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RESEARCH ARTICLE

Factors associated with the COVID-19 booster vaccine intentions of young adults in the United States

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ABSTRACT

Young adults experience high coronavirus disease 2019 (COVID-19) incidence yet have the lowest vaccination and booster rates among adults. Understanding the factors influencing their intentions regarding boosters is essential for crafting effective public health strategies. We examined the psychosocial factors (attitudes, norms, perceived behavioral control) associated with their intentions to receive a COVID-19 booster. This cross-sectional study included 292 young adults aged 18–25 residing in Philadelphia who completed an online survey from September 2021 and February 2022 (mean age 21.98, standard deviation 2.25; 51% racial/ethnic minorities). The survey included measures of attitudes, norms, and perceived behavioral control related to COVID-19 vaccination. We employed structural equation modeling analysis to examine the intention of young adults to receive the COVID-19 booster and their vaccine-related attitudes, norms, and perceived behavioral control. Covariates included race/ethnicity and gender. Subjective norms were significantly associated with the intention to receive a COVID-19 booster (standardized $\hat{\beta} = 0.685$, $p = .018$). Attitudes and perceived behavioral control showed no significant association with intention. Subgroup analyses based on race/ethnicity revealed that attitudes (standardized $\hat{\beta} = 0.488$, $p = .004$) and subjective norms (standardized $\hat{\beta} = 0.451$, $p = .050$) were predictors among young adults from racial and ethnic minority backgrounds, while only subjective norms (standardized $\hat{\beta} = 1.104$, $p = .002$) were significant for non-Hispanic White young adults. Public health efforts should prioritize engaging healthcare providers and peer groups in order to influence subjective norms and promote collective responsibility and acceptance for vaccination. Tailored interventions and diverse communication strategies targeting specific subgroups of young adults may be useful to ensure comprehensive and effective vaccination initiatives.

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Introduction

The coronavirus disease 2019 (COVID-19) pandemic that emerged in late 2019 has posed an unprecedented global challenge to public health.[1–3] In the United States (U.S.), as in many parts of the world, efforts to combat the spread of the virus have included widespread vaccination campaigns.[4] These campaigns have been instrumental in curbing the initial wave of infections, reducing complications from infection, and reducing the burden on healthcare systems. While COVID-19 is no longer classified as a public health emergency of international concern,[5] a key strategy for maintaining immunity and controlling the virus's spread involved administering initial and booster doses of COVID-19 vaccines.[6]

As of October 2023, young adults in the U.S., particularly those aged 18 to 24, exhibited the lowest vaccination rates, including for booster shots, compared to other adult populations aged older than 24.[7] Moreover, young adults aged 18 to 29 had the highest COVID-19 incidence rates among all adult groups, rendering this age group a significant contributor to ongoing community transmission.[8,9] This population was also considered a primary contributor to the resurgence of COVID-19 in the U.S. in 2020.[10] Many young adults perceive themselves as less likely to experience the negative effects of COVID-19, which resulted in poorer adherence to mitigation strategies.[11] Since their symptoms are often mild, they may be less inclined to isolate, thereby increasing the likelihood of unknowingly transmitting the virus.[12] As young adults often interact with a wide range of individuals across diverse age groups, including high-risk individuals such as elderly relatives, understanding their intentions regarding COVID-19 boosters is essential for crafting effective public health strategies.

The decision to obtain a COVID-19 vaccination booster is influenced by a complex interplay of factors.[13] The Theory of Planned Behavior (TPB) provides a valuable lens through which to understand and predict human behavior, particularly in the context of health-related decisions. According to the TPB, three main factors influence behavioral intentions: (1) an individual's positive or negative perception and assessment of a specific behavior (attitudes toward behavior), (2) the perceived social pressure to engage or not engage in the behavior (subjective norms), and (3) the perceived ease or difficulty of carrying out the behavior (perceived behavioral control). Together, these elements shape an individual's intention to

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perform a particular behavior and are crucial determinants of actual behavior.[14]

TPB has been successfully applied to numerous health-related behaviors including vaccination decisions and has yielded valuable insights into the factors that drive or hinder people's intentions to engage in these behaviors.[13] Table 1 summarizes findings from previous studies that utilized the TPB to investigate intentions to receive COVID-19 boosters across various countries and populations. Most studies included adults of all ages, highlighting a scarcity of studies specifically addressing intentions to receive boosters tailored for young adults. Two studies focused on young adults and included only college students.[22,26] Some studies incorporated all three TPB constructs, while others included only a subset. Of the two studies focusing on young adults, one involving interdisciplinary college students included all three TPB constructs, with attitudes and subjective norms found to be significant predictors.[22] The other study, which involved only medical students, included attitudes as the sole construct, and it was also found to be a significant predictor.[26]

Studies on other respiratory vaccines in young adults present inconsistent findings. For example, a study involving U.S. college students found that subjective norms predicted their intention to receive the COVID-19 primary series, while attitudes and perceived behavioral control did not.[32] Moreover, in two U.S. studies applying the TPB to investigate young adults' intentions regarding influenza vaccines, one study focused on those who had not received a flu shot. It found that attitudes, subjective norms, and perceived behavioral control were all significant predictors.[33] Conversely, another study examining influenza vaccination intentions among young adults found that attitudes and subjective norms were significantly associated with intentions, while perceived behavioral control did not play a significant role.[34]

In this context, we employed the TPB as the foundational framework to investigate the intentions of a diverse sample of young adults in Philadelphia regarding receiving COVID-19 booster shots. Our aim is to uncover the underlying factors influencing these intentions, encompassing an examination of attitudes, perceived behavioral control, and subjective norms. While several instruments based on TPB exist to assess intentions across various populations, the unique context of the COVID-19 pandemic and the introduction of booster vaccinations necessitated the development of a new TPB-based instrument tailored to the young adult population. Existing instruments may not fully capture the specific factors influencing young adults' intentions to receive a COVID-19 booster, including their unique perceptions, diverse social influences, and beliefs about control. Additionally, the unprecedented nature of the pandemic and the cultural and regional specificities of our target population demanded a contextually relevant tool. Therefore, we developed a new TPB instrument to comprehensively and accurately assess the determinants of young adults' behavioral intentions in this novel and specific context, seeking insights into how these constructs impact their decision-making process.

