Young adults' intention to encourage COVID-19 vaccination among their grandparents: A nationwide cross-sectional survey of college students in China

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ABSTRACT

Background: During a vaccination plateau phase, traditional vaccination promotion strategies such as the mobilization of government and community appear to have limited impact on expanding the coverage. New strategies to promote vaccination are needed especially in older adults. Our study aimed to assess college students' intention to encourage coronavirus disease 2019 (COVID-19) vaccination among their grandparents and its correlates.

Methods: A cross-sectional survey was conducted in China from May to June 2022. We collected information on socio-demographics of college students and their grandparents, constructs of health belief model (HBM) and theory of planned behavior (TPB) for college students, and college students' intention to encourage COVID-19 vaccination among their grandparents. Multilevel logistic regression models were performed to assess correlates of intention.

Results: We enrolled 2681 college students who reported information for 6302 grandparents. 2272 students (84.7 %) intended to encourage COVID-19 vaccination for 4744 (75.3 %) grandparents. Intention was associated with having received a booster dose of COVID-19 vaccine (AOR 3.28, 95 % CI 1.68–6.42), having ever lived with their grandparents (2.07, 1.46–2.93), and having grandparents who regularly went outdoors (2.85, 1.70–4.76). HBM and TPB models showed that college students who had higher levels of perceived susceptibility (1.79, 1.12–2.87), perceived severity (1.52, 1.12–2.06) of COVID-19 among their grandparents, and higher levels of subjective norms (2.88, 1.61–5.15) were more likely to have the intention.

Conclusion: College students' intention to encourage COVID-19 vaccination among their grandparents was high. It may be potentially viable to engage college students in promoting COVID-19 and other routine vaccination among older adults.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic continues to challenge global health, significantly affecting older adults due to their increased susceptibility and higher risk of severe disease [1–4]. In the Omicron wave in Hong Kong in 2022, the deaths of adults aged 60 and older due to COVID-19 accounted for 96 % of the death toll [5]. As an aging country with 265 million people aged over 60 [6], China faces critical challenges in controlling COVID-19 spread among this vulnerable group.

COVID-19 vaccination is an important strategy to control the COVID-19 pandemic among older adults. COVID-19 vaccines can effectively reduce the risk of severe illness, hospitalization, and death caused by COVID-19 among older adults [7]. Real-world data from the Omicron

wave in Hong Kong in 2022 show that three doses of CoronaVac vaccines are over 95 % effective against the most severe or fatal outcomes of COVID-19 in older adults [8]. Given older adults' relatively weaker immune function [2], COVID-19 vaccination becomes evident and urgent to fortify the protective shield for older adults. Quick and concerted vaccination programs are implemented by governments globally, older adults are the first priority group to be vaccinated. China began older -adults' COVID-19 vaccination in April 2021 [3]. As of November 28, 2022, 86.4 % of older adults were fully vaccinated, and 68.7 % had received a booster shot [9], which was lower than that in other countries such as the United States (92.1 %, 70.7 %) and Japan (92.4 %, 90.3 %) [3]. The coverage of COVID-19 full and booster vaccination among older adults still needs to be improved. In addition, with changes in measures to prevent and control the COVID epidemic in China, it is urgent to strengthen the vaccination of older adults.

Family members, especially descendants, offer important social support for older adults [10,11]. Older adults in China are more trusted in COVID-19 vaccination information from their relatives [12]. The Chinese government also encourages family members to assist older adults to receive COVID-19 vaccination [13]. A cross-sectional study conducted in China found that 60.21 % of older adults would like to get COVID-19 vaccination with the recommendation of their children or grandchildren, which ranked only second to the national appeal [14]. In China, many older adults developed strong bonds with their grandchildren through intergenerational interaction, i.e. grandparents passing on their knowledge to grandchildren [15], which is valuable and can have a lasting impact on both generations [16]. As grandchildren who have received high education and have better access to media sources [17], college students may receive and then transfer COVID-19 messaging to their grandparents and play a unique role in encouraging COVID-19 vaccination among their elderly family members. College students may also be able to leverage intergenerational bonds and trust to assuage fears and convince otherwise hesitant grandparents to receive vaccination. There are 55.3 million college students in China [18,19], so the potential role of college students can not be underestimated.

Health Belief Model (HBM) serves as an important theoretical framework in predicting an individual's engagement in preventive health behaviors, such as vaccinations [20]. Key components of the HBM include perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and cues to action [20]. Additionally, theory of planned behavior (TPB) is another influential model explaining individual health behavior [21]. It posits that a person's intention to engage in a particular behavior is determined by three core constructs, namely attitudes, subjective norms, and perceived behavioral control (PBC) [21,22]. HBM and TPB have been extensively used to predict people's intention to take vaccines [23]. In the context of college students' intention to encourage COVID-19 vaccination among their grandparents, HBM and TPB were used to explore the motives of college students' willingness to encourage COVID-19 vaccination among their grandparents and investigate the reasons behind their unwillingness.

