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Explaining higher Covid-19 vaccination among some US primary care professionals

Qian Huang [a], Melissa B. Gilkey [a,b], Peyton Thompson [c], Brigid K. Grabert [a,b], Susan Alton Dailey [a], Noel T. Brewer [a,b,*]

[a] Department of Health Behavior, Gillings School of Global Public Health, University of North Carolina, USA
[b] Lineberger Comprehensive Cancer Center, University of North Carolina, USA
[c] Department of Pediatrics, Division of Infectious Diseases, School of Medicine, University of North Carolina, USA

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ABSTRACT

Background and objective: Research in several countries shows higher Covid-19 vaccination willingness and uptake among physicians than nurses. Our paper aims to characterize and explain this difference.

Methods: In early 2021, we surveyed 1047 U.S. primary care professionals who served adolescents, ages 11–17. The national sample included physicians (71%) as well as nurses and advanced practice providers. The survey assessed the three domains of the Increasing Vaccination Model: *thinking and feeling*, *social processes*, and *direct behavior change*.

Results: Covid-19 vaccine uptake was higher among physicians than among nurses and advanced practice providers (91% vs. 76%, $p < .05$). Overall, in the *thinking and feeling* domain, higher confidence in Covid-19 vaccination, higher perceived susceptibility to the disease, and stronger anticipated regret were associated with higher vaccine uptake (all $p < .05$). In the *social processes* domain, perceiving more positive social norms for Covid-19 vaccination, receiving recommendations to get the vaccine, and wanting to help others were associated with higher vaccine uptake (all $p < .05$). In the *direct behavior change* domain, receiving an invitation to get the vaccine and better access to vaccination were associated with higher uptake (both $p < .05$). Of these variables, most of the *thinking and feeling* and *social processes* variables mediated the association of training with vaccine uptake.

Conclusions: Physicians had higher Covid-19 vaccine uptake than nurses and advanced practice providers, corresponding with their more supportive vaccine beliefs and social experiences. Efforts to reach the remaining unvaccinated cohort can build on these findings.

1. Introduction

The Covid-19 pandemic has led to an estimated 386 million people infected with the virus globally and has claimed the lives of more than 5 million people, as of February 2022 (World Health Organization, 2022). Clinical trials and post-licensure surveillance have established that several Covid-19 vaccines effectively prevent serious health problems and death from the disease (Baden et al., 2021; Polack et al., 2020). To date, over 10 billion doses of Covid-19 vaccines have been administered worldwide, including over 541 million doses in the US (Centers for Disease Prevention and Control, 2022a; World Health Organization, 2022). In the largely high-income countries with widespread availability, vaccination is associated with declines in Covid-19 morbidity and mortality (Abu-Raddad et al., 2021; Benenson et al., 2021; Hall et al., 2021).

When Covid-19 vaccinations first became available, the U.S. prioritized vaccinating physicians and other health care workers. They are at high risk of exposure to Covid-19 when providing care to patients (Bandyopadhyay et al., 2020). In addition, virus-related isolation and quarantine place extra burdens on them (Benenson et al., 2021). While Covid-19 vaccine uptake has been high among health care workers, some have not received vaccination (Kwok et al., 2021). Research in

Abbreviations: PA, physician assistant; NP, nurse practitioner; IVM, Increasing Vaccination Model.

* Corresponding author. Department of Health Behavior, Gillings School of Global Public Health, University of North Carolina, 325 Rosenau Hall CB 7440, Chapel Hill, NC, 27599, USA.
E-mail address: ntb@unc.edu (N.T. Brewer).

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several countries shows that physicians have higher Covid-19 vaccination willingness and uptake than nurses (Kose et al., 2020; Kwok et al., 2021; Maraqa et al., 2021). This discrepancy raises concerns about nurses' health and the health of their patients (Lipsitch and Dean, 2020). As efforts to vaccinate adolescents continue, both physicians and nurses play an important role as advocates for the vaccine.

1.1. The Increasing Vaccination Model

To better understand why health care workers get Covid-19 vaccines, we adopted the Increasing Vaccination Model (IVM) (Brewer, 2021; Brewer et al., 2017). The Centers for Disease Control and Prevention and the World Health Organization have been using the model to organize vaccination uptake research and programs (National Academies of Sciences and Medicine, 2020; World Health Organization, 2018). WHO has used an adapted version of the model to develop surveys to understand childhood vaccine uptake and receipt of Covid-19 vaccines among older adults and health workers (Bolsewicz et al., 2021; Wiley et al., 2021). CDC has used the same adapted model to develop surveys on uptake of Covid-19 vaccines among adults and children (Centers for Disease Control and Prevention, 2021).