Our hypotheses are:

(1) Consistent with the TPB, we hypothesized that there will be a direct and positive association between the intention to receive the COVID-19 booster and the following constructs within the young adult populations: (a) attitudes toward COVID-19 vaccination; (b) subjective norms; and (c) perceived behavioral control.
(2) Given reported differences in vaccine-related attitudes and uptake by race/ethnicity,[35–37] we hypothesized that there will be a difference in these associations between non-Hispanic White young adults and young adults from other racial/ethnic groups.

Methods

This cross-sectional study is a component of the larger Philadelphia CEAL (Community Engagement Alliance) initiative,[38,39] which aimed to address disparities in COVID-19 testing, vaccine uptake, and participation in clinical trials within communities disproportionately impacted by the pandemic in Philadelphia. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement[40] was used to ensure proper reporting of this observational study.

Participants

In the present study, eligibility criteria included participants who had completed the full primary series of the COVID-19 vaccine, consistent with our outcome of intending to receive a booster shot. The series could be either two doses of Moderna/Pfizer-BioNTech or one dose of Johnson & Johnson's Janssen. Additionally, we restricted the age to 18 years or older to maintain consistency with young adult populations.[41]

We initially recruited 359 residents of Philadelphia without any dependent children via online and community-based outreach to participate in a self-administered online survey conducted through Qualtrics from September 2021 to February 2022.[39] During data collection, Philadelphia's young adult population exhibited diversity across ethnicity, race, culture, and socioeconomic background.[42] COVID-19 booster shots became available starting in September 2021. Among the initial pool, we excluded 34 individuals who did not complete the full primary series of the COVID-19 vaccine. We also excluded an additional 24 participants who were younger than 18. Furthermore, nine participants who did not respond to any of the survey items used in the present study were excluded. As a result, the final dataset included 292 young adult participants. All study procedures received approval from the Institutional Review Board at the University of Pennsylvania (#848650). Written informed consent was obtained from all participants after fully explaining the nature and potential consequences of the study.

Table 1. Studies applying the TPB to examine COVID-19 booster intention.