There remains a lack of research regarding college students' influence on COVID-19 vaccination uptake among older adults. Our study aimed to assess college students' intention to encourage COVID-19 vaccination among their grandparents and investigate factors associated with their intention.

Methods

Study design and participants

An anonymous online survey was conducted using an electronic questionnaire from 18 May to 17 June 2022 in China. The questionnaire was set up via "Wenjuanxing" (a Chinese online platform providing survey functions), evaluated by 3 experts and revised based on a pre-survey conducted among college students in Shenzhen, China. Convenience sampling and snowball sampling were applied in this study.

College students distributed the questionnaire via their social network including WeChat and QQ (two of the most popular instant messaging platforms in China) using posters. Interested college students could access the online questionnaire through the QR code on the posters and share it with other college students. This cross-sectional survey is the part of a cross-sectional and experimental study, which aimed to investigate college students' willingness to encourage their grandparents to get a COVID-19 vaccination and examine the impact of their encouragement. The protocol of this study has been previously published [24].

College students (junior college students, undergraduate students, graduate students) who meet the following criteria were eligible: (1) aged 16 years or older; (2) had at least one living grandparent aged 60 years or older. College students were excluded if they: (1) submitted the questionnaire within 120 s; 2) failed to correctly answer the quality-control questions in the questionnaire; 3) reported that all grandparents had received a COVID-19 booster dose. Grandparents of eligible college students were also included, unless they were (1) under the age of 60 or (2) had taken a COVID-19 booster dose.

Questionnaire

A structured questionnaire was formulated and used to collect data from college students and their grandparents. College students obtained their grandparents' information via phone calls or face-to-face communication, and completed the questionnaire entirely. The questionnaire consisted of two parts with 55 items (some items were conditionally displayed based on responses to other items) (Fig. 1). Part one contained college students' socio-demographic characteristics and HBM and TPB constructs. Part two was about the socio-demographic characteristics and health-related characteristics of each grandparent. The items of HBM and TPB were adopted with modification from previous studies which assessed acceptance of COVID-19 vaccine among the general population [21,25]. Several quality-control questions were also included to ensure response validity. Additionally, the same IP address was restricted to accessing the questionnaire only once to recruit different participants.

The dependent variable was college students' intention to encourage COVID-19 vaccination among their grandparents, measured by the item "Would you like to encourage COVID-19 vaccination for your grandfather/grandmother?" (No, or Yes). In this item, college students were asked to report their intention to encourage COVID-19 vaccination for each of their grandparents.

The independent variables were grouped into five blocks:

(1) College students' socio-demographics: gender, age, ethnicity, educational background, major, the status of COVID-19 booster dose vaccination, and attention to news of COVID-19 vaccination for older adults.

(2) College students' knowledge of COVID-19 and COVID-19 vaccination in older adults included 7 items on a 5-point scale (from "1 = strongly disagree" to "5 = strongly agree"). The variable was transformed to categorical (No, Yes), with a score ≤ 26 as no (determined by restricted cubic spline).

(3) HBM predictor variables (Table 1): perceived susceptibility (included 2 items, Cronbach α = 0.77), perceived severity (included 3 items, Cronbach α = 0.81), perceived benefits (included 2 items, Cronbach α = 0.82), perceived barriers (included 1 item) and cues to action (included 3 items, Cronbach α = 0.81).

(4) TPB predictor variables (Table 1): attitude (included 1 item), subjective norms (included 3 items, Cronbach α = 0.76), and PBC (included 1 item).

