Supplementary Information

Section 1: Randomized Controlled Trials

1.1 Participants, eligibility, and enrollment

We conducted three parallel randomized controlled trials (RCTs) in partnership with the University of California, Los Angeles (UCLA) Health, a large health system in California. On September 14, 2022, UCLA Health sent a mass email to patients informing them of the authorization of COVID-19 bivalent boosters, providing a timeline for when UCLA Health would begin offering bivalent booster appointments, and advising patients to get the bivalent booster from a local pharmacy if they would like to get it sooner.

We designed text-message-based interventions to improve patients' booster uptake rates. Our initial enrollment criteria include UCLA Health primary care or specialty attributed patients who: (1) completed the COVID-19 primary vaccine series as of October 10, 2022 based on the most comprehensive immunization records UCLA Health could access at that time, (2) did not receive any COVID-19 dose within two months prior to October 10, 2022, (3) were at least 18 years old, and (4) had a phone number on file that had not previously been opted out of UCLA Health text messaging. This initial eligibility determination process resulted in 386,615 patients.

The RCTs were reviewed and approved by the institutional review board (IRB) at University of California, Los Angeles, which determined that a waiver of informed consent was appropriate.

1.2 Study design and intervention messages

All 386,615 patients were first randomly assigned to either one of the 14 message conditions or the holdout condition. The chance of being randomly assigned to any given message condition was the same across the 14 messages conditions, and the chance of being randomly assigned to the holdout condition was three times the chance of being randomly assigned to one message condition. We oversampled the holdout condition because we had three parallel RCTs. Within each condition, patients were then randomly assigned to one of 11 workdays (from October 18, 2022 to November 1, 2022). Finally, within each condition and each day, patients were randomly assigned with an equal probability to one of three time slots (9am, 12pm, and 4pm), which allowed us to keep the total number of messages sent at any given point in time within the limit imposed by UCLA Health's text messaging vendor.

If assigned to one of the message conditions, patients received the corresponding text message at the randomly assigned time on the randomly assigned day. Patients in the holdout condition did not receive any text message from this research effort. Since all conditions were randomized and launched simultaneously, we can not only analyze the effectiveness of interventions within each RCT but also compare interventions across RCTs.

The first RCT (https://clinicaltrials.gov/ct2/show/NCT05586165) contained three message conditions. The *Simple-Enhance Protection* message encouraged patients to enhance their protection against COVID-19 and book an appointment for bivalent COVID-19 boosters. The *Bundle-Tagging Flu Shot* message additionally informed patients that they could get the flu vaccine at their booster appointment. The *Bundle-Booster & Flu Shot message* encouraged patients to enhance protection against COVID-19 and the flu, and told patients that they could save time by bundling two vaccines at once.

1. *Simple-Enhance Protection*
    - UCLA Health: [Patient name], this fall, enhance your protection against COVID-19!

      Book an appointment for your bivalent COVID-19 booster at:
      (1) UCLA Health https://my.uclahealth.org/MyChart/Scheduling

      OR

      (2) CVS Pharmacy (may have more availability)
      https://www.cvs.com/vaccine/intake/store/schedule-options

2. *Bundle-Tagging Flu Shot*
    - UCLA Health: [Patient name], this fall, enhance your protection against COVID-19!

      Book an appointment for your bivalent COVID-19 booster at:

      (1) UCLA Health https://my.uclahealth.org/MyChart/Scheduling; you can also protect yourself against the flu by asking for the flu vaccine at your booster appointment.

      OR

      (2) CVS Pharmacy (may have more availability)
      https://www.cvs.com/vaccine/intake/store/schedule-options; you can add the flu vaccine to your COVID-19 booster appointment.

3. *Bundle-Booster & Flu Shot*
    - UCLA Health: [Patient name], this fall, enhance your protection against COVID-19 and the flu!

      You can save time by bundling two vaccines at once.