Authors (Years)	Country (Region)	Sample	*N*	Included TPB Constructs	Other Predictors	Key TPB Findings
Almokdad et al. (2023)[15]	South Korea	All adults (Mean age: 28.46)	315	ATT, SN, PBC	Universalism, benevolence, conformity, tradition, security, herd immunity awareness, ascribed responsibility	ATT, SN and PBC were found to be associated with COVID-19 booster intention.
Barattucci et al. (2022)[16]	Italy	All adults (Mean age: 40.06 ± 13.8)	1,095	SN	Gender, age, education, fear of the vaccine, fear of COVID-19, trust in science, trust in vaccine, COVID-19 knowledge, vulnerability, and severity	SN was found to be associated with COVID-19 booster intention.
Catalano et al. (2023)[17]	USA (southeastern region)	All adults (Age ≥18, mean age not reported)	288	ATT, SN, PBC		ATT and SN were found to be associated with COVID-19 booster intention.
Geers et al. (2022)[18]	USA (national sample)	All adults (Mean age: 31.66 ± 11.05)	551	ATT	Trust in development, COVID-19 worry, side effect concern, political affiliation	ATT was found to be associated with COVID-19 booster intention.
Folcarelli et al. (2022)[19]	Italy	All adults (Mean age: 32.1 ± 15.9)	615	ATT	Perceived risk of COVID-19 infection, booster dose hesitancy, gender, age, marital status, cohabitants, education, student status, chronic conditions, COVID-19 history, friends/family diagnosed, self-rated health (global and post-vaccine), received official information, need for more information on the booster	ATT was found to be associated with COVID-19 booster intention.
Hagger and Hamilton (2022)[20]	USA (region not reported)	All adults (Mean age: 52.14 ± 14.55)	479	ATT, SN, PBC	Political orientation, vaccine hesitancy, belief in free will, age, sex, education level, employment status, ethnicity, previous COVID-19 diagnosis, previous influenza vaccine	ATT, SN and PBC were found to be associated with COVID-19 booster intention.
Hwang et al. (2024)[21]	Malaysia	All adults (Age ≥18, mean age not reported)	1,914	ATT, SN	Age, income, gender, education, employment status, marital status, previous COVID-19 infection, region, satisfaction, perceived usefulness, perceived barriers, perceived benefits, cues to action	ATT and SN were found to be associated with COVID-19 booster intention.
Liu et al. (2024)[22]	USA (midwestern region)	Young adults (College students with a mean age of 20.27 ± 2.75)	419	ATT, SN, PBC	Age, sex, race, ethnicity, chronic conditions, smoking, financial status, parent education, health insurance, vaccination history	ATT and SN were found to be associated with COVID-19 booster intention.
Lounis et al. (2022)[23]	Algeria	All adults (Age ≥18, mean age not reported)	787	ATT	Sex, age, education, profession, chronic illness, previous COVID-19 infection, post-vaccination relief, regret	ATT was found to be associated with COVID-19 booster intention.
Maria et al. (2022)[24]	Indonesia	All adults (Age ≥18, mean age not reported)	1,684	ATT, SN, PBC	Education, income, comorbidity, previous COVID-19 infection, perceived barriers, perceived severity, perceived benefits, perceived susceptibility, anticipated regret, self-efficacy	ATT and SN were found to be associated with COVID-19 booster intention.
Orellana et al. (2023)[25]	Bolivia	All adults (Mean age: 26.61 ± 13.11)	720	ATT, SN	Vaccine origin, completed minimum required doses, received third dose, information sources (government authorities, scientific), confidence in COVID-19 vaccines, confidence in previous vaccines, time since last dose, biosafety norms	ATT and SN were found to be associated with COVID-19 booster intention.
Sugawara et al. (2021)[26]	Japan	Young adults (Medical students with a mean age of 21.1 ± 2.5)	496	ATT	Age, sex, grade, allergy history (food, medication, animals, pollen, dust mites, unknown), anaphylaxis, asthma, atopic dermatitis	ATT was found to be associated with COVID-19 booster intention.
Wang et al. (2022)[27]	China (Hong Kong)	Older adults (Age ≥65)	395	ATT, SN	Education, pneumococcal vaccination history, uncertainty, materials addressing COVID-19 booster concerns, materials helpful for booster decision	Neither ATT nor SN was found to be associated with COVID-19 booster intention.
Wang et al. (2023)[28]	China (Nanjing)	Older adults (Age ≥60)	214	ATT, SN	Perceived severity, perceived vulnerability, response efficacy, self-efficacy, response cost	SN was found to be associated with COVID-19 booster intention.
Wong et al. (2022)[29]	Malaysia	All adults (Mean age: 32.1 ± 11.3)	1,010	ATT	Age, gender, ethnicity, marital status, occupation, income, living area, chronic condition, COVID-19 history, past COVID-19 vaccination side effects, pandemic fatigue, adherence to recommended COVID-19 measures	ATT was found to be associated with COVID-19 booster intention.
Xiang et al. (2023)[30]	China (Macao)	All adults (Age ≥18, mean age not reported)	469	ATT	Psychological reactance, perceived threat to freedom, message frame, freedom restoration postscript, other-referencing cue, age, education, income	ATT was found to be associated with COVID-19 booster intention.
Zhou et al. (2022)[31]	China (Nanjing)	Adult parents (Median age: 32, SD not reported)	1,602	ATT, SN, PBC	Belief in problem severity, perceived risk of disease, assessment of protection behavior effectiveness, self-efficacy in implementing behavior, and estimated cost of action	ATT, SN and PBC were found to be associated with COVID-19 booster intention.

Abbreviations: ATT (attitudes), SN (subjective norms), PBC (perceived behavioral control), COVID-19 (coronavirus disease 2019).

Measures

TPB constructs

The questionnaire related to COVID-19 vaccines was designed specifically for this study by researchers based on TPB and adhered to TPB questionnaire construction, measurement, and elicitation guidelines.[14,43,44] The items were developed to encompass the core constructs of TPB, which included (1) intention, (2) attitudes, (3) perceived behavioral control, and (4) subjective norms. Adaptation was required for subjective norms questions to specify the relevant individuals important to young adults, with choices informed by existing literature.[45,46] The questionnaire featured positively framed items, including nine items for attitudes, eight items for subjective norms, and eight items for perceived behavioral control. Respondents provided their feedback on a five-point Likert scale, ranging from '1 = disagree strongly' to '5 = agree strongly.' Higher scores on the items related to attitudes, subjective norms, and perceived behavioral control indicated more positive cognitive responses from the participants. Given the time-sensitive nature of the pandemic and the need to swiftly collect data, conducting a pilot study was not feasible. However, the questionnaire items were carefully developed based on established constructs from the TPB. Moreover, they were subjected to rigorous review by field experts to ensure content validity.[47]

Vaccine intentions

The intention to receive a booster vaccine for participants was assessed using a single item: 'Are you willing to get a COVID-19 booster if one becomes available?' Given that a COVID-19 booster became available in September 2021,[48] some survey participants had already received a booster at the time of the survey. Participants provided responses on a scale, with options '1 = yes,' '2 = no,' '3 = I don't know,' and '4 = I have already received a booster.' These responses were subsequently dichotomized as follows: '2 = no' and '3 = I don't know' were grouped as '0 = no/I don't know,' while '1 = yes' and '4 = I have already received a booster' were combined as '1 = yes/already received.'

Statistical analysis

Descriptive statistical analysis, which included generating frequency distributions and calculating means, was carried out using R version 4.2.3. To assess the hypothesized TPB model, Structural Equation Modeling (SEM) was employed via the Lavaan package in R.[49,50] SEM is a statistical technique that allows for the simultaneous examination of relationships between observed and latent constructs within the hypothesized model. It helps determine whether the model adequately fits the data and provides estimates of the strength of associations between the modeled constructs.[51,52]

We adopted a two-stage modeling approach to evaluate the hypothesized TPB model.[53] In the initial stage, Confirmatory Factor Analysis (CFA) was conducted to assess the factorial validity of the latent constructs and the adequacy of the measurement model. This stage included the evaluation of three latent constructs: attitudes, perceived behavioral control, and subjective norms. Modification indices were examined to identify potential sources of model misfit, which served as a basis for refining the measurement model as necessary.