(5) Grandparents' socio-demographics: gender, age, educational background, type of residence, cohabitation history with grandchildren (living together for one year or more), living conditions,
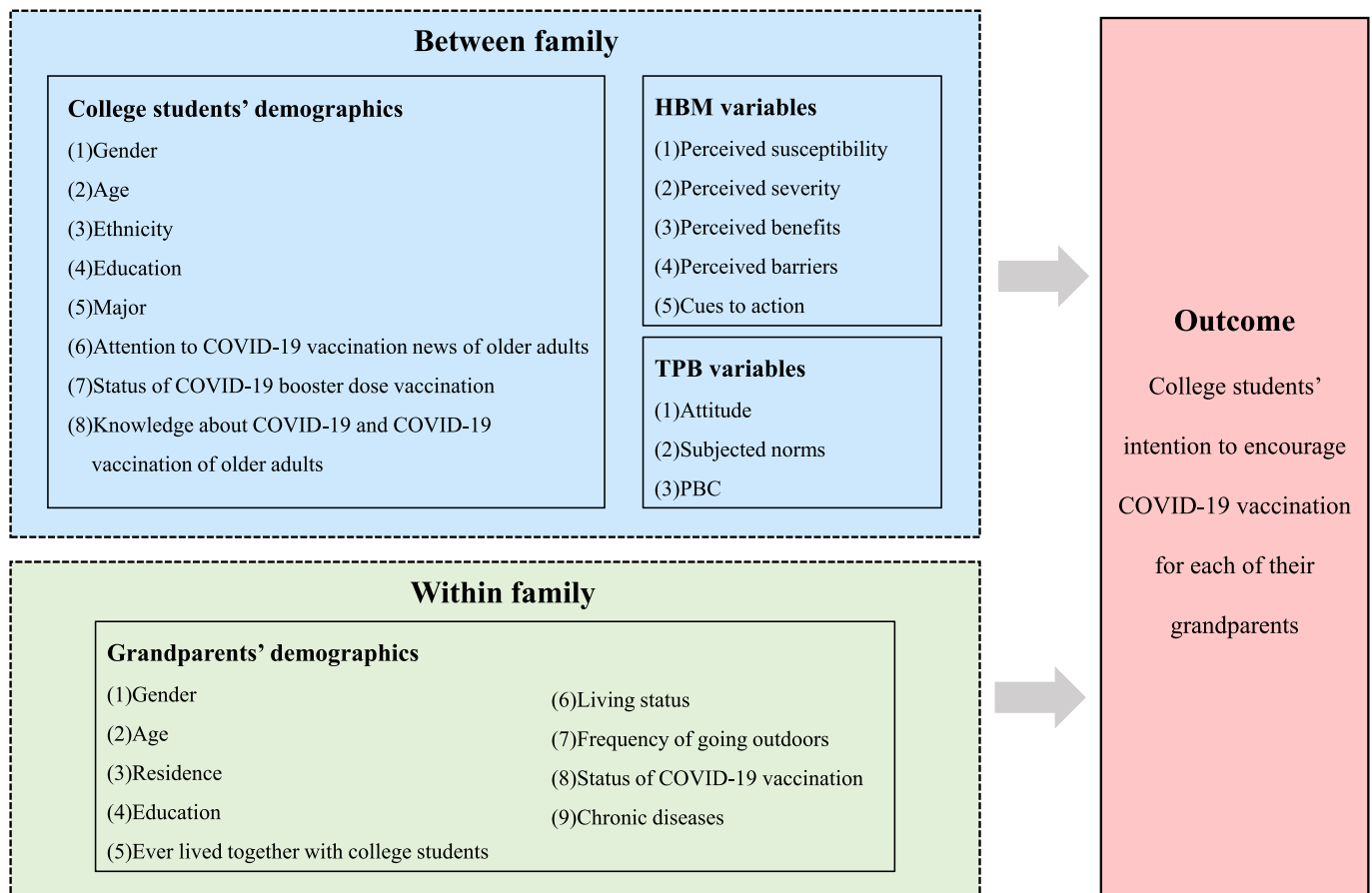
Fig. 1. Conceptual framework for the multilevel predictors of college students' intention to promote COVID-19 vaccination among their grandparents. HBM: health belief model; TPB: theory of planned behavior; PBC: perception of behavioral control.

frequency of going outdoors, the status of COVID-19 vaccination, and chronic disease (having one or more of the following: cardiovascular diseases, diabetes mellitus, tumor, chronic respiratory diseases, liver cirrhosis, chronic renal failure, nervous system diseases, and mental disease).

Items in the HBM and TPB were measured on a 1–5 scale (from "1 = strongly disagree" to "5 = strongly agree"). The items of perceived severity and cues to action were reverse-scored. Scores of the HBM- and TPB-independent categories were the mean scores of their included items.

Statistical analysis

Descriptive statistics (frequencies, percentages, averages, and standard deviations) were used to describe the characteristics of college students and their grandparents. Cronbach's α test was applied to test the reliability of HBM and TPB measures. Variance inflation factor analysis was used to analyse the collinearity of variables and showed no collinearity among the variables.

Considering that older adults were nested in families, the condition that all participants are independent, as required for general logistic regression, does not hold. Thus, multilevel logistic regression models were applied, allowing analysts to account for the clustered nature of the data [26]. Assuming that each college student had a different intercept, we applied random intercept, fixed slop models to investigate factors associated with college students' intention to encourage COVID-19 vaccination among their grandparents. HBM and TPB constructs were grand-mean centered to facilitate the interpretation of some estimates. The fixed effects were reported as adjusted odds ratio (AOR) while

random effects were reported by variance, intraclass correlation (ICC). The Akaike's information criterion (AIC) was used to determine the goodness of fit.

Two-sided *P* values < 0.05 were considered statistically significant. All analyses were performed using R (V. 4.2.1, Foundation for Statistical Computing, Vienna, Austria).

