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Do Side Effects to the Primary COVID-19 Vaccine Reduce Intentions for a COVID-19 Vaccine Booster?

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Abstract:	Background Vaccines are being administered worldwide to combat the COVID-19 pandemic. Vaccine boosters are essential for maintaining immunity and protecting against virus variants. The side effects of the primary COVID-19 vaccine (e.g., headache, nausea), however, could reduce intentions to repeat the vaccination experience, thereby hindering global inoculation efforts. Purpose The main aim of this research was to test whether side effects to a primary COVID19 vaccine relate to reduced intentions to receive a COVID-19 booster. The second aim was to explore psychological and demographic predictors of booster intentions. Methods Secondary data analyses were conducted on a US national sample of 551 individuals recruited through the online platform Prolific. Key measures in the data set were side effects reported from a primary COVID-19 vaccination and subsequent intentions to receive a booster vaccine. Psychological and demographic variables that predicted

	primary vaccination intentions in prior studies were also measured. Results Booster intentions were high. COVID-19 booster vaccine intentions were uncorrelated with the number of side effects, intensity of side effects, or occurrence of an intense side effect from the primary COVID-19 vaccine. Correlational and regression analyses indicated intentions for a booster vaccination increased with positive vaccination attitudes, trust in vaccine development, worry about the COVID-19 pandemic, low concern over vaccine side effects, and Democratic political party affiliation. Conclusions Side effects to a primary COVID-19 vaccine were not directly associated with lower intentions to receive a booster of the COVID-19 vaccine. However, many variables that predict primary vaccination intentions also predict booster intentions.
Response to Reviewers:	Dr. Ma, My co-authors were delighted to hear you are recommending the manuscript “Do Side Effects to the Primary COVID-19 Vaccine Reduce Intentions for a COVID-19 Vaccine Booster?” (ANBM-D-21-00484) for publication to the journal Annals of Behavioral Medicine. Please find uploaded word files of all manuscript documents., Thank you for your efforts regarding this paper. Sincerely, Dr. Andrew L. Geers Professor of Psychology Department of Psychology University of Toledo

Do Side Effects to the Primary COVID-19 Vaccine Reduce Intentions for a COVID-19 Vaccine Booster?

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Running Head: COVID-19 Booster Vaccine

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Abstract

Background: Vaccines are being administered worldwide to combat the COVID-19 pandemic. Vaccine boosters are essential for maintaining immunity and protecting against virus variants. The side effects of the primary COVID-19 vaccine (e.g., headache, nausea), however, could reduce intentions to repeat the vaccination experience, thereby hindering global inoculation efforts.

Purpose: The aim of this research was to test whether side effects to a primary COVID-19 vaccine relate to reduced intentions to receive a COVID-19 booster. The secondary aim was to test if psychological and demographic factors predict booster intentions.

Methods: Secondary data analyses were conducted on a US national sample of 551 individuals recruited through the online platform Prolific. Key measures in the data set were side effects reported from a primary COVID-19 vaccination and subsequent intentions to receive a booster vaccine. Psychological and demographic variables that predicted primary vaccination intentions in prior studies were also measured.

Results: Booster intentions were high. COVID-19 booster vaccine intentions were uncorrelated with the number of side effects, intensity of side effects, or occurrence of an intense side effect from the primary COVID-19 vaccine. Correlational and regression analyses indicated intentions for a booster vaccination increased with positive vaccination attitudes, trust in vaccine development, worry about the COVID-19 pandemic, low concern over vaccine side effects, and Democratic political party affiliation.

Conclusions: Side effects to a primary COVID-19 vaccine were not directly associated with lower intentions to receive a booster of the COVID-19 vaccine. However, many variables that predict primary vaccination intentions also predict booster intentions.

Keywords: Side effects; reactogenicity, booster; vaccine; intentions, COVID-19

Introduction

Vaccination is a critical step for ending the pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). To date, it is estimated that 6.86 billion doses of coronavirus disease 2019 (COVID-19) vaccines have been administered worldwide [1]. Although primary vaccination is critical to overcoming the pandemic, it may not be sufficient to deliver long-term protection against SARS-CoV-2. Neutralizing antibodies from a primary vaccine are expected to wane over time, requiring supplemental boosters [2]. Randomized clinical trials of COVID-19 booster doses with both mRNA and viral vector vaccines have thus far supported the benefit of administering boosters [3–5]. How soon booster vaccines should be given after primary vaccination is currently debated. In the U.S., the Centers for Disease Control and Prevention (CDC) currently endorses a booster vaccine six months following primary vaccination [6]. Based on this recommendation, by the end of the 2021 calendar year, approximately 160 million individuals in the U.S. alone qualified for a COVID-19 booster [7]. Consequently, combating COVID-19 now includes the challenge of encouraging vaccinated individuals to obtain booster shots.

As individuals are often more willing to repeat a protective health behavior than implement a new protective behavior, uptake of booster vaccines could be less challenging than initial vaccination [8,9]. However, important challenges to receiving boosters may arise. For example, we know from the Theory of Planned Behavior (TPB) that personal attitudes towards a protective health behavior can impact our intentions to and subsequent engagement in such behaviors [10]. Indeed, studies have shown that positive attitudes towards the initial COVID-19 vaccination program predicted intentions to receive the COVID-19 vaccine [11–13]. As such, it was anticipated that factors that lower primary vaccination motivation, such as negative attitudes toward vaccination and lack of trust in vaccine development, act as barriers to receiving booster doses [14–16].