Once the measurement model was specified, the subsequent step involved conducting SEM to assess whether the hypothesized TPB model (Figure 1) exhibited a satisfactory fit to the data and to estimate the relationships within the model. The SEM model included four latent variables (attitudes, perceived behavioral control, subjective norms, intention) while gender, race and ethnicity were treated as observed variables (Figure 1). To account for the binary outcome of intention, we employed the diagonally weighted least square estimator with a probit link. Once the SEM was established, we proceeded with a subgroup analysis to compare the SEM model among young adults from racial and ethnic minority backgrounds against a model for non-Hispanic White young adults based upon the definition from the National Institute on Minority Health and Health Disparities.[54] This examination was prompted by prior research findings suggesting variations in vaccination intentions associated with race and ethnicity.[35–37]

To evaluate the model's fit to the data, we assessed several fit indices, including the chi-square (χ^2) test, comparative fit index (CFI), non-normed fit index (NNFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR).[55,56] A statistically non-significant result for the chi-square test ($p > .05$) would suggest a good fit for the model. However, the significance of the chi-square test is greatly influenced by sample size, and large samples can yield significant p-values even with minor model misspecifications.[57] Therefore, emphasis was placed on the other fit indices.

To address missing data, participants who did not respond to any of the survey items used in the present study were excluded from the analyses. This decision was made because incomplete surveys may not occur randomly and could be indicative of a lack of interest or engagement, potentially introducing bias into the variability of response variables. For participants with partially missing survey data, we employed multiple imputations using chained equations.[58] Prior to conducting multiple imputation, we conducted Little's MCAR test

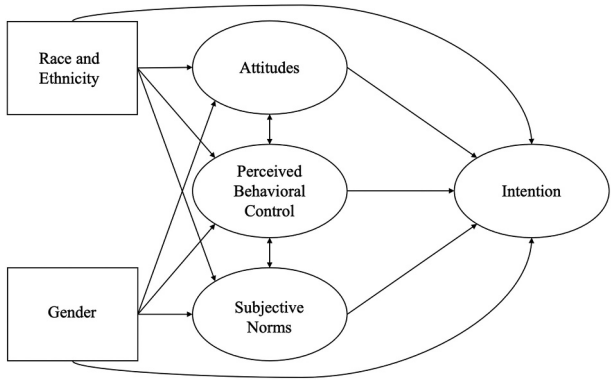

Figure 1. The hypothesized theory of planned behavior (TPB) model. The hypothesized theory of planned behavior (TPB) model, including four latent variables: (1) intention, (2) attitudes, (3) perceived behavioral control, and (4) subjective norms and two observed variables: race/ethnicity and gender.

Table 2. Demographic characteristics.

	Young adult participants (n = 292)
Intention (n (%))	
Intended to receive a booster	259 (88.7)
Not intended to receive a booster	33 (11.3)
Age (mean (standard deviation))	21.98 (2.25)
Race and Ethnicity (n (%))	
Hispanic/Latinx	25 (8.6)
Non-Hispanic Multiracial/Other	21 (7.2)
Non-Hispanic Asian	69 (23.6)
Non-Hispanic Black or African American	34 (11.6)
Non-Hispanic White	143 (49.0)
Gender (n (%))	
Woman	190 (65.5)
Man	84 (29.0)
Transgender or gender diverse	16 (5.5)
Sexual Orientation (n (%))	
Straight (i.e., not gay, lesbian or bisexual)	160 (56.7)
Bisexual	66 (23.4)
Gay	24 (8.5)
Lesbian	16 (5.7)
Other	16 (5.7)

to evaluate whether the assumptions required for multiple imputation were upheld in our dataset. The test produced a p-value of 0.846, supporting the use of multiple imputation.[59] Subsequently, the imputed datasets were combined using Rubin's rules,[60] resulting in a common set of $m = 5$ imputations. This approach not only helped retain data for use in multivariable models but also enhanced the robustness and reliability of our analysis. Following the completion of the imputation process, we generated a binary indicator variable, denoting '0 = not imputed/no missing' and '1 = imputed.' This variable was then included as a control variable in the SEM analysis. Its incorporation allowed us to assess and potentially adjust for any effects related to imputation, contributing to the overall rigor and validity of the study's findings. Lastly, to bolster the reliability of our analysis, we introduced bootstrap standard errors with 1,000 replicates to enhance the robustness of the estimates.

Results

Table 2 presents the socio-demographic characteristics of 292 participants. The participants had an average age of 21.98 years (SD = 2.25). The sample was racially diverse, with non-Hispanic White young adult participants comprising 49% of the group. Additionally, 56.7% identified as heterosexual, 23.4% as bisexual, and 8.5% as lesbian or gay Regarding their intention to receive a booster, 88.7% expressed the intention to receive one, while 11.3% reported not intending to do so. The means of TPB constructs among participants were as follows: attitudes (mean 4.5; SD 0.54), subjective norms (mean 4.6; SD 0.55), and perceived behavioral control (mean 4.1; SD 0.57) (Table 3).