The first domain of the IVM, what people *think and feel*, includes disease risk appraisals, vaccine confidence, and motivation (or hesitancy). *Risk appraisals* encompass people's perceived susceptibility to and severity of disease, fear of infection and disease, and anticipated regret (Kiviniemi et al., 2018). *Vaccine confidence* refers to perceived importance, safety, and trustworthiness of a vaccine (Shapiro et al., 2021). *Motivation* refers to willingness or intention to get a vaccine as well as hesitancy (Shapiro et al., 2021). Correlational studies support all of these constructs as correlates of vaccination (Brewer et al., 2007; Schmid et al., 2017). Randomized trials have not yet found that interventions reliably increase vaccine uptake through these pathways (Parsons et al., 2018).

The second domain, *social processes*, includes social norms and social preferences. Social norms encompass descriptive norms about others' vaccination behavior and injunctive norms about what influential people want the person to do (Fishbein and Ajzen, 2011). Social preferences encompass altruistic beliefs about delaying vaccination ("I delayed vaccination so that others could get it first") and freeriding beliefs ("Others are getting vaccinated so I don't have to"). These social processes are reliably associated with vaccination behavior in correlational studies (Schmid et al., 2017), in lab experiments without behavioral outcomes (Shim et al., 2012), and in intervention work in other behaviors (Zhang and Centola, 2019). However, randomized trials have yet to establish that interventions increase vaccination through these pathways (Schmid et al., 2017). The model identifies the importance of a provider recommendation, and such recommendations may rely on dynamics from each of the domains. For the sake of simplicity, we place provider (and other) recommendations in social processes.

The third domain, *direct behavior change*, concerns forces that promote vaccination without changing what people think or feel, or the social world they live in. The domain encompasses barriers to vaccination (e.g., inadequate vaccine supply and difficulties in making appointments) that can interrupt acting on existing good intentions to vaccinate and thus reduce vaccination uptake (Schmid et al., 2017). The domain also includes the effects of interventions designed to facilitate vaccination, such as reminder or recall and onsite vaccination (Jacobson Vann et al., 2018; Milkman et al., 2021; The Community Guide, 2008). Interventions in this last category have been among the most reliable in generating intervention effects, although some reviews have found limitations to their impact (Chang et al., 2021; Yokum et al., 2018).

In the current study, we sought to characterize Covid-19 vaccine uptake and beliefs among U.S. pediatric primary care professionals in a national survey. We also sought to explain differences in vaccination between physicians, nurses, and other primary care professionals, based on constructs in the three domains of the IVM.

2. Methods

2.1. Participants

Study participants were U.S. primary care professionals who served adolescents ages 11–17 and were members of a standing survey panel assembled by an international survey company. Participants included physicians, physician assistants (PAs), nurse practitioners (NPs), and nurses. Recruitment for the panel included online registration, referrals, marketing emails, digital ads, and a verification process for identity validation. For our survey, eligible participants were physicians, nurses, and advanced practice providers (i.e., physician assistants and nurse practitioners) who served adolescents (ages 11–17) in the U.S. (except Vermont because state law excluded their participation). Of the primary care professionals invited to participate, 1055 responded, yielding response rates of 61% among physicians and 41% among nurses and advanced practice providers (calculated using AAPOR Response Rate 4) (American Association for Public Opinion Research, 2002). We excluded data of eight respondents who reported seeing no adolescent patients, resulting in a final sample size of 1047.

2.2. Procedures

Our study was part of a larger survey on the shortfall of adolescent vaccine uptake during the pandemic, to which we added items about Covid-19 vaccination. In February and March 2021, panel members received an emailed invitation and two reminders and had a two-week window for responding. At the time this survey was in the field, three Covid-19 vaccines had emergency use approval in the U.S.. Participants provided informed consent and completed the survey online. The survey company required responses to all questions; thus no data were missing. After taking the survey, participants received incentives that ranged between $15-$80 (depending on professional experience), with the majority receiving $39. The University of North Carolina institutional review board approved the study protocol.

2.3. Measures

The survey assessed whether respondents had received at least one dose of Covid-19 vaccine, whether they had ever delayed receiving Covid-19 vaccine, and whether they refused to receive Covid-19 vaccine (World Health Organization, 2020). For demographic and professional characteristics, the survey assessed respondents' training (physician vs. non-physician, which included nurses and advanced practice providers), specialty (pediatrics, family medicine, and other areas of medicine), years in practice, number of adolescent patients seen per week, Covid-19 test results, race/ethnicity, gender, practice type, whether their clinic was a member of a healthcare system, proportion of vaccine doses provided through the Vaccines for Children program, whether their clinic had experienced financial difficulties because of Covid-19, location, and area of their clinic. Some demographic items came from Gilkey et al. (2015).