      (1) At UCLA Health, you can book an appointment for your bivalent COVID-19 booster and then ask for the flu vaccine at your booster appointment:
      https://my.uclahealth.org/MyChart/Scheduling

      OR

      (2) At CVS Pharmacy (may have more availability), you can book one appointment to get both the bivalent COVID-19 booster and flu vaccine:
      https://www.cvs.com/vaccine/intake/store/schedule-options

The second RCT contained six message conditions (https://clinicaltrials.gov/ct2/show/NCT05586178). The *Simple-No Info* message informed patients that they could now get the new bivalent COVID-19 booster. The four other messages were built on top of it. They either provide information about the bivalent booster based on insights gleaned from our online survey (see SI Section 5), or leverage the psychological principle about consistency, or do both. The *Info-Uniqueness* message emphasized that the new bivalent booster is different from the COVID-19 vaccines that patients already got, and that the bivalent booster could extend protection by targeting the most contagious, dominant variants of the virus, while strengthening protection from earlier variants. The *Info-Eligibility Clarification* message was designed to address potential confusion about which populations were eligible for the bivalent booster or could benefit from it. Specifically, the *Info-Eligibility Clarification* message explained that regardless of whether someone is at high risk, received the original boosters, or previously got COVID-19, they were eligible for the bivalent booster, and this updated booster would strengthen their protection. The *Info-Severity* message pointed out the frequently underestimated chances of a healthy adults developing severe or long-lasting COVID-19 symptoms, and then pointed to the bivalent booster as one effective way to reduce the chances. The *Consistency* message applauded patients for having completed a COVID-19 vaccine primary series and encouraged them to get the bivalent booster as the next step. The *Consistency & Info-Uniqueness* message combines the *Consistency* message and the *Info-Uniqueness* message.

1. *Simple-No Info*
    - UCLA Health: [Patient name], you can now get the new bivalent COVID-19 booster.

      Book your booster appointment at：

      UCLA Health https://my.uclahealth.org/MyChart/Scheduling

      OR a Pharmacy nearby (may have more availability) https://www.vaccines.gov/search/?medicationGuids=018b22d2-054b-4d42-8279-d4efb511aec6%2C25e72c3c-8f6c-4738-9638-08911a400e70&appointments=true&medicationKeys=pfizer_covid_19_vaccine_bivalent_booster%2Cmoderna_covid_19_vaccine_bivalent_booster

2. *Info-Uniqueness*
    - UCLA Health: [Patient name], you can now get the new bivalent COVID-19 booster, which is different from the COVID-19 vaccines you already got.

      The updated booster can extend your protection by targeting the most contagious, dominant variants of the virus, while strengthening your protection from earlier variants.

      Book your booster appointment at：

UCLA Health https://my.uclahealth.org/MyChart/Scheduling

OR a Pharmacy nearby (may have more availability)
https://www.vaccines.gov/search/?medicationGuids=018b22d2-054b-4d42-8279-d4efb511aec6%2C25e72c3c-8f6c-4738-9638-08911a400e70&appointments=true&medicationKeys=pfizer_covid_19_vaccine_bivalent_booster%2Cmoderna_covid_19_vaccine_bivalent_booster

3. *Info-Eligibility Clarification*
    - UCLA Health: [Patient name], you can now get the new bivalent COVID-19 booster.

      Regardless of whether you are at high risk, received the original boosters, or previously got COVID-19, you are eligible based on your medical records, and this updated booster will strengthen your protection.

      Book your booster appointment at：

      UCLA Health https://my.uclahealth.org/MyChart/Scheduling

      OR a Pharmacy nearby (may have more availability)
      https://www.vaccines.gov/search/?medicationGuids=018b22d2-054b-4d42-8279-d4efb511aec6%2C25e72c3c-8f6c-4738-9638-08911a400e70&appointments=true&medicationKeys=pfizer_covid_19_vaccine_bivalent_booster%2Cmoderna_covid_19_vaccine_bivalent_booster

4. *Info-Severity*
    - UCLA Health: [Patient name], the chances that a healthy adult will develop severe or long-lasting COVID-19 symptoms are higher than many people realize.