Measurement model

The complete measurement model is depicted in Table 3. The standardized factor loadings within this model varied from 0.269 to 0.899 and were all statistically significant ($p < .001$). The standardized correlation coefficients, which represent the relationships between the model's factors, spanned from 0.208 to 0.657 (Table 4). All factor correlations remained below the established threshold of 0.85.[61] These findings collectively affirm the model's overall satisfactory level of discriminant validity across its latent constructs.[61]

The initial three-factor measurement model produced the following fit indices: $\chi^2 = 1113.405$; degrees of freedom (df) = 272; $p < .001$; CFI = 0.785; NNFI = 0.763; RMSEA = 0.103 with a 95% confidence interval (CI) of 0.096–0.111; SRMR = 0.118 (Table 5, Model 1). Based on modification indices, the model fit could be improved by allowing a correlation between residuals of three items in the subjective norm construct: (1) "My family would approve of me receiving a COVID-19 vaccine," (2) "My mother would approve of me receiving a COVID-19 vaccine," and (3) "My father would approve of me receiving a COVID-19 vaccine." Given the close interrelation of the concepts of family, mother, and father for young adults,[62] these residual correlations made theoretical sense and were thus incorporated into the model. With these adjustments, the final measurement model yielded the following fit indices: $\chi^2 = 956.784$; df = 269; $p < .001$; CFI = 0.824; NNFI = 0.804; RMSEA = 0.094 with a 95% CI of 0.086–0.102; SRMR = 0.082 (Table 5, Model 2).

Structural model

The measurement model fit indices were optimized once we aligned our latent factors with the theoretical pathways proposed by the Theory of Planned Behavior ($\chi 2 = 786.920$; df = 365, $p < .001$; CFI = 0.946; NNFI = 0.952; RMSEA = 0.063 with 95% CI = 0.056–0.070; SRMR = 0.077) (Table 5, Model 3). Among the hypothesized effects, only the subjective norm construct was found to be a statistically significant predictor of intention (standardized $\beta = 0.685$, $p = .018$; 95% CI = 0.235 to 1.136). On the other hand, attitudes (standardized $\beta = 0.131$, $p = .572$; 95% CI = −0.327 to 0.589) and perceived behavioral control (standardized $\beta = 0.171$, $p = .293$; 95% CI = −0.153 to 0.495) were not statistically significant in influencing intention to receive the COVID-19 booster (Table 6). Race and ethnicity (standardized $\beta = 0.151$, $p = .317$; 95% CI = −0.139 to 0.442), and gender (standardized $\beta = 0.289$, $p = .056$; 95% CI = 0.000 to 0.573) did not show statistically significant associations with intention (Figure 2).

Subgroup analyses

Both subgroups had sample sizes exceeding 100, with 142 young adults from racial and ethnic minority backgrounds and 132 non-Hispanic White young adults.[63] The structural model for both groups exhibited a good fit ($\chi^2 = 1011.497$; df = 702, $p < .001$, CFI = 0.954, NNFI = 0.958, RMSEA = 0.057 with 95% CI = 0.051–0.063, SRMR = 0.097) (Table 5, Model 4). The hypothesized effects varied across racial and ethnic subgroups (Table 6). Among young adults from racial and ethnic minority backgrounds, attitudes (standardized $\beta = 0.488$, $p = .004$) and subjective norms (standardized $\beta = 0.451$, $p = .050$) were significantly associated with the intention to receive COVID-19 boosters (Figure 3). In contrast, among non-Hispanic White young adults,

Table 3. The theory of planned behavior measurement model.

Latent Factors	*N*	Items	Mean	SD	Standardized Factor Loadings
Attitude	292	Receiving a COVID-19 vaccine would protect me from getting COVID-19.	4.5	0.91	0.580
(α = 0.87)	210	If I get a COVID-19 vaccine, I could go to school in person.	4.6	0.70	0.343
	292	If I get a COVID-19 vaccine, I could safely participate in school, group, and sports activities.	4.3	0.78	0.683
	292	If I get a COVID-19 vaccine, I could travel safely.	4.2	0.86	0.662
	292	If I get a COVID-19 vaccine, I would be less worried about getting COVID-19.	4.4	0.81	0.692
	292	Receiving a COVID-19 vaccine would help protect our community from COVID-19.	4.6	0.63	0.744
	292	Receiving a COVID-19 vaccine would make me safe around other people.	4.4	0.80	0.781
	198	Receiving a COVID-19 vaccine would help protect other students and teachers in my school from COVID-19.	4.6	0.70	0.710
	281	Receiving a COVID-19 vaccine would protect others in my family from getting COVID-19.	4.7	0.60	0.742
Subjective Norm	292	Most people who are important to me would approve of me receiving a COVID-19 vaccine.	4.5	0.77	0.662
(α = 0.82)	178	My boyfriend/girlfriend would approve of me receiving a COVID-19 vaccine.	4.7	0.62	0.529
	292	My family would approve of me receiving a COVID-19 vaccine.	4.4	0.87	0.550
	291	My friends would approve of me receiving a COVID-19 vaccine.	4.6	0.61	0.648
	265	My doctor would approve of me receiving a COVID-19 vaccine.	4.9	0.45	0.689
	81	My pastor or other religious leader would approve of me receiving a COVID-19 vaccine.	4.4	0.80	0.269
	292	My mother would approve of me receiving a COVID-19 vaccine.	4.4	1.02	0.378
	292	My father would approve of me receiving a COVID-19 vaccine.	4.4	0.97	0.417
Perceived	292	I am sure I can get a COVID-19 vaccine, even if I have many problems in my life.	4.3	0.82	0.478
Behavioral	292	I am sure I can get a COVID-19 vaccine, even if I am very busy.	4.4	0.74	0.668
Control	292	I am sure I can get a COVID-19 vaccine, even if it is hard to find a place that offers the vaccine.	4.1	0.89	0.824
(α = 0.91)	292	I am sure I can get a COVID-19 vaccine, even if it is offered at inconvenient times.	4.0	1.05	0.894
	292	I am sure I can get a COVID-19 vaccine, even if it is hard to make an appointment.	3.9	1.05	0.899
	257	I am sure I can get a COVID-19 vaccine, even if I have to take time off from work or school to be vaccinated.	4.1	1.05	0.663
	292	I am sure I can get a COVID-19 vaccine, even if the place that offers the vaccine is far from my home.	3.8	1.10	0.762
	292	I am sure I can get a COVID-19 vaccine, even if the waiting time is very long.	4.0	0.93	0.753
Intention	292	Are you willing to get a COVID-19 booster if one becomes available?	1.2	0.58	Not applicable