The survey assessed constructs in the three domains of the IVM, where possible using items adapted from WHO (World Health Organization, 2020). In the *thinking and feeling* domain, the survey assessed disease risk appraisal (3 items) and vaccine confidence (5 items). For Covid-19 risk appraisal, the survey assessed perceived susceptibility to Covid-19, anticipated regret for not getting vaccinated (if they were to get Covid-19), and anticipated regret for getting vaccinated (if they were to have a side effect). For Covid-19 vaccination confidence, the survey assessed perceived effectiveness of Covid-19 vaccines, effectiveness against new variants of Covid-19, effectiveness in allowing a respondent to see friends and family, safety of Covid-19 vaccines, and the extent to which a respondent perceived the vaccine licensure was rushed. Because the vaccine confidence items were highly correlated, we calculated a vaccine confidence scale by averaging the five variables ($\alpha = 0.78$). The

Table 1
Demographic correlates of Covid-19 vaccine uptake ($n = 1047$).

	n (%)	Respondents who have received at least one dose/ Total respondents in category (%)	aOR (95% CI)
Respondent characteristics			
Training			
Nurses and advanced practice providers	300 (29)	228/300 (76)	1
Physician	747 (71)	680/747 (91)	2.49 (1.54, 4.03)**
Specialty			
Pediatrics	299 (29)	275/299 (92)	1
Family and other medicine	748 (71)	633/748 (85)	.55 (.33, .91)*
Years in practice			
0–9 years	252 (24)	225/252 (89)	1
10–19 years	395 (38)	343/395 (87)	.99 (.58, 1.67)
20+ years	400 (38)	340/400 (85)	.76 (.45, 1.29)
Adolescent patients seen per week			
1-9 adolescents	283 (27)	244/283 (86)	1
10-24 adolescents	431 (41)	383/431 (89)	1.41 (.86, 2.29)
25+ adolescents	333 (32)	281/333 (84)	1.11 (.66, 1.88)
Positive Covid-19 test results			
No	949 (91)	832/949 (88)	1
Yes	98 (10)	76/98 (78)	.59 (.34, 1.02)
Race			
White	717 (69)	612/717 (85)	1
Asian	170 (16)	162/170 (95)	2.35 (1.07, 5.17)**
Other	160 (15)	134/160 (84)	.67 (.38, 1.12)
Gender			
Female	515 (49)	430/515 (84)	1
Male	492 (47)	444/492 (90)	1.31 (.82, 2.08)
Non-binary/prefer not to say	40 (4)	34/40 (85)	.88 (.30, 2.57)
Clinic characteristics			
Practice			
One provider	127 (12)	106/127 (84)	1
Group practice	569 (54)	487/569 (86)	1.26 (.70, 2.27)
Hospital/academic institution/other	351 (34)	315/351 (90)	1.97 (.99, 3.92)
Member of healthcare system			
No	457 (44)	391/457 (86)	1
Yes	590 (56)	517/590 (88)	.98 (.65, 1.50)
Vaccine doses through the Vaccines for Children program			
0% of doses	177 (20)	155/177 (88)	1
1–49% of doses	613 (59)	527/613 (86)	.72 (.42, 1.25)
50% + of doses	257 (25)	226/257 (88)	.80 (.41, 1.55)
Financial strain due to pandemic			
None, or a little	360 (34)	301/360 (84)	1
A moderate amount	489 (47)	433/489 (89)	1.57 (1.03, 2.38)*
A lot	198 (19)	174/198 (88)	1.35 (.78, 2.34)
Rurality			
Urban	363 (35)	331/363 (91)	1
Suburban	525 (50)	449/525 (86)	.59 (.37, .93)*
Rural	159 (15)	128/159 (81)	.55 (.31, .98)*
Region			
Northeast	265 (25)	238/265 (90)	1
Midwest	247 (24)	212/247 (86)	.73 (.41, 1.28)
South	333 (32)	274/333 (82)	.58 (.34, .97)*
West	202 (19)	184/202 (91)	.97 (.50, 1.88)

Note. Analyses controlled for all variables in table. Other primary care professional = physician assistant, nurse practitioner, and nurse. Latinx $n = 5$, mixed race $n = 20$, missing $n = 86$. Federally qualified health center or community health center $n = 56$, State or local department of public health $n = 7$, local, community, or non-profit organization $n = 31$, other $n = 3$. aOR = adjusted odds ratio. CI = confidence interval.
*$p < .05$; **$p < .001$.

5-point response scale ranged from strongly disagree (coded as 1) to strongly agree (5).

In the *social processes* domain, the survey assessed descriptive and injunctive norms for Covid-19 vaccination (4 items). The 6-point response scale ranged from 0% to 100%. Because these items were highly correlated, we averaged them to create a social norms scale ($\alpha = 0.79$). The survey assessed perceived social stigma from not receiving Covid-19 vaccination, altruistic beliefs ("I delayed getting Covid-19 vaccination so that other people can get it first"), and freeriding beliefs ("Other people getting the Covid-19 vaccine makes me feel like I don't need it"). The 5-point response scale ranged from strongly disagree (coded as 1) to strongly agree (5). The survey also assessed sources of recommendation for Covid-19 vaccine (i.e., family and friends, professional organizations, state or national guidelines, employers, and health care providers).