      You can now get the new bivalent COVID-19 booster, which can effectively reduce your chance of developing severe illness and long-lasting COVID-19 symptoms.

      Book your booster appointment at：

      UCLA Health https://my.uclahealth.org/MyChart/Scheduling

      OR a Pharmacy nearby (may have more availability)
      https://www.vaccines.gov/search/?medicationGuids=018b22d2-054b-4d42-8279-d4efb511aec6%2C25e72c3c-8f6c-4738-9638-08911a400e70&appointments=true&medicationKeys=pfizer_covid_19_vaccine_bivalent_booster%2Cmoderna_covid_19_vaccine_bivalent_booster

5. *Consistency*

- UCLA Health: [Patient name], based on your medical records, you have completed a COVID-19 vaccine primary series. Great job protecting your health.

  Now, you can get the new bivalent COVID-19 booster.

  Book your appointment at:

  UCLA Health https://my.uclahealth.org/MyChart/Scheduling

  OR a Pharmacy nearby (may have more availability)
  https://www.vaccines.gov/search/?medicationGuids=018b22d2-054b-4d42-8279-d4efb511aec6%2C25e72c3c-8f6c-4738-9638-08911a400e70&appointments=true&medicationKeys=pfizer_covid_19_vaccine_bivalent_booster%2Cmoderna_covid_19_vaccine_bivalent_booster

6. *Consistency & Info-Uniqueness*
   - UCLA Health: [Patient name], based on your medical records, you have completed a COVID-19 vaccine primary series. Great job protecting your health.

     Now, you can get the new bivalent COVID-19 booster, which is different from the COVID-19 vaccines you already got. The updated booster can extend your protection by targeting the most contagious, dominant variants of the virus, while strengthening your protection from earlier variants.

     Book your booster appointment at:

     UCLA Health https://my.uclahealth.org/MyChart/Scheduling

     OR a Pharmacy nearby (may have more availability)
     https://www.vaccines.gov/search/?medicationGuids=018b22d2-054b-4d42-8279-d4efb511aec6%2C25e72c3c-8f6c-4738-9638-08911a400e70&appointments=true&medicationKeys=pfizer_covid_19_vaccine_bivalent_booster%2Cmoderna_covid_19_vaccine_bivalent_booster

The third RCT contained five messages (https://clinicaltrials.gov/ct2/show/NCT05586204). The *Ownership w/ Narrow Link* message informed patients that they were eligible for the new bivalent COVID-19 booster, and encouraged people to claim their dose today by booking an appointment at UCLA Health or CVS Pharmacy. The *Ownership w/ Broad Link* message replaced the link to CVS Pharmacy with a link to www.vaccines.gov where people can find information about various venues (including CVS) that offered bivalent COVID-19 boosters and were close to them. The *Doctor Recommendation Only* message aimed at leveraging doctors' endorsement to elevate patients' intentions to get the booster. This message informed patients that they were eligible for the new bivalent COVID-19 booster, and then highlighted that UCLA Health doctors strongly recommended them to get the updated booster, as it was designed to extend protection against

COVID-19 by targeting the most contagious, dominant variants of the virus. Notably, the *Doctor Recommendation Only* message did not contain links to appointment scheduling websites. The *Doctor Recommendation & Ownership w/ Narrow Link* message combined the *Ownership w/ Narrow Link* message with the *Doctor Recommendation Only* message. Similarly, the *Doctor Recommendation & Ownership w/ Broad Link* message combined the *Ownership w/ Broad Link* message with the *Doctor Recommendation Only* message.

1. *Ownership w/ Narrow Link*
    - UCLA Health: [Patient name], your medical records indicate that you are now eligible for the new bivalent COVID-19 booster.