Another potential barrier to COVID-19 booster vaccination intentions is the side effects from the primary COVID-19 vaccines. Many side effects have been reported for COVID-19 vaccines, with the CDC listing the most likely side effects in the U.S. as injection site pain and swelling, fatigue, headache, muscle pain, chills, fever, and nausea [17]. In one survey, 70% of community members reported COVID-19 vaccine side effects, with the most common being fatigue/tiredness (58.2%) and injection site pain and swelling (53.5%) [18]. Although COVID-19 vaccine side effects are primarily non-serious, their frequency and unpleasantness may significantly lessen the desire to repeat the vaccination experience [19]. This is underpinned by theories of health behavior including the Health Belief Model (HBM; [20]), and Protection Motivation Theory (PMT; [21]) whereby the perceived barriers and costs of engaging in a protective health behavior, can reduce intentions, even when the behavior has known beneficial outcomes. Therefore, unsurprisingly, concerns about vaccine side effects have found to be associated with lower COVID-19 primary vaccination intentions [22]. Taken together, these findings lead us to expect the experience of side effects to COVID-19 vaccines, in particular the amount and intensity of the side effects experienced (adding to the perceived barriers/costs), would reduce uptake of a COVID-19 booster vaccine.

This issue was assessed in the present research via secondary data analyses of a prospective longitudinal study of a US national sample [23]. We tested the hypothesis that booster intentions are related to the total number of side effects reported, the intensity of side effects reported, as well as if the participant reported experiencing an intense side effect from the primary COVID-19 vaccine. Moreover, we assessed the relationship between booster intentions and a diverse range of potential side effects in addition to the primary side effects reported in the initial COVID-19 vaccine clinical trials and publicized by the CDC. Also, research has found that side effects vary with the vaccine received. For example, in the US,

the Moderna vaccine generated more side effects than the Pfizer-BioNTech or Janssen/Johnson & Johnson vaccines [24]. We surmised that vaccine reactogenicity may moderate the link between side effects and booster intentions, such that vaccines causing more side effects would be the most likely to be associated with reduced booster intentions. Therefore, we also analyzed the relationship between side effect reports and booster intentions separately by vaccine type (Pfizer-BioNTech, Moderna, or Janssen/Johnson & Johnson).

As a secondary aim, we tested if variables previously related to primary COVID-19 vaccination intentions, predicted booster vaccine intentions, as underpinned by prominent theories of health behavior.

Methods

Study design and sample

We analyzed data from a preregistered prospective longitudinal study conducted with a US national sample of individuals aged ≥18 years (Open Science Framework, https://osf.io/h7pzg/). The sample size for that original study was based on a power analysis conducted using the Pwr2Ppl package for R [25] to ensure that the sample was sufficient to detect psychological predictors of vaccine side effects [26]. Using a small to medium effect size (r = .2) to obtain .95 power with an alpha of .05, the power analysis indicated the original study required 500 participants. The obtained sample of 551 individuals, with alpha set to .05, provides 94% power to detect a modest correlation of r = .15. Participants were enrolled through the online recruitment platform, Prolific [27]. The study, approved by the local Institutional Review Board (board and ID # redacted for blind review), consisted of two surveys, one completed pre-vaccination (Survey 1) and the other post-vaccination (Survey 2). Vaccination status was substantiated by Prolific's recruitment management system for Survey 1, self-reports at the start of both surveys, and for Survey 2, information listed on

participants' CDC vaccination card. Participants provided digital informed consent before beginning Survey 1.

Survey 1 assessed psychological and demographic predictor variables and Survey 2 assessed vaccine side effects and booster intentions. Eligibility criteria for Survey 1 included not yet having received a COVID-19 vaccine, as indicated in both the Prolific recruitment management system and self-reported at the beginning of Survey 1. Individuals were ineligible for participation if they reported having no intention of receiving a COVID-19 vaccine. Survey 1 was open between April 15th to 28th, 2021, and Survey 2 was opened 5 weeks after the conclusion of Survey 1, between May 21st and July 19th, 2021. Eligibility for Survey 2 included completing Survey 1 and a full COVID-19 vaccination since responding to Survey 1. This resulted in a final sample of 551 individuals. Although full vaccination status was not available for non-responders of Survey 2, 585 of the 1561 individuals completing Survey 1 reported to the Prolific recruitment system they had received at least one COVID-19 vaccine dose by the close of Survey 2. This provides an approximated 94% retention rate. Sample characteristics are shown in Table 1.

Outcome Measure

Booster intentions. Two Likert-type items were provided at the end of Survey 2 to assess booster intentions. The items were derived from prior vaccination research [28,29]. The questions were, "If it is recommended in the United States, I want to get a booster shot within a year to maintain my vaccination against the COVID-19 viruses" and "If it is recommended in the United States, I intend to receive a COVID-19 booster shot within a year". Responses to both items were made on a scale ranging from 1 *(strongly disagree*) to 10 (*strongly agree*). Scores on the scales were highly correlated ($r = .85$, $p < .0001$) and were averaged to create an index of booster intentions.