For the *direct behavior change* domain, the survey assessed self-efficacy to access vaccination ("I am confident I could get a Covid-19 vaccine if I want to") and availability of vaccination at their workplace ("Covid-19 vaccination has been available for me at my place of work"). Additionally, the survey included five questions on perceived barriers to receiving Covid-19 vaccine (e.g., time and location of vaccination and convenience of making appointments). The questions about barriers had a binary response scale of no (coded as 0) or yes (1). Finally, the survey assessed type of information received about the vaccines (none, availability, or an invitation to get vaccinated). The survey also assessed whether respondents received incentives for vaccination and whether their workplace required Covid-19 vaccination (no coded as 0 and yes coded as 1). The full survey is available at https:

//noelbrewer.web.unc.edu/hpv/and the supplemental document (online appendix 2).

2.4. Statistical analysis

We report frequencies for dichotomous variables and mean (M) and standard deviation (SD) for continuous variables. We first examined whether physicians and other primary care professionals (i.e., physician assistants, nurse practitioners, and nurses) had different uptake of Covid-19 vaccine (any doses) using multivariable logistic regression controlling for all demographic variables. We then examined psychological correlates of vaccine uptake using logistic regression controlling for the statistically significant demographic variables. The logistic regressions examined each psychological variable separately because many were highly correlated. We conducted all logistic regression analyses using IBM SPSS version 27 (IBM Corp, 2020). We report adjusted odds ratios (aORs) with 95% confidence intervals (CIs). We modeled vaccination as the outcome as it is a standard for vaccination quality metrics and research (e.g., Healthy People 2030, 2021).

Finally, we examined whether the IVM variables mediated (i.e., explained) the relationship between training and vaccine uptake, following the approach of MacKinnon and colleagues (2000, 2007). We conducted mediation analyses for each IVM variable, controlling for the statistically significant demographic variables. The mediation analyses provided three findings: 1) the *a* pathway of training (physician vs. non-physician) predicting the mediator (psychological variable); 2) the *b* pathway of the mediator predicting vaccine uptake; and 3) the product of pathways *a* and *b*, which was the mediation effect. We conducted all mediation analyses with the lavaan package (version 0.6–8) (Rosseel, 2012) in R (version 4.0.5) (R Core Team, 2021), using maximum likelihood estimation and a bootstrap of 500 iterations. We report standardized regression coefficients with confidence intervals of 95%. Analyses used two-tailed tests and a critical alpha of .05.

3. Results

About 71% of respondents were physicians (Table 1), 12% were nurses, and 17% were advanced practice providers. About 29% specialized in pediatrics or worked in pediatric clinics, and the remainder were associated with family medicine or another specialty (71%). Almost three-quarters of the respondents (73%) saw more than 10 adolescent patients weekly. About 9% had received a positive Covid-19 test result. Respondents' clinics were largely in areas that were suburban (50%) or urban (35%).

In the overall sample, most primary care professionals (87%) had received at least one dose of Covid-19 vaccine. Almost all physicians (91%) had received at least one dose of Covid-19 vaccine. In contrast, only about three-quarters of nurses and advanced practice providers had received the vaccine (76%, aOR = 2.49, 95%CI 1.54–4.03; Table 1). Uptake was higher among Asian compared to white respondents, those working in urban compared to suburban and rural areas, and in the Northeast compared to the South (all $p < .05$).

Not having received the vaccine showed a consistent gradient across training (Fig. 1). Past delayed vaccination was reported by pediatricians (7%), family and other physicians (11%), advanced practice providers (19%), but especially by nurses (23%). Past refusal was less common but again especially prevalent among nurses (3%, 6%, 13%, and 17%), as was not having received the vaccine (5%, 11%, 20%, 29%).

3.1. Psychological correlates of Covid-19 vaccination

What people think and feel. Scores on all vaccine confidence variables (except for rushed licensure) were higher for vaccinated than unvaccinated respondents (all $p < .001$; Table 2). For example, vaccinated respondents believed the vaccine was safer (*M* [*SD*] = 4.50 [0.73] vs. 3.35 [1.17]; aOR = 2.98, 95%CI 2.41–3.68). Vaccinated respondents also believed the vaccine is more effective (*M [SD]* = 4.60 [0.86] vs. *M [SD]* = 3.92 [1.11], aOR = 1.67, 95%CI 1.42–1.98). Higher perceived susceptibility to getting Covid-19 and both measures of anticipated regret were associated with vaccine uptake (all $p < .001$).