Ethics approval

The study involves human participants and was approved by the Ethics Committee of the School of Public Health (Shenzhen), Sun Yat-sen University (Approval number: SYSU-PHS-2022025). Electronic informed consent was obtained from all participants before commencing the survey.

Results

Participants' characteristics

Fig. 2 shows the inclusion flowchart of the study population. A total of 4452 questionnaires were collected over the study period. After quality control, a total of 2681 college students and 6302 grandparents were included in the analysis. On average, each college student had 2.35 living grandparents who met the study criteria.

Characteristics of participants are presented in Table 2. The majority of college students were female (64.4 %), 16–25 years old (91.7 %), junior college or undergraduate students (90.3 %), and had received a COVID-19 booster dose (78.2 %). More than half of grandparents were women (55.3 %), 70–79 years old (50.8 %), living in rural (65.7 %), had an education of primary school and below (59.2 %), and ever lived

Table 1

Items, response scales and internal consistency for assessing measures of the two theoretical behavior models: HBM and TPB.

Items	Mean (SD)	α
HBM		
Perceived susceptibility		0.77
If I don't persuade, the risk of infection will be higher for my grandparents who have not received COVID-19 vaccine.	3.88 (0.89)	
If I don't persuade, the risk of severe or death will be higher for my grandparents who have not received COVID-19 vaccine.	4.10 (0.78)	
Perceived severity		0.81
Even if my grandparents are infected with COVID-19, I don't think it will cause serious health damage to them.	3.78 (1.25)	
Even if my grandparents are infected with COVID-19, I believe there is a high probability of recovery.	3.11 (1.15)	
Even if my grandparents are infected with COVID-19, I don't think it will cause too much family burden.	3.37 (1.18)	
Perceived benefits		0.82
I believe COVID-19 vaccine can effectively prevent my grandparents from infection of COVID-19.	3.94 (0.80)	
I believe COVID-19 vaccine can effectively prevent my grandparents from severe or death if infected with COVID-19.	4.02 (0.75)	
Perceived barriers		–
Persuading grandparents to receive COVID-19 vaccine requires a lot of time to communicate.	3.42 (1.04)	
Cues to action		0.81
Only with professional's guidance in health education will I persuade my grandparents to receive COVID-19 vaccine.	2.80 (1.15)	
Only when I have friends infected with COVID-19 will I persuade my grandparents to receive COVID-19 vaccine.	3.46 (1.20)	
Only when the government promotes COVID-19 vaccination will I persuade my grandparents to receive COVID-19 vaccine.	3.25 (1.18)	
TPB		
Attitude		–
Persuading my grandparents to receive COVID-19 vaccine is a tedious process that requires time and effort.	3.13 (1.08)	
Subjective norms		0.76
Persuading my grandparents to receive COVID-19 vaccine is a sign of filial piety.	3.55 (0.94)	
Persuading my grandparents to receive COVID-19 vaccine is a sign of shouldering social responsibility.	3.80 (0.79)	
Most of my friends will also persuade their grandparents to receive COVID-19 vaccine.	3.95 (0.79)	
PBC		
I believe I can successfully persuade my grandparents to receive COVID-19 vaccine.	3.93 (0.78)	–

HBM: health belief model.
TPB: theory of planned behavior.
PBC: perception of behavioral control.
Cronbach's α indicates the internal consistency: HBM α = 0.77, TPB α = 0.69.

together with college students (59.2 %). 49.5 % of older adults had chronic diseases, and 25.4 % did not get a booster dose of COVID-19 vaccine.

Model applicability evaluation

Three models were constructed to evaluate the applicability of HBM and TPB. In addition to the variables for college students and their grandparents, we included the HBM constructs in model 1, the TPB constructs in model 2, and the HBM and TPB constructs in model 3, respectively. The AIC of the three models were 5207.4, 5208.1, and 5194.2, respectively (Table 3). According to the AIC, the best model fit was Model 3. Hence, we decided to include the HBM and TPB in the multilevel logistic regression model.

Factors associated with intention to encourage COVID-19 vaccination among grandparents

In our study, 2272 college students (84.7 %) intended to encourage COVID-19 vaccination for 4744 (75.3 %) grandparents. The results of multilevel logistic regression were shown in Table 3. At the within-family level, college students were more likely to have the intention to encourage COVID-19 vaccination among their grandparents who ever lived with college students (AOR: 2.07, 95 % CI: 1.46–2.93), and usually went outdoors (2.85, 1.70–4.76). Meanwhile, compared with grandparents who did not receive COVID-19 vaccines, college students were more likely to have the intention to encourage COVID-19 vaccination among their grandparents whose status of COVID-19 vaccination were unclear (3.78, 2.14–6.68). College students were less likely to have the intention to encourage COVID-19 vaccination among their grandparents who were female (0.78, 0.61–0.99), and whose condition of chronic diseases were unclear (0.55, 0.33–0.92).