Abbreviations: COVID-19 (coronavirus disease 2019), SD (standard deviation).

Table 4. Standardized factor correlations from the confirmatory factor analysis.

Constructs	Correlation coefficients
Attitude – Subjective norm	0.657
Attitude – Perceived behavioral control	0.334
Attitude – Intention	0.323
Subjective norm – Perceived behavioral control	0.436
Subjective norm – Intention	0.461
Perceived behavioral control – Intention	0.208

only subjective norms were significantly associated with intention (standardized $\beta = 1.104$, $p = .002$), while attitudes did not have a statistically significant effect (standardized $\beta = -0.386$, $p = .062$) (Figure 4). Additionally, non-Hispanic White young adult men showed lower intentions compared to non-Hispanic White young adult women (standardized $\beta = -0.373$, $p = .037$).

Discussion

The results of this SEM analysis provided valuable insights into the factors associated with the intentions of young adults to receive the COVID-19 booster. One of the most significant findings of this study is the dominant role of subjective norms in shaping the intention to receive the COVID-19 booster among young adult participants. Subjective norms, which reflect the influence of family and peer approval,[14] emerged as the only statistically significant predictor of intention. This suggests that the perception of approval from one's immediate social circle is a key driver in motivating young adults to receive a booster.

This finding aligns with prior research underscoring the substantial impact of social factors on health-related behaviors among young adult populations,[64,65] especially regarding vaccination decisions.[32–34] Of particular note, within the subjective norm items, the desire for acceptance and

Table 5. Fit indices for the TPB measurement and structural models.

Fit Indices	Model 1	Model 2	Model 3	Model 4
χ2	1113.405	956.784	786.920	1011.497
df	272, $p < .001$	269, $p < .001$	365, $p < .001$	702, $p < .001$
CFI	0.785	0.824	0.946	0.954
NNFI	0.763	0.804	0.952	0.958
RMSEA	0.103	0.094	0.063	0.057
95% CI RMSEA	0.096–0.111	0.086–0.102	0.056–0.070	0.051–0.063
SRMR	0.118	0.082	0.077	0.097

Model 1: Measurement model without modification.
Model 2: Measurement model with modification.
Model 3: Structural model.
Model 4: Multigroup structural model by race.
Abbreviations: TPB (the theory of planned behavior), df (degrees of freedom), CFI (comparative fit index), NNFI (non-normed fit index), RMSEA (root mean square error of approximation), SRMR (standardized root mean square residual), CI (confidence interval).

Table 6. Estimated regression coefficients for the structural equation model (Model 3).

Effects	Unstandardized $\hat{\beta}$	95% CI	Standardized $\hat{\beta}$	95% CI
Overall (n = 292)				
Attitude	0.152	−0.392 to 0.678	0.131	−0.327 to 0.589
Subjective norm	0.954*	0.365 to 1.808	0.685*	0.235 to 1.136
Perceived behavioral control	0.223	−0.19 to 0.599	0.171	−0.153 to 0.495
Race and ethnicity	0.067	−0.075 to 0.196	0.151	−0.139 to 0.442
Gender	0.141	−0.010 to 0.297	0.289	0.000 to 0.573
Non-Hispanic White (n = 132)				
Attitude	−0.594	−1.218 to 0.029	−0.386	−0.716 to 0.057
Subjective norm	2.309*	0.857 to 3.762	1.104*	0.703 to 1.505
Perceived behavioral control	−0.065	−0.704 to 0.574	−0.040	−0.432 to 0.351
Gender (reference: women)	−0.662*	−1.285 to −0.039	−0.373*	−0.691 to −0.055
Race and ethnic minority (n = 142)				
Attitude	0.490*	0.154 to 0.827	0.488*	0.153 to 0.823
Subjective norm	0.537*	0.000 to 1.074	0.451*	0.022 to 0.879
Perceived behavioral control	0.207	−0.189 to 0.603	0.153	−0.143 to 0.449
Gender (reference: women)	−0.256	−0.795 to 0.284	−0.190	−0.579 to 0.198

Abbreviation: CI (confidence interval).
*p < .05.