Social processes. Social norms were more favorable toward Covid-19 vaccination among vaccinated than unvaccinated respondents (*M [SD]* = 57.74 [25.40] vs. *M [SD]* = 78.61 [15.01], aOR = 1.05, 95%CI 1.04–1.06). All four social norm variables were also associated with vaccine uptake (all $p < .001$). Altruistic motivation for delaying Covid-19 vaccination ("let others get it first") and freeriding beliefs were both less common among vaccinated than unvaccinated respondents (both $p < .001$).

Recommendations to get Covid-19 were common. Respondents had received recommendations guidelines (63%), employers (66%), professional organizations (56%), health care providers (49%), and from friends and family (48%). These recommendations were associated with uptake (all $p < .05$; Table 3).

Direct behavior change. Nearly half of vaccinated respondents (55%) perceived no barriers to accessing Covid-19 vaccination, whereas only 45% of unvaccinated respondents perceived no barriers. The most common perceived barriers were inadequate vaccine supply (34%), difficulty in getting an appointment (22%), the vaccination clinic being too far away (6%), and not being able to get time off work (6%). These perceived barriers were mostly unrelated to vaccine uptake, except for inadequate vaccine supply ($p < .05$).

Respondents who did not receive information about vaccine availability had lower uptake than those who received the information (70% vs. 81%, aOR = 0.53, 95%CI 0.28-0.98). Respondents who received invitations to get a Covid-19 vaccine had higher uptake than those who received only availability information (91% vs. 81%, aOR = 2.60, 95% CI 1.72–3.92). Both self-efficacy to access vaccination and vaccine availability at workplaces were higher among vaccinated than unvaccinated respondents (both $p < .001$). Vaccine uptake was higher among respondents who had received incentives for getting vaccinated compared to respondents receiving no incentives ($p < .05$).

3.2. Mediation

Mediation analyses sought to further explain the difference between physicians and non-physicians in Covid-19 vaccine uptake from the *thinking and feeling* domain, anticipated action regret, anticipated inaction regret, and vaccine confidence partially explained the differences in Covid-19 vaccine uptake (all $p < .001$, Online Appendix 1). From the *social processes* domain, mediators were social norms, altruistic motivation, freeriding beliefs, national guidelines, and recommendations from respondents' own professional societies (all $p < .05$). However, recommendations from employers and health care providers suppressed the association of training and vaccine uptake (both $p < .05$), meaning that the differences between physicians and non-physicians would be larger than observed without these recommendations (MacKinnon et al., 2000). Finally, none of the *direct behavior change* domain variables was a mediator.

3.3. Motivators of future Covid-19 vaccination

When we asked unvaccinated respondents what would motivate them to get the vaccine, the most common response was more data on safety (71%, Fig. 2). The next two most common responses were more data on effectiveness in preventing disease (49%) and more data on effectiveness in preventing transmission (37%).

4. Discussion

In our national study of primary care professionals involved with adolescent vaccination, uptake of Covid-19 vaccine was high overall. Uptake was highest among physicians and lowest among nurses. The

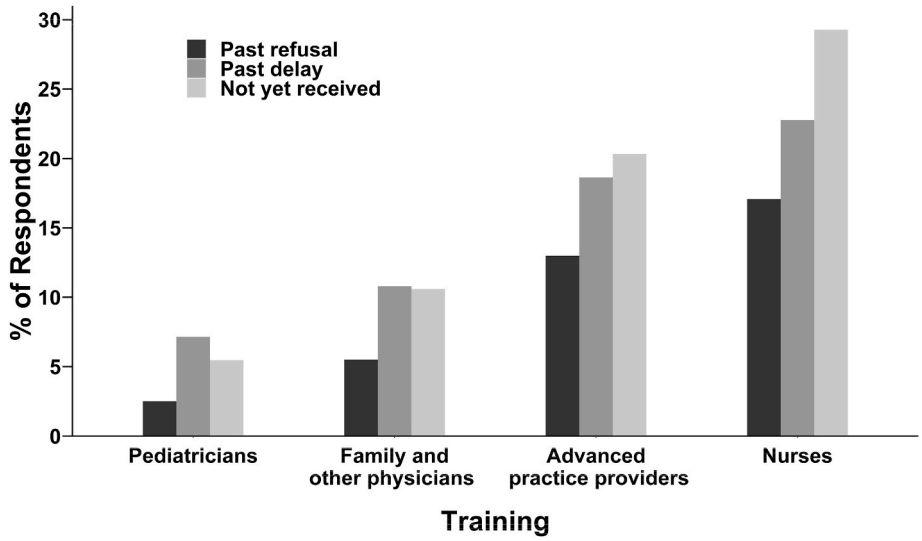

Fig. 1. Covid-19 vaccine refusal, delay, and non-receipt (n = 1047).

correlates of vaccination aligned well with the IVM in each of its three domains—*thinking and feeling*, *social processes*, and *direct behavior change*. The findings offer insight into what motivates vaccination and identify opportunities for future interventions.