At the between-family level, intention was associated with being female (1.77, 1.01–3.11) and having received a booster dose of COVID-19 vaccination (3.28, 1.68–6.42). From the constructs of HBM, college students who thought their grandparents were more susceptible to COVID-19 (1.79, 1.12–2.87), and the infection of COVID-19 would induce severe consequences to their grandparents (1.52, 1.12–2.06) were more likely to have the intention to encourage COVID-19 vaccination among their grandparents. From the constructs of TPB, college students who reported stronger subjective norms (2.88, 1.61–5.15) were more likely to have the intention.

Discussion

To the best of our knowledge, this is the first study to investigate grown-up grandchildren's intention to encourage COVID-19 vaccination among their grandparents. In our study, most of the college students intended to encourage their grandparents to get vaccinated, particularly those who had received a booster dose of the COVID-19 vaccine. College students' intention was positively associated with higher levels of perceived susceptibility and perceived severity of COVID-19 among their grandparents, subjective norms, and cohabitation history with grandparents.

College students' intention to encourage COVID-19 vaccination among their grandparents was high (84.7 %), reflecting strong intergenerational bonds. A similar study based on intergenerational bonds in the United States found that 55 % of parents were likely to have their children get COVID-19 vaccination in 2021 [27]. This rate is lower than the intention among college students in our study. This may be due to the time of the survey and the cultural difference. Our survey was conducted in 2022, a period when more comprehensive information about the safety and effectiveness of COVID-19 vaccines had become widely available. College students who have several grandparents may be alert to this information and access due information, resulting in positive perceptions. Meanwhile, there is a strong tradition of filial responsibility and reverence for older adults in China, which could enhance the propensity of college students to prioritize the health of their grandparents. College students usually have intimate relationships with their grandparents, as over half of college students in our study had ever lived with their grandparents and were aware of their grandparents' health conditions. They may have a high perception of the importance of COVID-19 vaccination among older adults. Given college students' high intention of encouragement, and older adults' trust in college students' recommendation [12], it may be an effective strategy to encourage college students to encourage COVID-19 vaccination among older adults.

At the within-family level, we found that college students were more likely to encourage their grandparents who usually went outdoors to get COVID-19 vaccination. This may be because older adults who usually go outdoors have a higher risk of being infected. Cohabitation history with
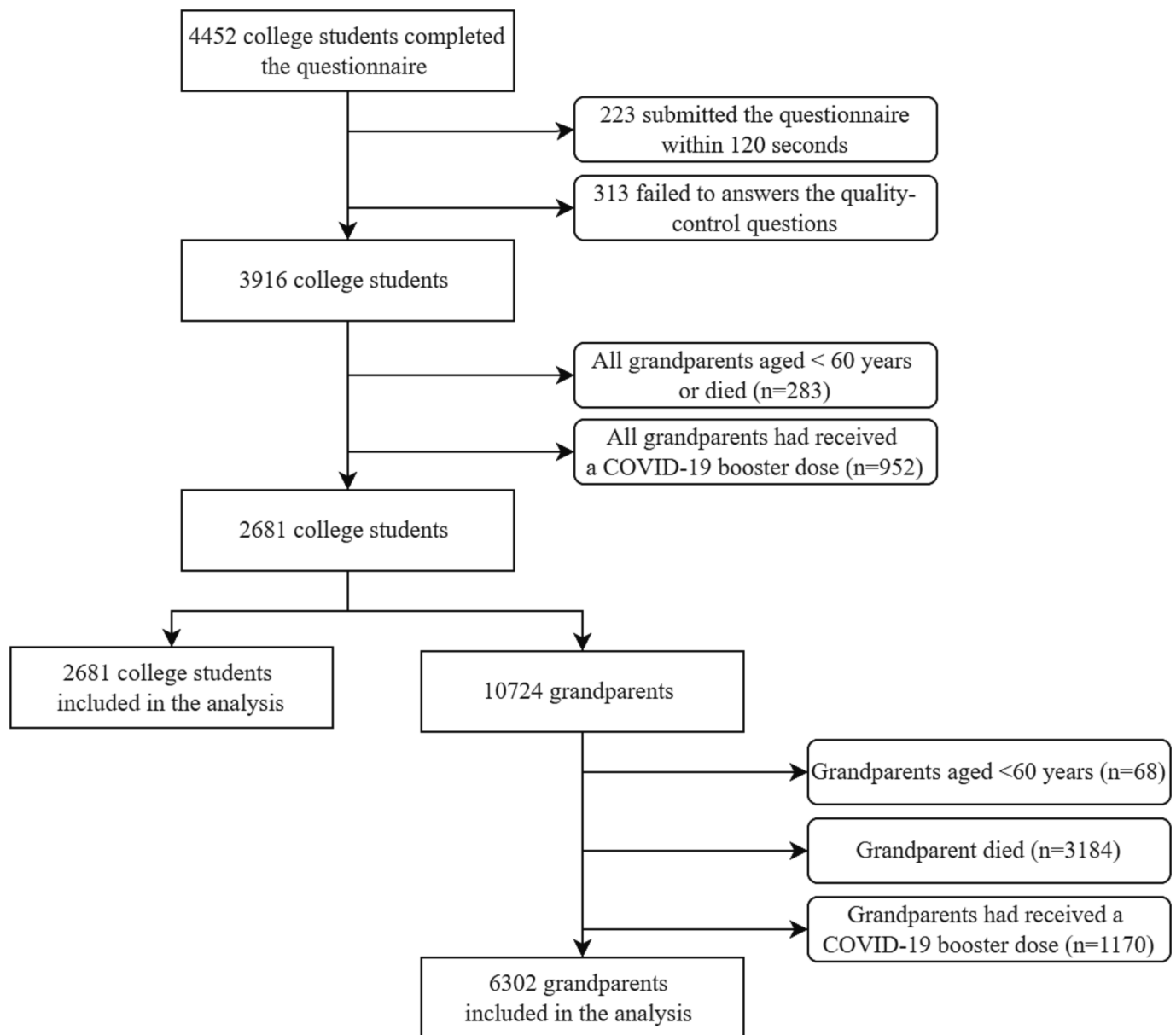
Fig. 2. Flowchart of the study population inclusion.