      To enhance your protection against COVID-19, claim your dose today by booking an appointment at:

      UCLA Health https://my.uclahealth.org/MyChart/Scheduling

      OR CVS Pharmacy (may have more availability)
      https://www.cvs.com/vaccine/intake/store/schedule-options

2. *Ownership w/ Broad Link*
    - UCLA Health: [Patient name], your medical records indicate that you are now eligible for the new bivalent COVID-19 booster.

      To enhance your protection against COVID-19, claim your dose today by booking an appointment at:

      UCLA Health https://my.uclahealth.org/MyChart/Scheduling

      OR a Pharmacy nearby (may have more availability)
      https://www.vaccines.gov/search/?medicationGuids=018b22d2-054b-4d42-8279-d4efb511aec6%2C25e72c3c-8f6c-4738-9638-08911a400e70&appointments=true&medicationKeys=pfizer_covid_19_vaccine_bivalent_booster%2Cmoderna_covid_19_vaccine_bivalent_booster

3. *Doctor Recommendation Only*
    - UCLA Health: [Patient name], your medical records indicate that you are now eligible for the new bivalent COVID-19 booster.

      Doctors at UCLA Health strongly recommend that you get this updated booster, as it is designed to extend your protection against COVID-19 by targeting the most contagious, dominant variants of the virus.

4. *Doctor Recommendation & Ownership w/ Narrow Link*
    - UCLA Health: [Patient name], your medical records indicate that you are now eligible for the new bivalent COVID-19 booster.

Doctors at UCLA Health strongly recommend that you get this updated booster, as it is designed to extend your protection against COVID-19 by targeting the most contagious, dominant variants of the virus.

Claim your dose today by booking an appointment at:

UCLA Health https://my.uclahealth.org/MyChart/Scheduling

OR CVS Pharmacy (may have more availability)
https://www.cvs.com/vaccine/intake/store/schedule-options

5. *Doctor Recommendation & Ownership w/ Narrow Link*
    - UCLA Health: [Patient name], your medical records indicate that you are now eligible for the new bivalent COVID-19 booster.

      Doctors at UCLA Health strongly recommend that you get this updated booster, as it is designed to extend your protection against COVID-19 by targeting the most contagious, dominant variants of the virus.

      Claim your dose today by booking an appointment at:

      UCLA Health https://my.uclahealth.org/MyChart/Scheduling

      OR a Pharmacy nearby (may have more availability)
      https://www.vaccines.gov/search/?medicationGuids=018b22d2-054b-4d42-8279-d4efb511aec6%2C25e72c3c-8f6c-4738-9638-08911a400e70&appointments=true&medicationKeys=pfizer_covid_19_vaccine_bivalent_booster%2Cmoderna_covid_19_vaccine_bivalent_booster

During the first three days of our campaign, each message (except for the *Doctor Recommendation Only* message) included two links: one directed people to make an appointment at UCLA Health and the other directed people to book an appointment somewhere else (either with a link to CVS or a link to www.vaccines.gov). However, appointment availability at UCLA Health was seriously limited, and text responses from patients during the first days of the experiment pointed out the severely limited supply of bivalent boosters at UCLA Health. Thus, starting from the fourth day of the RCTs, we removed the link to UCLA Health from all messages, acknowledged the limited supply at UCLA Health, and encouraged patients to get the bivalent booster somewhere else. Notably, the essence of the messages (e.g., the psychological principles leveraged and the information provided about the bivalent boosters) remained the same, and the change was applied to all messages. The exact wording of the messages after the link update can be found at https://osf.io/qhw95/?view_only=2d0c071d4a494c569b68fcd5bcacf410.