Higher proportions of nurses and advanced practitioners were unvaccinated compared to physicians and reported ever having delayed or refused Covid-19 vaccination. These findings are in line with those of Kwok et al. (2021) that seasonal influenza vaccine uptake was lower among nurses. In addition, Shekhar et al. (2021) found lower intentions to get a Covid-19 vaccine among nurses. Lower vaccine uptake among nurses is troubling. Nurses are highly respected by the public (Gallup, 2020); given that they outnumber physicians by about four times (Organisation for Economic Co-operation and Development, 2020), nurses' voices may be particularly influential in their communities and especially in communities where physicians are in short supply. Thus, unvaccinated primary care professionals, especially nurses, pose an unnecessary risk to patients. Regarding other demographics, our findings of higher Covid-19 vaccine uptake for Asian respondents, people from urban areas, and some U.S. regions (e.g., the Northeast) are consistent with other studies (Centers for Disease Prevention and Control, 2022b).

Our study findings are broadly consistent with the IVM. In the domain of *thinking and feeling*, vaccine confidence – including perceived safety, effectiveness against diseases and new variants, ability to see friends and family, and rushed licensure – was associated with vaccine uptake. This aligns with the tradition of social cognitive models of health behavior that emphasize evaluations of hazards and remedial actions (Conner et al., 2017; Martinelli and Veltri, 2021). In our study, the benefits and harms of vaccination were generally stronger mediators than perceived risk, which is broadly consistent with the compatibility principle in the Theory of Reasoned Action in that risk perception is more distal to action (Fishbein and Ajzen, 2011). These findings underline the importance of confidence for ensuring the success of vaccination programs, although methods for reliably raising vaccine confidence are not well understood. Researchers and practitioners should identify more novel and sophisticated approaches to increasing vaccine confidence.

In the domain of *social processes*, social norms, altruistic motivations, and freeriding beliefs were associated with uptake. These findings match those of other studies on COVID-19 vaccination among health care professionals in other countries (Kaplan et al., 2021; Rosental and Shmueli, 2021). A defining characteristic of COVID-19 vaccination has been the polarization and vocal demonstration of one's vaccination status in social media and other forums (Al-Hasan et al., 2021). These expressions likely made norms both for and against vaccination much more knowable and salient (Cucciniello et al., 2022), in line with the Theory of Reasoned Action (Lueck and Spiers, 2020; Matute et al., 2021) and the IVM (Brewer et al., 2017). It may be useful for professional societies and clinics to establish clear recommendations around Covid-19 vaccination to help boost Covid-19 vaccine uptake (Klompas et al., 2021; Rothstein et al., 2021). Interestingly, we found that recommendations from employers and health care providers suppressed some of the differences by training because recommendations were more commonly received by non-physicians; more nurses who had received a recommendation were vaccinated than those who had not. Future studies should explore whether improving these recommendations is a promising way to increase uptake among non-physicians.

In the domain of *direct behavior change*, we found that behavioral nudges – receiving an invitation to get the vaccine, having vaccination available at the workplace, and incentives – were all associated with vaccine uptake. Moreover, inadequate vaccine supply was associated with lower vaccine uptake. Greater self-efficacy to access vaccination was associated with greater uptake, which aligns with several previous findings (Kreps et al., 2020; Neufeind et al., 2020). This association also underscores the importance of self-efficacy in informing health behavior, as suggested by the Theory of Reasoned Action (Fishbein and Ajzen, 2011). The findings for this domain align with previous research, showing the strength of behavioral nudges in encouraging vaccination and suggesting opportunities for interventions (Becchetti et al., 2021; Brewer et al., 2017). It is somewhat surprising that the variables in the *direct behavior change* were among the least explanatory of variables in the three domains of the IVM. It may be because some of the interventions operate in ways that people have little ability to self-reflect on (Nisbett and Wilson, 1977).

Analyses found mediators in two IVM domains (*thinking and feeling* and *social processes*), but no mediators came from the *direct behavior change* domain. Many of the *direct behavior change* constructs were associated with vaccination. They did not, however, vary across physicians and other primary care professionals, which may reflect the similarity of their work settings. Also, the rollout of Covid-19 vaccines happened quickly in US, especially for health care professionals who were among the first eligible groups. In contrast, Chu and Liu (2021) found that inequity in distribution of Covid-19 vaccines was a barrier to accessing vaccination in the general public.

Table 2
Psychological correlates of Covid-19 vaccine uptake, continuous variables (n = 1, 047).