grandparents was also a significant factor associated with college students' intention. Cohabitation facilitates increased intergenerational interaction, which can foster closer ties and stronger bonds between the generations [28]. Thus, college students who ever lived with their grandparents may have a greater sense of responsibility for the health of their grandparents. Moreover, college students who were unclear about their grandparent's status of chronic disease were less likely to have the intention. A possible reason for this may be that they could not give the right advice based on their grandparents' health status and did not have a clear understanding of vaccination contraindications among older adults. This finding suggests the importance of targeted education on vaccination when allowing college students to participate in COVID-19 vaccination campaigns, especially vaccination contraindications among older adults.

At the between-family level, the intention of encouragement was positively associated with being female, which may be explained by the fact that their better adherence to government recommendations [29]. Intention was also associated with college students having received a booster dose of COVID-19 vaccine, which mirrors findings of previous

studies that vaccinated parents were more likely to vaccinate their children against COVID-19 [23,27]. Moreover, college students who received a COVID-19 booster dose tended to have positive attitudes and better impressions of COVID-19 vaccination and were, therefore, more likely to have the intention to encourage. It also supports the idea that by sharing college students' vaccination experiences to alleviate their grandparent's concerns about vaccination, these college students can serve as role models for their grandparents.

From the perspective of HBM, our study found that higher levels of perceived susceptibility and perceived severity of COVID-19 among grandparents significantly improve college students' intention. These results accord with the findings of other studies, in which individuals with increased perceived risk and severity of COVID-19 were less likely to be vaccine hesitant [30,31]. It can thus be suggested that the government could encourage college students' intentions by publicizing the susceptibility and severity of older adults' infections of COVID-19. This can also be used to engage college students in promoting vaccination coverage of general routine vaccines among older adults.

In the TPB constructs, subjective norms, consisting of the aspects of

Table 2
Characteristics of college students and their grandparents.

	N (%)
College students' characteristics	
Total N of college students	2681
Gender	
Male	954 (35.6)
Female	1727 (64.4)
Age, year	
16–25	2458 (91.7)
26–35	223 (8.3)
Ethnicity	
Han	2503 (93.4)
Other	178 (6.6)
Education	
Junior college/Undergraduate students	2420 (90.3)
Graduate students	261 (9.7)
Major	
Non-medical	2084 (77.7)
Medical	597 (22.3)
Attention to COVID-19 vaccination news of older adults	
Seldom	949 (35.4)
Sometimes	1232 (46.0)
Often	500 (18.6)
COVID-19 booster dose vaccination	
No	585 (21.8)
Yes	2096 (78.2)
Knowledge of COVID-19 and COVID-19 vaccination in older adults	
No	1611 (60.1)
Yes	1070 (39.9)
HBM constructs	
Perceived susceptibility(M ± SD)	3.99 (0.75)
Perceived severity(M ± SD)	3.42 (1.02)
Perceived benefits(M ± SD)	3.98 (0.71)
Perceived barriers(M ± SD)	3.42 (1.04)
Cues to action(M ± SD)	3.17 (1.00)
TPB constructs	
Attitude(M ± SD)	3.13 (1.08)
Subjective norms(M ± SD)	3.77 (0.69)
PBC(M ± SD)	3.93 (0.78)
Grandparents' characteristics	
Total N of grandparents	6302
Gender	
Male	2815 (44.7)
Female	3487 (55.3)
Age, year	
60–69	2079 (33.0)
70–79	3203 (50.8)
≥80	1020 (16.2)
Residence	
Urban	2159 (34.3)
Rural	4143 (65.7)
Education	
Primary school and below	3762 (59.7)
Junior school and above	1576 (25.0)
Unclear	964 (15.3)
Ever lived together with college students	
No	2573 (40.8)
Yes	3729 (59.2)
Living status	
Alone	859 (13.6)
With couple or children	5348 (84.9)
In nursing home	95 (1.5)
Frequency of going outdoors	
Seldom	701 (11.1)
Sometimes	1032 (16.4)
Often	3683 (58.4)
Unclear	886 (14.1)
COVID-19 vaccination	
Not vaccinated	923 (14.6)
Not completed the full vaccination course	697 (11.1)
Not vaccinated a booster dose	1603 (25.4)
Unclear	3079 (48.9)
Chronic diseases	
No	1450 (23.0)
Yes	3120 (49.5)
Unclear	1732 (27.5)

