-0.133	0.260	0.357	0.324
Qualified medical institutions	0.032	0.305	0.444	0.246	0.569	0.309
Qualified social organizations.	-0.426	0.319	0.746**	0.256	0.377	0.317
Testing sample						
Blood	0.179	0.331	0.130	0.272	-0.183	0.361
Oral fluid	0.228	0.202	0.086	0.174	0.411	0.239
Additional services						
Free heath checks	0.860***	0.246	0.272	0.202	0.583*	0.254
Free distribution of HIV prevention products	0.429	0.247	0.224	0.204	0.001	0.254
Free HIV counseling	0.300	0.289	0.700**	0.251	0.204	0.299
Testing cost	-0.003	0.003	-0.001	0.002	-0.004	0.003
Observations	7376		7376		7376	
AIC	4270.463		4261.112		4302.814	
BIC	4394.766		4385.414		4427.117	
Log likelihood	-2118.232		-2112.556		-2133.407	
LR chi-square value	203.160, $P < 0.001$		188.960, $P < 0.001$		182.110, $P < 0.001$	

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

revealed that participants preferred HIV self-testing over a healthcare provider test, likely due to convenience considerations [23]. The reason for the inconsistent results might be the different samples. Undergraduates pay more attention to the professionalism of the testing process and the reliability of the results. Concerning testing sample, we found participants preferred oral fluid, whereas research in Tanzania revealed over two-thirds disliked oral sampling for HIV testing, primarily citing a lack of familiarity with oral test kits and insufficient information about their accuracy [51]. On additional services, undergraduates favored HIV testing accompanied by additional services (e.g., free health checks, free HIV counseling), consistent with the prior study that participants preferred HIV testing in which support services were available [50]. Similarly, a Tanzanian study revealed that integration of a general health check or an examination for sexually transmitted infections (STI) with HIV testing may increase the appeal of HIV testing offers to high-risk populations [52]. It is important to emphasize the provision of additional services in HIV testing. For testing cost, free HIV testing was preferred, consistent with existing research [53]. In addition, our study found that minimum travel time didn't influence undergraduates' preferences for HIV testing, which was different from other studies [54]. This might be because undergraduates' diverse and wide-ranging daily activities (e.g., weekend outings) reduce their sensitivity to travel time. In addition, lots of HIV testing preferences studies were conducted in African regions like Tanzania and South Africa, but we found few similar studies in Asian areas. Hence, our study provides empirical references for Asian countries.

We found that the testing location was the most important attribute when undergraduates chose HIV testing services. This attribute, encompassing convenience and professionalism, jointly influenced their decisions based on personal preferences. Our results indicated that undergraduates showed strong preferences for qualified medical institutions for HIV testing relative to other places. This might be because they were most concerned about testing accuracy and standardization, which qualified medical institutions could offer. Despite the ease and convenience of HIV self-testing [55], it carries risks of false results compared to testing performed by qualified medical institutions [56, 57]. Undergraduates probably placed greater trust in the procedures that were carried out by professional nursing staff and their services, anticipating more scientifically rigorous results [58]. Therefore, qualified medical institutions could regularly train campus clinic doctors and establish partnerships. This would enable campus clinics to send samples to qualified medical institutions for accurate analysis. Such an arrangement could enhance the credibility of on-campus testing services, potentially increasing undergraduates' participation in HIV testing in the future.

Testing sample was one of the attributes that undergraduates paid more attention to. Compared with urine testing, we found that undergraduates preferred oral fluid testing, followed by blood testing. This preference had been attributed to operational convenience and testing accuracy. Compared to blood and oral fluid testing, urine testing required undergraduates to find a suitable sampling spot themselves, causing inconvenience. Blood testing mainly included venous blood collection and fingertip blood collection [28], and recipients typically considered that blood testing possessed high sensitivity and specificity [51]. Oral fluid was more convenient for users and might have increased the frequency of testing [59]. Some studies indicated that the accuracy of oral fluid was lower than that of blood tests [60], but they still maintained relatively good accuracy [61]. Furthermore, compared to blood testing, oral fluid was non-invasive. The aforementioned reasons might explain why undergraduates preferred oral fluid testing the most. Thus, blood and oral fluid testing could be popularized, and oral fluid testing might be launched in campus clinics to enhance undergraduates' uptake of HIV testing services.

There are many free HIV testing services available in China. To strengthen HIV prevention and control, the *Chinese Regulations on HIV/AIDS Prevention and Control (2006)* established the "Four Frees and One Care" policy [62]. The four frees includes: free antiretroviral drugs for low-income HIV patients; free counseling and testing; waived school fees for orphans of AIDS patients; free prenatal HIV counseling, screening, and treatment for pregnant women. In our study, undergraduates preferred HIV testing additional services with free health checks, followed by free HIV counseling services and free distribution of HIV prevention products. This might have been related to undergraduates' concerns about their own health, need for psychological security, and the pursuit of convenience. A study showed that higher education had a positive effect on health and healthy behaviors [63]. Based on this, it could be reasonably inferred that undergraduates tended to exhibit a higher level of concern for their own health. HIV testing with free health checks could provide undergraduates with opportunities for comprehensive health assessment, which might have been of great attraction to them. Free health checks could be added to HIV testing services in the future to further address their needs. As a rather special and serious infectious disease, HIV induced fear and stigma among many college students, which hindered them from getting tested for HIV [64, 65]. Free HIV counseling services could specifically address their concerns, offer psychological support, and dispel their psychological fears and stigmas. Other studies also demonstrated the importance of

providing supportive HIV counseling services [66]. Furthermore, the comprehensive HIV testing services that offered the free distribution of HIV prevention products enhanced convenience by eliminating the need to visit multiple locations for purchases. The aforementioned findings reflect the specific demands of undergraduates regarding HIV testing and carried great significance for HIV prevention and control endeavors in universities.