	Unvaccinated (n = 139) Mean (SD)	Vaccinated (n = 908) Mean (SD)	aOR (95% CI)
What people think and feel			
Disease risk appraisal			
Perceived susceptibility to Covid-19	2.37 (1.18)	2.84 (1.21)	1.29 (1.09, 1.52)**
Anticipated inaction regret	3.52 (1.34)	4.41 (1.02)	1.69 (1.46, 1.95)**
Anticipated action regret	3.85 (1.22)	2.76 (1.25)	.52 (.44, .62)**
Vaccine confidence			
Vaccine confidence scale	3.24 (1.00)	4.26 (.62)	4.28 (3.26, 5.62)**
Perceived effectiveness	3.92 (1.10)	4.60 (.86)	1.67 (1.42, 1.98)**
Perceived effectiveness against new variants	3.07 (1.10)	3.87 (.89)	2.24 (1.82, 2.76)**
Allows me to see friends and family	3.03 (1.13)	3.46 (1.07)	1.40 (1.18, 1.66)**
Perceived safety	3.35 (1.17)	4.50 (.73)	2.98 (2.41, 3.68)**
Rushed licensure	3.39 (1.28)	1.93 (1.06)	.39 (.32, .46)**
Social processes			
Social norms			
Social norms scale	57.74 (25.40)	78.61 (15.01)	1.05 (1.04, 1.06)**
Descriptive norms, doctors	62.96 (28.61)	85.87 (16.22)	1.04 (1.03, 1.05)**
Descriptive norms, nurses	61.52 (26.43)	74.93 (19.51)	1.03 (1.02, 1.03)**
Descriptive norms, other clinic staff	57.02 (28.27)	69.22 (22.84)	1.02 (1.01, 1.03)**
Injunctive norms: family, friends want me to	49.46 (35.92)	84.40 (21.98)	1.04 (1.03, 1.04)**
Reduced social stigma	3.47 (1.02)	3.59 (.94)	1.11 (.91, 1.34)
Social preferences			
Altruistic motivation (let others get it first)	2.88 (1.44)	1.90 (1.15)	.57 (.49, .66)**
Freeriding beliefs	1.99 (1.03)	1.43 (.89)	.60 (.50, .71)**
Direct behavior change			
Vaccine available at workplace	3.28 (1.66)	4.12 (1.44)	1.42 (1.27, 1.59)**
Self-efficacy to access vaccination	4.13 (1.08)	4.43 (.97)	1.37 (1.15, 1.62)**

Note. Analyses controlled for training, specialty, respondent race/ethnicity, clinic rurality, clinic financial strain, and clinic region. SD = standard deviation. OR = odds ratio. aOR = adjusted odds ratio. CI = confidence interval. Online Appendix 1 reports more details from the mediation analyses.
*$p < .05$; **$p < .001$.

Table 3
Psychological correlates of Covid-19 vaccine uptake, categorical variables (n = 1, 047).

	Respondents who have received at least one dose/Total respondents in category (%)	aOR (95% CI)
Social processes		
Recommendation from friends or family		
No	452/540 (84)	1
Yes	456/507 (90)	1.58 (1.08, 2.31)*
Recommendation from own professional organization		
No	374/459 (82)	1
Yes	534/588 (91)	1.92 (1.31, 2.81)**
Recommendation from state or national guidelines		
No	312/387 (81)	1
Yes	596/660 (90)	1.98 (1.36, 2.89)**
Recommendation from employer		
No	285/354 (81)	1
Yes	623/693 (90)	2.52 (1.71, 3.70)**
Recommendation from healthcare provider		
No	451/539 (84)	1
Yes	457/508 (90)	1.95 (1.32, 2.87)**
Direct behavior change		
Inadequate vaccine supply		
No	615/696 (88)	1
Yes	293/351 (84)	.57 (.39, .84)*
Clinic too far away		
No	850/982 (87)	1
Yes	58/65 (89)	1.42 (.62, 3.30)
Difficulty getting an appointment		
No	709/820 (87)	1
Yes	199/227 (88)	1.00 (.62, 1.59)
Appointments takes too long		
No	863/996 (87)	1
Yes	45/51 (88)	1.10 (.44, 2.73)
Cannot get off work		
No	856/984 (87)	1
Yes	52/63 (83)	.72 (.35, 1.48)
Lack of childcare/eldercare		
No	891/1029 (87)	1
Yes	17/18 (94)	2.17 (.27, 17.22)
Information received		
No information	50/71 (70)	.53 (.28, .98)*
Availability of Covid-19 vaccination (ref.)	247/306 (81)	1
Invitation to get it	611/670 (91)	2.60 (1.72, 3.92)**
Workplace offered incentives for Covid-19 vaccination		
No	814/949 (86)	1
Yes	94/98 (96)	4.06 (1.44, 11.44)*
Workplace required Covid-19 vaccination		
No	839/972 (86)	1
Yes	69/75 (92)	1.69 (.70, 4.05)

Note. Analyses controlled for training, specialty, respondent race/ethnicity, clinic rurality, clinic financial strain, and clinic region. aOR = adjusted odds ratio. CI = confidence interval. Online Appendix 1 reports more details from the mediation analyses.
*$p < .05$; **$p < .001$.