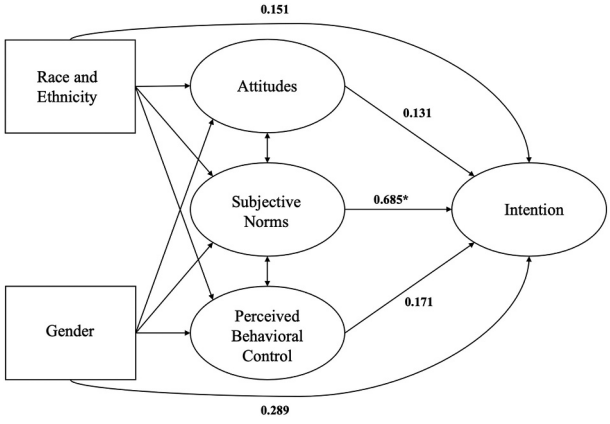

Figure 2. The structural equation model. *p < 0.05.

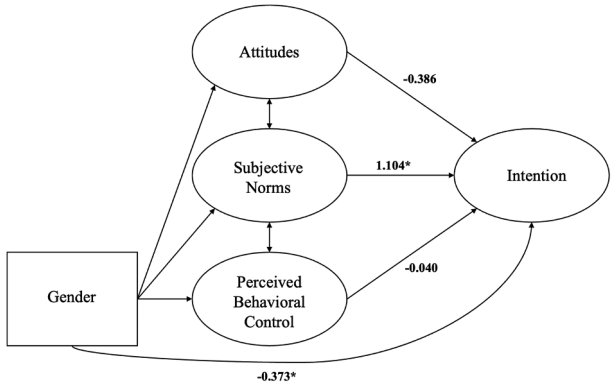

Figure 4. The structural equation model for non-Hispanic White young adults. *p < 0.05.

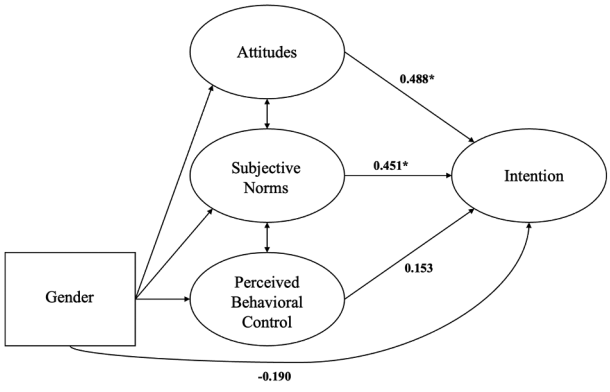

Figure 3. The structural equation model for young adults from racial and ethnic minority backgrounds. *p < 0.05.

approval from healthcare providers and peers received the highest mean scores. Moreover, our survey results revealed that participants ranked the Centers for Disease Control and Prevention (CDC), Food and Drug Administration (FDA), and healthcare providers as their top three most trusted sources of information about COVID-19 vaccines. Therefore, public health interventions should strategically leverage these insights by developing approaches that harness the influence of social networks and encourage discussions within healthcare provider and peer groups to emphasize the critical importance of COVID-19 vaccination, in alignment with the continued emphasis from trusted government organizations like the CDC and FDA.

In contrast, attitudes and perceived behavioral control, while integral components of TPB, did not demonstrate statistically significant associations with the intention to receive the COVID-19 vaccine booster. Although this finding is consistent with a recent U.S.-based study that employed the TPB model to examine college students' intentions to receive COVID-19 primary series,[32] it diverges from two previous studies focused on college students' intentions to receive COVID-19 boosters, which identified attitudes as a significant predictor.[22,26] It is important to note that there are only a few studies that specifically focus on young adults' intentions regarding booster vaccination, and those that do exist are primarily conducted among college students. To address this limitation, our study included young adults from varied educational backgrounds. By doing so, we aimed to capture the diverse experiences and perspectives of young adults more comprehensively. This broader inclusion enhances the applicability and relevance of our findings for public health interventions aimed at promoting booster vaccination uptake among this age group, making our results more generalizable and useful for designing effective vaccination strategies.

Additionally, the previous studies either controlled for race/ethnicity or did not include race in their models. Given ongoing reports of racial and ethnic disparities in COVID-19 vaccine uptake,[66,67] our study uniquely investigates factors associated with the intentions of young adults across diverse racial and ethnic backgrounds. Our subgroup analysis revealed that attitudes significantly predicted the intention to receive the booster only among young adults from racial and ethnic groups other than non-Hispanic White young adults. This finding aligns with our study that examined parents' intentions to vaccinate their children against COVID-19 using the TPB, conducted during the same time period in Philadelphia.[47] Among parents from racial and ethnic groups other than non-Hispanic White individuals, both attitudes and subjective norms exhibited significant positive associations with the intention to vaccinate their children. However, for non-Hispanic White parents, only subjective norms played a more prominent role in shaping their intentions.[47] This suggests that the influence of attitudes on vaccination intentions may vary significantly across different racial and ethnic groups. These nuances highlight the importance of considering demographic factors, such as race and ethnicity, when examining the determinants of health behaviors. Our study underscores the need for targeted interventions tailored to the specific needs and motivations of diverse populations to enhance vaccine uptake.

The absence of a relationship between COVID-19 booster attitudes and intentions is not consistent with prior studies in the U.S. that examined young adults' influenza vaccination intentions using the TPB model, where attitudes were identified as a significant predictor.[33,34] Several potential reasons might account for this inconsistency. First, it is important to consider the unique context of the COVID-19 pandemic, characterized by rapidly changing information, vaccine hesitancy, and the emergence of new variants. These factors could have differentially influenced young adults' intentions compared to the more established and familiar context of seasonal influenza. Second, social and peer pressures specific to COVID-19 vaccination, such as vaccine mandates or societal expectations, may have overridden individual attitudes. Last, differences in the implementation of vaccination campaigns, communication strategies, and public health interventions for COVID-19 and influenza could also contribute to varying outcomes within the TPB framework. Moreover, it is important to note that our study was conducted during the initial Omicron wave, characterized by a high number of COVID-19 infections and associated hospitalizations. It is conceivable that attitudes among young adults may have evolved since then, particularly given the dynamic nature of the pandemic. Therefore, it would be valuable for future research to reassess young adults' attitudes and intentions toward COVID-19 vaccination in light of evolving circumstances and updated public health measures.