Primary Predictors

Vaccine side effects. To assess COVID-19 vaccine side effects in Survey 2, participants completed the 36-item General Assessment of Side Effects scale (GASE; [30]), modified to include nine additional symptoms relevant to COVID-19 and vaccine side effects, such as pain at the injection site (the side effect list is provided in the supplemental material). For each of the 45 symptoms, participants indicated the side effects they experienced as a direct result of their COVID-19 vaccination (0, *not experienced*; 1, *mild intensity*; 2, *moderate*; 3, *severe*). Given the recent public discourse about mild versus severe disease, we included definitions of mild (*complaint causes mild distress or discomfort, but no impairment in daily functioning*), moderate (*complaint causes moderate distress or discomfort or at least some impairment in daily functioning*), and severe (*complaint causes severe distress and discomfort, severe impairment in daily functioning, or acute danger to health*) symptom experiences for participants, with a focus on impact on daily functioning. To avoid confusion with severe vaccine side effects, herein we refer to the highest responses on the side effect scales as “intense”.

This is a more comprehensive side effect assessment than is frequently used to assess COVID-19 vaccine side effects. The benefit of this broader assessment is the ability to identify unexpected symptoms that were attributed as vaccine side effects. A similar approach has been used in previous research into travel vaccinations [31]. As two of the available vaccines required two doses, whereas one vaccine required a single dose, instructions directed participants to report all side effects they experienced from their entire vaccination experience (one or two doses). This strategy was employed to collect all pre- and post-vaccination responses in two survey waves. Due to the greater availability of the two-dose vaccines at the time of data collection, most participants received a two-dose vaccine (89.5%, see Table 1) and thus reported side effects aggregated across both doses.

To examine the possibility that side effects relate to booster intentions, three different types of scales were created from these side effect items. First, a *total number of side effects scale* was created by counting the number of side effects participants reported out of all possible side effects listed, resulting in scores ranging between 0 and 45. Second, a *total side effect intensity scale* was created by summing responses on the experienced side effects, resulting in scores ranging between 0 and 135. Third, a dichotomous *occurrence of an intense side effect scale* was created, with those participants indicating they experienced any side effect as severe given the value of "1", and the remaining participants the value of "0". These three measures allow us to test if the number of side effects experienced, intensity of experienced side effects (overall symptom load; [32,33]), or the experience of an intense side effect relate to booster intentions. Finally, because it is possible that participants would respond differently to the full range of side effect items and the side effect items specifically publicized by the CDC, the three aforementioned side effect scales were created separately for all the 45 side effect items and for the 7 side effect items announced by the CDC (i.e., pain at injection site, fever, chills, headache, joint pain, nausea, fatigue). This resulted in 6 side effect indices (Table 2). These different combinations were examined because prior to data analysis, it was unknown as to which combination of side effects may relate to booster intentions (if any). For example, one could anticipate that a higher intensity of CDC side effects would be the most predictive, as the CDC side effects were the most likely to be experienced. Alternatively, one could also anticipate that it would be the higher intensity of all possible side effects (overall symptom load), CDC and non-CDC, that would be most predictive, as this variable would capture a full array of unwanted negative outcomes that followed vaccination.

Secondary Predictors

The secondary predictors were administered in Survey 1 and were variables previously found to predict intentions to obtain a primary COVID-19 vaccine. The psychological variables included vaccination attitudes [16,34,35], vaccine-related trust [14,15,36], worry about the COVID-19 pandemic [37], and concern of COVID-19 vaccine side effects [38,39]. For data analysis purposes, the demographic variables of sex [40], race (White or another race) [38,40], and political party affiliation (Democratic party affiliated or not) [41] were subsequently recoded dichotomously, age continuously [38], and income, and education [38,40,41] ordinally. The demographic questions are presented in the Supplemental Materials and the percentages and number of individuals identifying with the different demographic groupings are presented in Table 1.

Vaccination attitudes. Anti-vaccination attitudes were assessed with the 12-item Vaccine Attitudes Examination (VAX) Scale [42]. An example scale item is, "vaccination programs are a big con." Responses could vary from 1 (*strongly disagree*) to 5 (*strongly agree*). In prior studies, the VAX scale has displayed high internal reliability (α = .86) and test-reliability over one month (r = .84). Previous studies have found VAX scores to predict primary COVID-19 vaccination intentions [16,34,35]. Here, all items were averaged to create a total scale (α = .90), with higher scores equating to stronger anti-vaccination attitudes.

Trust in vaccine development. Four items, previously used by Webster and Rubin [43], assessed trust in vaccine development. An example item is, "I trust the current process through which vaccines are developed". Responses range from 1 (*strongly disagree*) to 5 (*strongly agree*). Scores on the four items were averaged (α = .88), with high scores indicating greater trust.

Worry about the COVID-19 pandemic. The seven-question COVID-19 worry scale was used to assess COVID-19 worry [44,45]. Each question is rated on a 1 (*not at all*) to 5 (*very much*) scale. An example item is, "How concerned are you about yourself being

affected by COVID-19?". Responses were averaged to create a total scale, with higher values signifying greater worry about the COVID-19 pandemic (α = .92).

Concern over COVID-19 vaccine side effects. Three items, based on previous research [28,40,46], measured concern about vaccine side effects. The items asked how worried, nervous, and scared participants were about COVID-19 vaccine side effects (e.g., "How nervous are you about experiencing side effects?"). Responses were on a 1 (*not at all*) to 5 (*extremely*) scale, averaged to form a vaccine side effect concern total score (α = .94).