4.1. Limitations

Study strengths include the national sample, theory-based approach, and behavioral outcome. Study limitations include the cross-sectional study design, which limits our ability to make causal inferences about relationships among the variables. It is plausible, for example, that people with higher confidence in vaccination would gravitate to training in prescribing roles, such as that of physicians and advanced practice providers. In addition, our study included US primary care professionals who served adolescents, ages 11–17, as part of a larger project on the shortfall of adolescent vaccines during the pandemic. The generalizability of our findings to other sectors of health care and to other countries remains to be established. Many of the mediation pathways were relatively small, but the general pattern of findings was conceptually meaningful. Future studies should continue exploring the

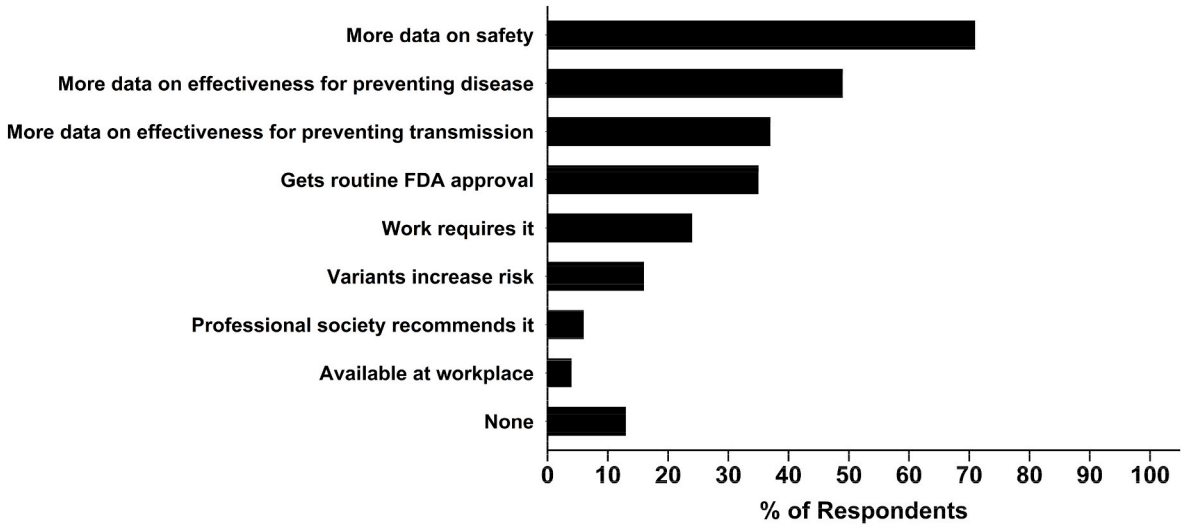

Fig. 2. Factors that would motivate unvaccinated respondents to get Covid-19 vaccination ($n = 68$).

mediating role played by these variables. Last, like most survey studies, our project relied on self-report rather than medical records to evaluate vaccine uptake. Self-reported vaccination is generally reliable (King et al., 2018; MacDonald et al., 1999) and may be especially so for Covid-19 vaccination given the intensive focus on the pandemic at the time, but we are unaware of data yet establishing the reliability of self-report for this relatively new vaccine.

5. Conclusions

Covid-19 vaccine uptake was higher among physicians than nurses and advanced practice providers in the context of US adolescent primary care. Although among the first groups prioritized for vaccination, some primary care professionals in our study were not vaccinated. Lower uptake among nursing staff is especially worrisome. The findings were broadly consistent with the IVM, with clear support for the *thinking and feeling* and *social processes* domains. Of course, many reliably effective interventions are in the *direct behavior change* domain, such as incentives and requirements, but were not yet widely implemented in the US when we conducted our study. Our findings provide valuable context for these interventions and programs.

Credit author statement

Qian Huang: Data analysis, Drafting of original and revised manuscript. Melissa B. Gilkey: Conceptualization, Methodology, Drafting of original and revised manuscript. Peyton Thompson: Drafting of original and revised manuscript. Brigid K. Grabert: Drafting of original and revised manuscript. Susan Alton Dailey: Data collection, Drafting of original manuscript. Noel T. Brewer: Conceptualization, Methodology, Data analysis, Drafting of original and revised manuscript.

Conflict of interest disclosures (includes financial disclosures)

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2022.114935.

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