HBM: health belief model.
TPB: theory of planned behavior.
PBC: perception of behavioral control.

filial piety, social responsibility, and behaviors of friends, was the most important factor influencing college students' intention. We found that the greater the pressure felt by college students from friends and society, the more likely they would have the intention to encourage, which is in line with those of previous studies [21,23,31,32]. This finding stresses the importance of recommendations and encouragement from government and healthcare organizations to improve college students' intention. Moreover, efforts should be made to encourage college students to share their experience about promoting COVID-19 vaccination among older adults with their friends, as previous research also reported peer norms are considered quite crucial in influencing health-related intentions and behaviors among college students [32,33].

The study has several limitations. First, selection bias may exist in our study. As participants were recruited voluntarily, college students who are more concerned about COVID-19 vaccination among their grandparents might be more likely to participate in our study. Second, the survey was conducted using an online survey platform, the representativeness of this study may be compromised. In this study, the ratio of male college students to female was disproportionate. Third, our study may be subject to information bias. Older adults may not be able to complete electronic questionnaires, and in this circumstance, college students reported information on their behalf. While we reminded college students to ask the information about their grandparents before completing the questionnaire, mitigating the risk of information bias, there remains unclear details regarding their grandparents' vaccination status. Finally, the study provided information of college students' intentions during a particular phase of the COVID-19 pandemic. However, these intentions would change with the evolving epidemic trends of COVID-19. The findings should be viewed in the context of a specific time frame.

Conclusion

College students' intention to encourage COVID-19 vaccination among older adults was high in China. The intention was associated with college students' perception of susceptibility and severity of COVID-19 among their grandparents, subjective norms, as well as their grandparents' outdoor activities. These findings indicated that the government could engage college students in promoting COVID-19 vaccination among older adults and craft targeted measures to motivate their willingness to participate.

CRediT authorship contribution statement

Zhihui Guo: Investigation, Methodology, Writing – original draft. **Xinyi Li:** Investigation, Methodology, Writing – original draft. **Junye Bian:** Data curation, Investigation, Project administration, Writing – review & editing. **Weijie Zhang:** Investigation, Writing – review & editing. **Zhen Lu:** Methodology. **Yinghui Sun:** Writing – review & editing. **Yanxiao Gao:** Writing – review & editing. **Leiwen Fu:** Writing – review & editing. **Huachun Zou:** Funding acquisition, Project administration, Writing – review & editing.

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.

Data availability

The original data can be accessed by contacting the corresponding

Table 3

Multilevel logistic regression model of college students' intention to persuade their grandparents to receive COVID-19 vaccine.