Due to a technical error, our text messaging vendor sent a small percentage of patients (0.34%) messages from two conditions. Also, a small number of patients (1.67%) did not receive their assigned message because of technical errors, invalid phone numbers, or patients opting out

of receiving messages from the short code that the vendor sent messages from (even though those patients did not opt out SMS communications from UCLA Health in general). We report results in the Main Text using each patient's randomly assigned condition, regardless of whether they actually got the message. All of the results reported in the Main Text are robust if we remove patients who did not receive their assigned message and if we further remove patients who received two messages by mistake.

1.3 Characteristics of final sample and balance check

At the analysis stage, we applied our pre-registered exclusion criteria to the 386,625 patients who were enrolled. First, our analyses exclude patients who received any dose of COVID-19 vaccine within the two months (or precisely 60 days) before their assigned message date, because those patients were not eligible for receiving the bivalent booster at the time of getting our message. Though we already tried our best to take into account whether patients received a dose within two months before October 10, 2022 when we selected the pool of patients to enroll, more patients got a dose between October 10, 2022, and their assigned message date, and the administrative data we relied on could include new information about doses patients obtained in the past as records got updated over time. Thus, at the analysis stage, we use the latest vaccination records we can access to more cleanly exclude patients who received any dose within two months before their message date.

Second, we exclude patients who received a COVID-19 bivalent booster before the assigned message date, as far as UCLA Health could track. Third, we exclude patients who had died before the study, since they could not have been reached by text messaging. We also pre-registered that we would exclude patients who scheduled a booster appointment at UCLA Health before the assigned message time. However, only a small portion of patients were able to schedule bivalent booster appointments there due to limited supply, and we learned after the experiments ended that some patients were able to get a bivalent booster at a doctor visit without making a bivalent appointment (which means that some patients may plan to get the booster at their upcoming normal doctor appointments but we could not tell it from the bivalent booster appointment data). Thus, data about appointments were not obtained in the end.

Importantly, the proportion of patients excluded from the analysis stage did not statistically significantly differ across conditions, as expected (Table 1).

The 317,175 patients in our analysis sample were an average of 50.05 years old (SD = 17.83), 42.17% were male, 48.81% were White (excluding Hispanic patients), and 14.17% were Hispanic. To ensure that our study arms were well-balanced, we predicted balance variables—including an indicator for whether patients were retained in the analysis, patient age (in years), and an indicator for whether a patient was male—as a function of experimental conditions using Ordinary Least Squares (OLS) regressions with robustness standard errors. F-tests were then conducted for the beta coefficients from the regressions to compare the overall significance across relevant conditions. To summarize across all categories of race/ethnicity, we analyzed the categorical variable of race/ethnicity using a Chi-squared test. Table 1 shows that the conditions were balanced on the rate of being retained in the analysis, gender, age, and race/ethnicity.

Table 1. Summary of patient characteristics by condition and balance checks.