Our study also contributes new insights into gender-specific differences in vaccination intentions among non-Hispanic White young adults. Gender did not emerge as a statistically significant predictor of vaccination intention in the overall structural model or in the subgroup model for young adults from racial and ethnic minority backgrounds. However, among non-Hispanic White young adults, gender differences were observed. Specifically, men from these backgrounds showed a lower intention to receive the COVID-19 vaccine booster compared to women. A study that examined gender differences in the intention to receive the COVID-19 primary series using the TPB reported that attitudes were associated exclusively with the intentions of men, whereas subjective norms were associated exclusively with the intentions of women.[68] Although we were unable to conduct multigroup analyses by gender due to a limited sample size for male participants, these findings underscore the importance of considering gender as a potential variable in understanding vaccination behaviors, particularly within specific demographic groups. The lower intention among non-Hispanic White young adult men could be attributed to several factors, such as differing levels of trust in the healthcare system, varying degrees of perceived risk, and different sources of information and influence. Future research should examine these factors within more diverse and larger populations to gain a comprehensive understanding of their impact on vaccination intentions. Additionally, these gender-based differences suggest that public health campaigns may need to adopt tailored strategies that address the unique concerns and motivations of men and women within these communities to enhance vaccine uptake effectively. Addressing such nuances is crucial for developing interventions that are both equitable and effective in reaching all segments of the population.

In the assessment of this study, several crucial considerations come to light. First, one of the study's strengths lies in its foundation on a theory-based approach, particularly focusing on the intentions of young adults related to COVID-19 booster shots. However, it is essential to recognize the study's limitations. First, the findings may not be universally applicable to all young adults due to the convenience sampling method used and the study's limited geographic scope, limited to a single city in the United States. Additionally, a notable aspect of our study is the overrepresentation of certain populations, particularly individuals identifying as bisexual, compared to other national surveys. This may be attributed to our specific focus on young adults from Generation Z, a demographic characterized by a higher representation of LGBTQ+ individuals.[69] Second, our model did not account for broader socio-cultural influences, such as school or workplace vaccine policies, including vaccine mandate policies. Future research should consider integrating multi-level theoretical frameworks to better comprehend and address these broader influences on vaccination behavior. Third, we also did not include the construct of "actual behavior" in our model. This decision was primarily due to the constraints of our study design and data collection methodology. Our data collection was conducted during a period when COVID-19 vaccination boosters were newly available, making it challenging to measure "actual behavior" reliably. Many participants had not yet had the opportunity to act on their intentions due to various external factors, such as vaccine availability and appointment scheduling issues. Therefore, we concentrated on "behavioral intention" as a proximal outcome, which is a strong predictor of "actual behavior" according to TPB. Despite this limitation, our study contributes valuable insights into the early stages of the

decision-making process, which are essential for designing effective public health interventions. Fourth, although we employed Little's MCAR test to examine whether multiple imputation was an adequate technique to handle missing data, we acknowledge that unmeasured constructs or the value of the variables with missing data could be associated with missingness in this data. Next, in the use of cross-sectional data to test a SEM model, it is crucial to clarify that the models are not designed to depict a causal pathway. This cross-sectional design, while valuable for providing a snapshot of young adults' intentions, may not fully account for the dynamic nature of the situation, characterized by evolving vaccine availability and shifting recommendations. To gain a more comprehensive understanding of how young adults' intentions change over time in response to these developments, longitudinal studies could provide further insight. Finally, our CFA results produced suboptimal fit indices initially and required modification. However, it is noteworthy that the fit improved once the theoretical pathways of the TPB were modeled onto our data, both in the overall sample and in racial/ethnic subgroup analyses, suggesting that the inclusion of theoretically-driven pathways enhanced the model's explanatory power and alignment with the observed data.

Conclusion

This study underscores the importance of subjective norms and the influence of social networks in motivating young adults to receive the COVID-19 vaccine booster. Public health interventions should prioritize leveraging social influences and trusted sources to promote COVID-19 booster uptake among young adults. Strategies should harness the power of social networks and encourage discussions within peer groups and healthcare provider interactions, emphasizing endorsements from respected health authorities. Integrating digital platforms and social media influencers could be a novel approach to reaching young adults. Collaborations with influencers who resonate with this demographic can amplify messages about the importance of COVID-19 boosters. Additionally, creating interactive online forums or virtual events where young adults can engage with healthcare professionals and peers in real-time discussions about vaccination could foster a more informed and supportive community. These digital engagement strategies, combined with culturally sensitive messaging and the leveraging of social networks, can create a more robust and effective campaign to increase COVID-19 booster uptake among young adults.

As the COVID-19 vaccination effort continues, understanding the dynamics of young adults' vaccine intentions is crucial. These findings can inform targeted and effective public health interventions that take into account the unique perspectives and influences that shape young adults' decisions about vaccination.

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Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors on request.

Human rights

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the University of Pennsylvania Institutional Review Board (IRB protocol#: 848650).

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