Statistical analyses

Counts, percentages, means, and standard deviations on measures were used for the descriptive analyses. Pearson correlations and point-biserial correlations were conducted to determine if side effects from the COVID-19 vaccines relate to vaccine booster intentions. Specifically, total number of side effects, side effect intensity, and the experience of an intense side effect from the total side effect scale and CDC side effect scale were correlated with booster intention scores. As participants could receive one of three different vaccines, these correlations were also examined separately for each vaccine (Pfizer-BioNTech, Moderna, or Janssen/Johnson & Johnson). Pearson and point-biserial correlations were then calculated to determine the relationship between the psychological and demographic variables and booster intentions. Further, to determine the unique predictive ability of the significant correlates of booster intentions, a simultaneous multiple linear regression was conducted. In this regression, booster intentions served as the criterion variable and the variables found to correlate significantly with booster intentions served as predictors. To account for multiple testing, we used the Benjamini and Hochberg's False Discovery Rate correction [47]. All statistical tests were two-tailed with corrected alpha set at 0.05. Analyses were performed using SPSS 27.0 [48].

Results

Sample information

The 551 participants (52.7% women; M_{age} =31.66; SD_{age} =11.05; age range =18-71) were 69% White, 12% Hispanic, 49.7% with a bachelor's degree education or higher, and 45.3% reported an income above $60,000. In this sample, 56.4% received the Pfizer-BioNTech vaccine, 33.1% the Moderna vaccine, and 10.5% the Janssen/Johnson & Johnson vaccine. See Table 1 for further demographic information.

Booster intentions and vaccine side effects scores

Means and standard deviations on measures are presented in Table 2 and Table 3. Although all participants received the primary COVID-19 vaccination, not all fully intended to obtain a booster. Booster intentions were relatively high with an average of 8.17 on a 10-point scale. Participants reported, on average, experiencing 8.77 (out of 45) side effects on the total side effect scale and 3.95 (out of 7) side effects on CDC side effect scale. For both the total side effect items and the CDC items, 95% reported experiencing at least one side effect. When considering all side effects, 118 (21.4%) reported experiencing an intense side effect, whereas 98 (17.8%) reported an intense side effect with only the CDC side effect items. Consistent with past studies [18,49] the most common side effects reported were pain at the injection site (81.3%), fatigue (72.6%), and headache (60.6%).

Relationships between vaccine side effects and booster intentions

Correlational analyses indicated that booster intentions were not significantly associated with the number of side effects, side effect intensity, and the experience of an intense side effect on either the total side effect scale or the CDC side effect scale (see Table 2). The lack of statistical significance of the correlations were the same when examined separately based on vaccine type (see supplemental material). Further, analyses of scales created from the 38 side effects not publicized by the CDC also did not correlate with booster

intentions (see supplemental material). Finally, as booster intentions displayed a negative skew, correlations were also conducted with log-transformed booster intention scores. The correlations between side effects and transformed booster intentions remained non-significant (see supplemental material).

Relationships among psychological and demographic predictors and booster intentions

Correlational analyses indicated that, of the psychological variables, vaccination attitudes, trust in vaccine development, worry about the COVID-19 pandemic, and concern of vaccine side effects correlated with booster intentions (see Table 3). Of the demographic variables, only affiliation with the Democratic political party correlated significantly ($r = .22$, $p < .001$) with intentions (see supplemental materials for correlations with all demographic variables). Further, as displayed in Table 4, each of the variables significantly correlated with booster intentions were a significant predictor when entered simultaneously into a multiple regression analysis ($p \leq .01$). The same results were found when log-transformed booster intention scores were used as the criterion variable (see supplemental material). Finally, Variance Inflation Factor (VIF) for the predictors in the regression were calculated and ranged from 1.08 to 1.52 (in both the primary regression and with the transformed booster intentions), suggesting a low level of multicollinearity that does not warrant corrective action.

Discussion

A U.S. national sample of 551 adults was used to assess if side effects from COVID-19 vaccines are associated with a reduced intention to receive a booster vaccine. Results indicated that in this sample, booster intentions were not associated with the number of side effects, side effect intensity, or the occurrence of an intense side effect from a primary COVID-19 vaccine. These findings were consistent across scales created from all the side effect symptoms and scales created from just the side effect symptoms publicized in the U.S. by the CDC. These results held when examined separately for the three different vaccines

administered in the U.S. A secondary aim of this research was to test whether psychological and demographic variables that predict primary vaccination intentions also predict booster vaccination intentions [41,50]. The psychological variables of positive vaccination attitudes, trust in vaccine development, worry about the COVID-19 pandemic, and low concerns about vaccine side effects predicted intentions to obtain a booster, supporting the models of health behavior (TPB, HBM, PMT) discussed earlier. Democratic political party affiliation also predicted booster intentions. Our results indicate the factors known to impede primary vaccination are likely to impede booster vaccination.

The present findings have implications for efforts to increase COVID-19 booster vaccinations. The data are the first to find that COVID-19 vaccine side effects may not create a barrier to booster vaccination efforts. Based on these results, there could be little benefit to booster vaccination campaigns that specifically targeted individuals with higher rates of side effects from their primary COVID-19 vaccinations.