We found that undergraduates were quite sensitive to testing costs. They were more inclined towards free HIV testing services, which was consistent with the results of existing research [32, 67]. This could be related to undergraduates' incomplete financial independence. For most undergraduates, their primary source of income was family support. The amount was limited and needed careful planning. They had to pay tuition fees and meet daily living expenses, so they were under certain financial stress [68]. HIV testing services were non-essential for daily life, and extra testing fees might have added to their financial burden. Free HIV testing services could meet their testing needs without adding economic burden, fitting their pursuit of high cost-performance. In addition, numerous studies showed that financial incentives could effectively motivate individuals to access HIV testing services [69–71]. The above findings suggested that the government could appropriately provide financial subsidies to institutions qualified for HIV testing to help reduce the cost of HIV testing. Additionally, establishing certain incentive mechanisms could boost undergraduates' demand for HIV testing services.

To help policymakers better design HIV testing services schemes that satisfy undergraduates' needs, we explored preference heterogeneity. We identified several factors influencing undergraduates' choices according to their demographic features, all of which centered on additional services attribute. This suggested that policymakers must prioritize and thoroughly consider undergraduates' preferences for additional services when formulating HIV testing strategies. First, compared with males, females were more inclined to receive the additional services of free health checks. This might have been related to female's greater emphasis on the comprehensiveness of health management and specific social role expectations. Females had higher overall health literacy than males [72]. Through physical examinations, they could comprehensively understand their physical conditions, meeting their needs for overall health maintenance. In social role expectations, females were assigned the specific role of family health advocates [73]. This might be the reason why females prefer to receive the additional services of free health checks more than males.

Second, undergraduates in lower grades were more prone to the additional service of free HIV counseling. This might have been because students in lower grades had less knowledge of HIV-related information compared with those in higher grades [74]. As a result, they were more likely to seek professional HIV counseling services for accurate information and guidance. Moreover, a number of existing studies had shown that college students had inadequate HIV knowledge [75–78]. Considering the results of our study, universities could promote HIV knowledge among undergraduates via lectures and courses.

Finally, non-heterosexual undergraduates were more prone to obtaining the additional services of free health checks. This difference in behavioral preferences might be because the non-heterosexual population has a higher likelihood of contracting sexually transmitted infections (STIs). Non-heterosexual population (including lesbian, gay, bisexual, and other subgroups) face higher risks of STIs [11, 79]. These risks might have driven them to seek preventive and comprehensive free health check services more proactively, so as to detect and handle potential health problems promptly.

This study had significant strengths alongside some limitations. Firstly, by selecting undergraduates in Wuhan, a city densely concentration of Chinese universities, we identified representative preferences for HIV testing services. These findings offer critical insights for public health policy design. Secondly, the methodologically rigorous application of the DCE revealed undergraduates' preferences for HIV testing services and identified preference heterogeneity. Thirdly, the research identified practically valuable preferences that inform policymakers in designing HIV testing plans, facilitate efficient resource allocation, and provide insights for university HIV prevention. Our study also had limitations. Firstly, the five service attributes analyzed (primarily derived from literature reviews and expert consultations) may have overlooked other influential factors. Secondly, although prior studies indicate strong correlations between stated and actual preferences [80], the hypothetical DCE scenarios might not fully reflect real-world decisions. Finally, there might be social desirability bias, as participants might have reported heterosexual orientation to align with social acceptability when choosing sexual orientation, impacting subsequent preference results. However, the survey's anonymity and completion during participants' free time likely mitigated such bias.

Conclusion

Testing location was the most important non-monetary attribute in HIV testing services, followed by testing sample and additional service. Thus, these attributes should be prioritized when formulating HIV policies. In addition, undergraduates preferred qualified medical institutions, oral fluid testing, and free health checks additional services for HIV testing. Thus, in the future, qualified

medical institutions could regularly train campus doctors and establish partnerships to address undergraduates' needs and promote their participation in HIV testing. Furthermore, this study included analyses of preference heterogeneity, offering valuable insights for policy formulation.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

Hangjing Zhang and Juyang Xiong designed the study, led the design and analysis of the discrete choice experiment. Hangjing Zhang, Juyang Xiong and Xuan Zhu contributed to the literature search and analysis. Hangjing Zhang, Juyang Xiong and Xuan Zhu designed the questionnaire and analyzed the data. Hangjing Zhang drafted the first manuscript, and all other authors revised the manuscript. All authors read and approved the final manuscript.

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Data availability

Original datasets will be available upon reasonable request to the corresponding author.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology (No. [2022] No. Lunshen Zi (S187)) in compliance with the Declaration of Helsinki. All participants provided informed consent at the beginning of the online survey. Participants were only allowed to proceed with the survey if they consented.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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