	Model 1 AOR	Model 2 AOR	Model 3 AOR
College students' characteristics			
Gender			
Male	Ref	Ref	Ref
Female	1.75 (0.99–3.10)	1.94 (1.10–3.42) *	1.77 (1.01–3.11) *
Age, year			
16–25	Ref	Ref	Ref
26–35	0.3 (0.09–1.00)	0.28 (0.09–0.89) *	0.25 (0.08–0.81) *
Ethnicity			
Han	Ref	Ref	Ref
Other	0.56 (0.19–1.65)	0.51 (0.17–1.49)	0.51 (0.18–1.46)
Education			
Junior college/ Undergraduate students	Ref	Ref	Ref
Graduate students	0.44 (0.17–1.16)	0.62 (0.23–1.64)	0.53 (0.20–1.40)
Major			
Non-medical	Ref	Ref	Ref
Medical	1.02 (0.53–1.95)	1.38 (0.72–2.66)	1.17 (0.61–2.22)
Attention to COVID-19 vaccination news of older adults			
Seldom	Ref	Ref	Ref
Sometimes	0.98 (0.55–1.77)	0.82 (0.45–1.48)	0.88 (0.49–1.56)
Often	0.62 (0.26–1.45)	0.39 (0.17–0.91) *	0.46 (0.20–1.09)
COVID-19 booster dose vaccination			
No	Ref	Ref	Ref
Yes	2.97 (1.51–5.83) **	3.13 (1.60–6.14) ***	3.28 (1.68–6.42) ***
Knowledge of COVID-19 and COVID-19 vaccination in older adults			
No	Ref	Ref	Ref
Yes	0.93 (0.51–1.72)	1.16 (0.64–2.09)	0.74 (0.40–1.36)
HBM constructs			
Perceived susceptibility(M ± SD)	2.13 (1.35–3.37) ***	–	1.79 (1.12–2.87) *
Perceived severity(M ± SD)	1.47 (1.08–2.00) *	–	1.52 (1.12–2.06) **
Perceived benefits(M ± SD)	1.73 (1.07–2.80) *	–	1.25 (0.76–2.06)
Perceived barriers(M ± SD)	0.87 (0.65–1.17)	–	0.87 (0.63–1.19)
Cues to action(M ± SD)	1.34 (0.98–1.84)	–	1.35 (0.98–1.85)
TPB constructs			
Attitude(M ± SD)	–	0.76 (0.58–1.00)	0.92 (0.68–1.26)
Subjective norms(M ± SD)	–	3.24 (1.82–5.77) ***	2.88 (1.61–5.15) ***
PBC(M ± SD)	–	1.32 (0.82–2.11)	1.23 (0.77–1.97)
Grandparents' characteristics			
Gender			
Male	Ref	Ref	Ref
Female	0.77 (0.60–0.99) *	0.78 (0.61–1.00) *	0.78 (0.61–0.99) *
Age, year			
60–69	Ref	Ref	Ref

Table 3 (*continued*)

	Model 1 AOR	Model 2 AOR	Model 3 AOR
70–79	1.2 (0.82–1.75)	1.27 (0.87–1.85)	1.2 (0.83–1.75)
≥80	0.64 (0.37–1.10)	0.68 (0.39–1.17)	0.65 (0.38–1.12)
Residence			
Urban	Ref	Ref	Ref
Rural	1.46 (0.98–2.16)	1.48 (1.00–2.20)	1.46 (0.99–2.15)
Education			
Primary school and below	Ref	Ref	Ref
Junior school and above	0.97 (0.66–1.44)	0.96 (0.65–1.42)	0.96 (0.65–1.40)
Unclear	1.16 (0.67–2.01)	1.18 (0.68–2.06)	1.19 (0.69–2.04)
Ever lived together with college students			
No	Ref	Ref	Ref
Yes	2.11 (1.48–3.01) ***	2.06 (1.44–2.94) ***	2.07 (1.46–2.93) ***
Living status			
Alone	Ref	Ref	Ref
With couple or children	1.09 (0.69–1.73)	1.05 (0.67–1.66)	1.08 (0.69–1.68)
In nursing home	2.39 (0.81–7.08)	2.3 (0.77–6.87)	2.34 (0.81–6.79)
Frequency of going outdoors			
Seldom	Ref	Ref	Ref
Sometimes	1.75 (0.99–3.10)	1.72 (0.97–3.04)	1.75 (1.00–3.08)
Often	2.82 (1.68–4.73) ***	2.86 (1.70–4.81) ***	2.85 (1.70–4.76) ***
Unclear	1.13 (0.58–2.23)	1.09 (0.56–2.15)	1.14 (0.59–2.23)
COVID-19 vaccination			
Not vaccinated	Ref	Ref	Ref
Not completed the full vaccination course	1.3 (0.70–2.43)	1.17 (0.63–2.17)	1.27 (0.68–2.35)
Not vaccinated a booster dose	1.56 (0.89–2.71)	1.45 (0.83–2.52)	1.54 (0.89–2.66)
Unclear	3.73 (2.10–6.65) ***	3.72 (2.08–6.63) ***	3.78 (2.14–6.68) ***
Chronic diseases			
No	Ref	Ref	Ref
Yes	0.7 (0.46–1.06)	0.71 (0.46–1.07)	0.71 (0.47–1.07)
Unclear	0.54 (0.32–0.91) *	0.56 (0.33–0.94) *	0.55 (0.33–0.92) *
Random effect			
Family-level variance	66.11	69.8	53.51
ICC	0.95	0.95	0.94
Model fit statistics			
AIC	5207.4	5208.1	5194.2

"*", $P < 0.05$; "**", $P < 0.01$; "***", $P < 0.001$.

AOR, adjusted odds ratio.

HBM: health belief model.

TPB: theory of planned behavior.

PBC: perception of behavioral control.

ICC: intraclass correlation coefficient.

AIC: Akaike information criterion (given a set of candidate models for the data, the preferred model is the one with the minimum AIC value).

author.

time on participating in our study.

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