Interestingly, in contrast to experienced side effects, concern about vaccination side effects predicted lower booster vaccination intentions. This is in conflict to what we would have expected from the HBM and PMT, whereby it was thought both experienced and concern for future side effects would predict booster intentions [20,21]. However, this may be due to the fact that reported worries about COVID-19 vaccination side effects are commonly about the potential for the occurrence of as-yet-unknown side effects [51–53], rather than worries about commonly reported vaccine side effects. In the current study, the disconnect between worry about and previous experience of primary vaccine side effects in predicting booster intentions may be because we asked about how worried, nervous, and scared participants were about side effects in general, rather than about specific common side effects. This question may have tapped into concerns about these unknown outcomes, thus predicting booster vaccine intentions better than experience, which was most often related to

common and well-known side effects (e.g., headache, fatigue). Irrespective of the reason, this particular finding suggests that campaigns aiming to increase booster intentions and uptake may benefit from focusing on concerns about the potential for unknown side effects to emerge.

Another important finding to emerge was that booster intentions were positively associated with worry about COVID-19, supporting the perceived severity construct in the HBM and threat appraisal process in the PMT as predictors of engagement in protective health behaviors. Inciting worry about COVID-19 however would clearly not be a sensible public health strategy to increase booster intentions. Nonetheless, a risk of high primary vaccination rates could be that perceptions of the risk of COVID-19 itself decrease and that individuals therefore do not consider receiving a booster necessary. As such, public health campaigns could benefit from reinforcing that antibody levels wane so mitigation of the risks of COVID-19 are contingent upon maintaining effective inoculation via booster vaccinations.

Prior studies have found political party affiliation to be associated with primary COVID-19 vaccination intentions [27,46,47] and here we find that it is also associated with booster intentions. Somewhat surprisingly, affiliation with the Democratic political party was the only demographic variable to correlate with booster intentions. Demographic variables, such as sex, have been inconsistent in predicting primary vaccine intentions and uptake in prior studies [38–40]. As such, there may be contextual factors varying across studies modulating these associations. It is also possible that other demographic variables would have been significant predictors with a larger sample. Although this could be the case, the current results support political affiliation (e.g., democratic party) as a stronger determinant of booster intentions than the other demographic variables measured in this survey. These findings are in agreement with others that have found political party affiliation to be stronger

predictor of primary vaccination hesitancy and intentions than many other demographic variables [46,47].

Reports of side effects were higher in this sample than in several other studies [18,54]. For example, in this sample 72.6% of participants reported fatigue, whereas in another recent study 58.2% reported fatigue [14]. This is likely a result of at least two design elements. First, because two of the available vaccines in the U.S. required two doses, whereas one vaccine required only a single dose, survey instructions were written to have participants report on the side effects they experienced from their entire vaccination experience (one or two doses). As the majority of participants (89.5%) received a two-dose vaccine, participants reported on their experience simultaneously for each of the two vaccine doses, resulting in elevated side effect scores. Second, the high level of side effect reporting on the total side effect score is also likely due to our use of a comprehensive side effect assessment. The present measure inquired about 45 possible side effects, whereas in one recent study [49], for example, 14 possible side effects were considered. The high reports of side effects on the total side effect scale in this study could suggest that prior studies do not assess all of the possible side effects resulting from the COVID-19 vaccines. It is also possible, however, that reports of some of the non-CDC side effects did not result directly from the vaccine. Rather, individuals may be misattributing everyday symptoms and feelings to the COVID-19 vaccine. Without a no-vaccine control group, these two possibilities are difficult to disentangle. As our comprehensive scale and 7-item CDC side effect scale yielded similar results, this possible misattribution does not appear to appreciably alter conclusions from the present study. There may, however, be downstream consequences to be considered other than booster intentions. For example, substantial misattribution of daily symptoms to COVID-19 vaccines could result in the transmission of misinformation about vaccine side effects through social communication. This possibility should be explored in future studies.

There are other limitations to this research to be acknowledged. Booster intentions, not actual booster vaccine uptake, were examined. This is notable, as intentions do not always match behavior. Additionally, booster intentions in this sample were high, likely because participant recruitment occurred relatively early in 2021 and prior to many educational and workplace vaccine mandates. And, to be included in the final sample, participants needed to be vaccinated relatively rapidly after completing Survey 1. The results may differ in studies that include individuals who waited longer to be vaccinated or received the vaccination after being mandated to do so. Relatedly, the majority of this sample received a two-dose vaccine rather than the single-dose Janssen/Johnson & Johnson. Although our analyses did not uncover differences due to vaccine type, the one dose sample was relatively small and future studies should include a larger sample of individuals receiving a one-dose vaccine to confirm these findings. The sample was also recruited through an online platform, Prolific, which may limit generalizability. Finally, the sample was limited to the U.S. and thereby only three of the many COVID-19 vaccines. It will be important for future studies to explore these associations across countries, time periods, and with different COVID-19 vaccines.

Despite these limitations, the current data provide an early examination of the predictors of COVID-19 vaccine booster intentions and provide novel information regarding possible determinants of long-term vaccine protection. Specifically, campaigns aiming to increase booster intentions do not need to focus on the individual's history of side effects, but could benefit from addressing concerns about unknown side effects and ensuring that mitigation of the risks of COVID-19 are seen as contingent on booster uptake.

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Table

Table 1. Participant characteristics.

Characteristics	*N* = 551	**%**
Age (*M* = 31.66; *SD* = 11.05; range = 18 – 71)		
18 to 24	160	29.1
25 to 31	158	28.8
32 to 38	112	20.4
39 to 45	50	9.2
46 to 52	32	5.8
≥53	37	6.7
Gender		
Female	289	52.7
Male	244	44.4
Non-binary	11	2.0
Other-identified	5	.9
Race/Ethnicity		
White	380	69.0
African American	29	5.3
Arab	2	.4
Asian	96	17.4
American Indiana/Alaskan Native	1	.2
Native Hawaiian/other Pacific Islander	3	.5
More than one race	31	5.6
Hispanic/Latino	66	12.0
Education		
Up to high school diploma	65	11.8
Some college	154	28.1
Associate degree	57	10.4
Bachelor degree	219	39.9
Master/professional/doctoral degree	54	9.8
Political Party Affiliation		
Democratic Party	311	56.6
Not Democratic Party	238	43.4
Income		
≤$19,999	71	13.0
$20,000 to $39,999	92	16.8
$40,000 to $59,999	110	20.0
$60,000 to $79,999	100	18.2
$80,000 to $99,999	62	11.3
$100,000 to $150,000	74	13.5
≥$150,000	39	7.1
U.S. states of participant residency	48	96.0
Vaccine Type		
Pfizer-BioNTech	311	56.4
Moderna	182	33.1
Janssen/Johnson & Johnson	58	10.5

Note. Three participants declined to provide their race and income information, 2 declined to report age, gender, education and political party affiliation.

Table 2. Correlations and descriptive statistics for side effect and booster intention variables.

Total side effect scores	2	3	4	*M (%)*	*SD*
1. Booster intentions	0.01	0.01	-0.01	8.19	2.39
2. Side effect intensity		0.96**	0.59**	12.65	6.21
3. Number of side effects			0.47**	8.77	6.51
4. Intense side effect reported				21.4%	

CDC side effect scores	2	3	4	*M (%)*	*SD*
1. Booster intentions	0.03	0.06	-0.01	8.19	2.39
2. Side effect intensity		0.83**	0.55**	6.21	4.04
3. Number of side effects			0.34**	3.96	2.04
4. Intense side effect reported				17.8%	

* $p < 0.05$; ** $p < 0.001$; significance values corrected for multiple testing using the Benjamini and Hochberg (1995) procedure.

Table 3. Correlations and descriptive statistics for psychological variables.

Study Variables	2	3	4	5	*M*	SD
1. Booster intentions	-0.49**	0.45**	0.26**	-0.27**	8.19	2.39
2. Vaccination attitudes		-0.53**	-0.09*	0.35**	2.13	0.72
3. Trust in development			0.08	-0.31**	3.60	0.85
4. COVID-19 worry				0.30**	3.21	1.08
5. Side effect concern					2.56	1.17

* $p < 0.05$; ** $p < 0.001$; significance values corrected for multiple testing using the Benjamini and Hochberg (1995) procedure.

Table 4. Linear regression analysis predicting COVID-19 booster intentions from significantly correlated variables.

	B	95% CI	SE	β	*t*	*p*	R^2	*F*	*p*
Vaccination attitudes	-0.89	(-1.16, -0.61)	0.14	-0.27	-6.36	<.001**			
Trust in development	0.60	(0.37, 0.83)	0.12	0.21	5.19	<.001**			
COVID-19 worry	0.58	(0.41, 0.74)	0.08	0.26	6.98	<.001**			
Side effect concern	-0.37	(-0.52, -0.21)	0.08	-0.18	-4.53	<.001**			
Political affiliation	0.52	(0.19, 0.86)	0.17	0.11	3.06	.002*			
Full regression model							0.37	63.45	<.001

* $p < .005$; **$p < .001$; significance values corrected for multiple testing using the Benjamini and Hochberg (1995) procedure.

SUPPLEMENTAL MATERIALS

Do Side Effects to the Primary COVID-19 Vaccine Reduce Intentions for a COVID-19 Vaccine Booster?

Supplemental Materials Table of Contents

The GASE side effect scale with additional COVID-19 items

***The 7 CDC side effect items are in bold.**

	Not experienced	Mild	Moderate	Severe
Headache				
Hair loss				
Dry mouth				
Dizziness				
Chest pain				
Sore throat				
Palpitations, irregular heartbeat				
Breathing problems				
Cough				
Congestion				
Runny nose				
Loss of taste or smell				
Low blood pressure, other circulation problems				
High blood pressure				
Abdominal pain				
Nausea				
Vomiting				
Constipation				
Diarrhea				
Reduced appetite				
Increased appetite				
Difficulty urinating				
Problems with sexual performance				
Females: Painful or irregular menstruation				
Skin rash or itching				
Tendency to develop bruises				
Tenderness or pain at injection site				
Fever, increased temperature				
Abnormal sweating				
Hot flashes				
Chills				
Convulsions or seizures				
Fatigue, loss of energy				
Tremor				
Insomnia, sleeping problems				
Nightmares or abnormal dreams				
Back pain				
Muscle ache or pain				
Joint ache or pain				
Swollen lymph nodes				

Agitation
Irritability, nervousness
Depressed mood
Thoughts about suicide
Anxiety, fearfulness

Demographic items

Please enter your age: _____

Gender Please select the gender with which you identify:

Male
Female
Non-binary
Prefer to self-identify _____

Race Please select the race(s) with which you identify:

American Indian or Alaskan Native
Arab or Arab American
Asian or Asian American
Black or African American
Native Hawaiian or Pacific Islander
White or European American
Other (please specify) _____

Ethnicity Are you of Hispanic or Latinx origin?

Yes
No

Income Please select your household income:

Under $10,000
$10,000-$19,999
$20,000-$29,999
$30,000-$39,999
$40,000-$49,999
$50,000-$59,999
$60,000-$69,999
$70,000-$79,999
$80,000-$89,999
$90,000-$99,999
$100,000-$149,999
$150,000-$199,999
$200,000-$249,999
More than $250,000

Please select or write in the political party you identify with.

Democrat
Republican
Independent
Self-identify _____

Education What is the highest grade of school you have completed, or the highest degree you have received?

No schooling completed, or less than 1 year
Nursery, Kindergarten, or Elementary
High School (grades 9 – 12, no degree)
High School graduate (or equivalent)
Some college
Associate's degree (including occupational or academic degrees)
Bachelor's degree (BA, BS, AB, etc.)
Master's degree (MA, MS, MENG, MSW, etc.)
Professional school degree (MD, DDC, JD, etc.)
Doctorate degree (PhD, EdD, etc.)

Supplemental Table 1: Variable correlations by vaccine type.

Supplemental Table 1a. Correlations and descriptive statistics for study variables – Pfizer.

Study Variables	2	3	4	5	6	7	8	*M (%)*	*SD*
1. Booster intentions	0.05	0.06	0.03	-0.58**	0.47**	0.35**	-0.24**	8.28	2.34
2. Side effect intensity		0.95**	0.66**	-0.10	-0.02	0.21*	0.02	12.16	5.82
3. Number of side effects			0.56**	-0.10	-0.02	0.18*	0.05	8.33	6.64
4. Intense side effect reported				-0.05	-0.04	0.22**	0.05	21.2%	
5. Vaccination attitudes					-0.57**	-0.19*	0.34**	2.11	0.71
6. Trust in development						0.11	-0.36**	3.62	0.81
7. COVID-19 worry							0.25**	3.24	1.08
8. Side effect concern								2.57	1.14

* $p < 0.05$; ** $p < 0.001$

Supplemental Table 1b. Correlations and descriptive statistics for study variables – Moderna.

Study Variables	2	3	4	5	6	7	8	*M (%)*	*SD*
1. Booster intentions	-0.09	-0.11	-0.03	-0.33**	0.31**	0.15*	-0.26**	8.44	2.20
2. Side effect intensity		0.96**	0.48**	0.05	-0.02	0.22*	0.18*	14.18	5.82
3. Number of side effects			0.35**	0.11	-0.04	0.22*	0.21*	9.88	6.54
4. Intense side effect reported				-0.01	-0.12	0.11	0.09	23.1%	
5. Vaccination attitudes					-0.46**	0.08	0.30**	2.06	0.66
6. Trust in development						0.01	-0.22*	3.64	0.84
7. COVID-19 worry							0.38**	3.21	1.06
8. Side effect concern								2.51	1.22

* $p < 0.05$; ** $p < 0.001$

Supplemental Table 1c. Correlations and descriptive statistics for study variables – Johnson and Johnson.

Study Variables	2	3	4	5	6	7	8	*M (%)*	*SD*
1. Booster intentions	-0.15	-0.07	-0.17	-0.35*	0.57**	0.13	-0.33*	6.92	2.83
2. Side effect intensity		0.94**	0.50*	0.02	-0.11	0.26	0.07	10.47	5.38
3. Number of side effects			0.35*	0.04	-0.03	0.23	0.07	7.67	5.26
4. Intense side effect reported				0.06	-0.17	0.23	0.05	17.2%	
5. Vaccination attitudes					-0.46**	0.00	0.49**	2.47	0.85
6. Trust in development						0.09	-0.32*	3.36	1.04
7. COVID-19 worry							0.33*	3.08	1.15
8. Side effect concern								2.71	1.24

* $p < 0.05$; ** $p < 0.001$

Supplemental Table 2. Correlations and descriptive statistics for study variables – Non-CDC side effects.

Study Variables	2	3	4	5	6	7	8	*M (%)*	*SD*
1. Booster intentions	-0.01	0.01	-0.01	-0.49**	0.45**	0.26**	-0.27**	8.19	2.39
2. Side effect intensity		0.96**	0.54**	0.01	-0.05	0.21**	0.08*	6.44	7.69
3. Number of side effects			0.47**	-0.03	-0.02	0.20**	0.10*	4.81	5.02
4. Intense side effect reported				-0.03	-0.08	0.19**	0.06	10.3%	
5. Vaccination attitudes					-0.53**	-0.09*	0.35**	2.13	0.72
6. Trust in development						0.08	-0.31**	3.60	0.85
7. COVID-19 worry							0.30**	3.21	1.08
8. Side effect concern								2.56	1.17

* $p < 0.05$; ** $p < 0.001$

Supplemental Table 3. Descriptive statistics and correlations among log-transformed booster intention, psychological variables, and demographic predictors.

Study Variables	2	3	4	5	6	7	8	9	*M (%)*	*SD*
1. Transformed booster intentions	0.43**	-0.46**	0.24**	-0.25**	0.03	-0.03	0.23**	0.05	2.03	0.47
2. Trust in development		-0.53**	0.08	-0.31**	-0.08	-0.08	0.16**	0.07	3.60	0.85
3. Vaccination attitudes			-0.09*	0.35**	-0.04	0.05	-0.22**	-0.02	2.13	0.47
4. COVID-19 worry				0.30**	0.12*	0.01	0.17**	-0.09*	3.21	1.08
5. Side effect concern					0.25**	0.03	-0.06	-0.06	2.56	1.17
6. Gender (% female)						0.01	0.07	0.00	52.7%	
7. Race (% white)							-0.01	0.06	69.0%	
8. Political affiliation (% Democratic party)								-0.01	56.6%	
9. Household income									6.71	3.44

* $p < 0.05$; ** $p < 0.001$; household income is on a 14-point scale, starting at under to $10,000, and increase $10,000 for each scale point.

Supplemental Table 4. Correlations and descriptive statistics for side effect and log-transformed booster intention variables.

Total side effect scores	2	3	4	*M (%)*	*SD*
1. Transformed booster intentions	0.02	0.02	0.02	8.19	2.39
2. Side effect intensity		0.96**	0.59**	12.65	6.21
3. Number of side effects			0.47**	8.77	6.51
4. Intense side effect reported				21.4%	

CDC side effect scores	2	3	4	*M (%)*	*SD*
1. Transformed booster intentions	0.05	0.08	0.05	8.19	2.39
2. Side effect intensity		0.83**	0.55**	6.21	4.04
3. Number of side effects			0.47**	3.96	2.04
4. Intense side effect reported				17.8%	

* $p < 0.05$; ** $p < 0.001$

Supplemental Table 5a. Correlations among demographic variables, psychological variables, and total side effect variables.

Study Variables	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Booster intentions	-0.05	0.05	0.04	0.45**	-0.49**	0.26**	-0.27**	0.03	-0.04	0.25**	0.01	0.01	-0.01
2. Age		0.00	0.21**	-0.12*	0.17**	0.05	0.04	-0.02	-0.23**	-0.08	-0.09*	-0.09*	-0.04
3. Household income			0.21**	0.07	-0.02	-0.09*	-0.06	0.00	0.06	-0.01	0.01	0.00	-0.04
4. Education level				0.02	0.01	-0.04	-0.05	-0.09*	0.03	0.08	-0.03	-0.04	-0.04
5. Trust in development					-0.53**	0.08	0.31**	-0.08	-0.08	0.16**	-0.02	-0.02	-0.08
6. Vaccination attitudes						-0.09*	0.35**	-0.04	0.05	-0.22**	-0.06	-0.03	-0.03
7. COVID-19 worry							0.30**	0.12*	0.01	0.17**	0.22**	0.20**	0.19**
8. Side effect worry								0.25**	0.03	0.06	0.07	0.10*	0.06
9. Gender (% female)									0.01	0.07	0.13*	0.12*	0.11*
10. Race (% white)										-0.01	0.02	0.04	0.00
11. Political affiliation (% Democratic party)											-0.01	-0.01	0.06
12. Side effect intensity												0.96**	0.43**
13. Number of side effects													0.47**
14. Intense side effect report													

* $p < 0.05$; ** $p < 0.001$

Supplemental Table 5b. Correlations among demographic variables, psychological variables, and CDC side effect variables.

Study Variables	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Booster intentions	-0.05	0.05	0.04	0.45**	-0.49**	0.26**	-0.27**	0.03	-0.04	0.25**	0.03	0.06	0.06
2. Age		0.00	0.21**	-0.12*	0.17**	0.05	0.04	-0.02	-0.23**	-0.08	-0.10*	-0.10*	0.06
3. Household income			0.21**	0.07	-0.02	-0.09*	-0.06	0.00	0.06	-0.01	0.03	0.01	-0.03
4. Education level				0.02	0.01	-0.04	-0.05	-0.09*	0.03	0.08	-0.01	-0.02	0.00
5. Trust in development					-0.53**	0.08	-0.31**	-0.08	-0.08	0.16**	0.04	0.06	0.00
6. Vaccination attitudes						-0.09*	0.35**	-0.04	0.05	-0.22**	-0.13*	-0.14*	-0.16**
7. COVID-19 worry							0.30**	0.12*	0.01	0.17**	0.19**	0.14*	0.11*
8. Side effect worry								0.25**	0.03	-0.06	0.05	0.05	-0.04
9. Gender									0.01	0.07	0.13*	0.10*	0.13*
10. Race										-0.01	0.01	0.00	-0.07
11. Political affiliation(% Democratic party)											0.05	0.03	-0.01
12. Side effect intensity												0.91**	0.42**
13. Number of side effects													0.47**
14. Intense sided effect reported													

* $p < 0.05$; ** $p < 0.001$

Supplemental Table 6. Linear regression analysis predicting log-transformed COVID-19 booster intentions from significantly correlated variables.

	B	95% CI	SE	β	*t*	*p*	R^2	*F*	*p*
Vaccination attitudes	0.10	(-0.17, -0.09)	0.02	0.22	5.16	<.001**			
Trust in development	-0.13	(0.06, 0.13)	0.02	-0.25	-5.77	<.001**			
COVID-19 worry	-0.05	(0.06, 0.11)	0.01	-0.16	-3.99	<.001**			
Side effect worry	0.08	(-0.08, -0.03)	0.01	0.24	6.22	<.001**			
Political affiliation	0.07	(0.01, 0.12)	0.03	0.09	2.43	.016*			
Full Model							0.33	53.15	<.001**

* $p < .005$; ** $p < .001$