	Included in Analysis (%)	Age (Years)	Male (%)	White (%)	Black (%)	Asian (%)	Other Race (%)	Unknow Race (%)	Hispanic (%)
				Panel A: Comparison Within RCT1					
Simple-Enhance Protection	82.25%	49.93	42.45%	48.82%	4.91%	11.33%	6.65%	14.25%	14.04%
Bundle-Tagging Flu Shot	82.19%	49.90	41.59%	49.48%	4.86%	11.40%	6.63%	13.65%	13.99%
Bundle-Booster & Flu Shot	81.85%	50.15	42.41%	48.69%	4.81%	11.07%	7.11%	14.35%	13.96%
F-test/Chi-squared test p-value	0.489	0.322	0.161				0.409		
				Panel B: Comparison Within RCT2					
Simple-No Info	82.02%	50.09	41.86%	48.43%	5.00%	11.47%	6.35%	14.43%	14.31%
Info-Uniqueness	81.99%	50.07	41.83%	48.80%	4.74%	11.27%	6.71%	13.99%	14.49%
Info-Eligibility Clarification	82.17%	50.13	42.22%	48.94%	4.95%	10.87%	7.24%	13.63%	14.37%
Info-Severity	82.20%	49.83	42.52%	49.52%	4.71%	11.17%	6.59%	13.71%	14.30%
Consistency	82.03%	50.28	42.39%	48.87%	4.77%	11.51%	6.96%	14.01%	13.88%
Consistency & Info-Uniqueness	81.91%	50.07	42.15%	48.53%	5.13%	11.44%	6.54%	14.31%	14.05%
F-test/Chi-squared test p-value	0.964	0.302	0.715				0.052		
				Panel C: Comparison Within RCT3					
Ownership w/ Narrow Link	82.25%	50.14	42.20%	49.31%	4.95%	11.28%	6.68%	13.91%	13.87%
Ownership w/ Broad Link	82.26%	50.13	42.11%	47.83%	4.85%	11.35%	7.16%	14.45%	14.35%
Doctor Recommendation Only	81.80%	49.86	41.57%	47.77%	5.06%	11.39%	6.75%	14.64%	14.40%
Doctor Recommendation & Owne	81.58%	50.10	42.12%	49.26%	4.69%	11.29%	6.67%	13.86%	14.21%
Doctor Recommendation & Owne	81.93%	49.93	41.88%	48.30%	5.06%	11.56%	6.61%	14.36%	14.12%
F-test/Chi-squared test p-value	0.253	0.419	0.728				0.134		
				Panel D: Compare 14 Message Conditions and Holdout Condition					
Holdout Condition	82.08%	50.06	42.53%	49.07%	4.85%	11.05%	6.70%	14.17%	14.16%
F-test/Chi-squared test p-value	0.866	0.515	0.531				0.094		

Note. We compared the messages within each RCT as well as all 15 conditions across three RCTs. For whether patients were retained in the analysis, patient age, and whether patients were male, F-test p-values were based on pairwise comparisons to compare the overall significance across the relevant conditions using the OLS regression models described above. To summarize across all categories of race/ethnicity, we ran a chi-squared test to assess whether there was any association between random assigned conditions and race/ethnicity.

1.4 Statistical analysis

Our pre-registered primary outcome measure is *Booster Uptake,* a binary measure of whether patients obtained a COVID-19 bivalent booster within four weeks of their assigned message date. To as comprehensively capture COVID-19 vaccinations as possible, we primarily relied on administrative records from the California Immunization Registry (CAIR) and obtained additional vaccination records from organizations that participate in Epic's healthcare information exchange.[1]

Following the pre-registrations, we report Ordinary Least Squares (OLS) regressions that predict *Booster Uptake.* All regressions, unless otherwise explained, control for patient gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, other/mixed, with people whose race was unknown to us and whose ethnicity was not Hispanic as the reference group), as well as indicators for the 33 time slots (i.e., 3 times across 11 days) that patients were randomly assigned to. We consistently use HC3 heteroskedasticity-robust standard errors.[2]

1.5 Results of RCT1

[1] For example, if an UCLA Health patient obtained the bivalent booster outside of California (and thus was not in CAIR's database), saw a doctor in a Kaiser hospital, and the doctor updated this patient's vaccination history in the Epic system, then UCLA Health would have this information on file about this patient.

[2] http://datacolada.org/99

The key question we hoped to address with RCT1 is whether reminding patients about the convenience of getting the flu shot at the same time as the booster could increase booster uptake. To answer this question, we first compared the two vaccine bundling messages that referenced the flu shot. We predicted *Booster Uptake* with an indicator of whether patients received the *Bundle-Booster & Flu Shot* message (or the *Bundle-Tagging Flu Shot* message, which was the reference group in this regression). As shown in Column 1 in Table 2, these two messages did not significantly differ from each other (p = 0.219). Thus, we followed the pre-registration to collapse these two conditions and compare them together with the *Simple-Enhance Protection* condition. We predicted *Booster Uptake* with a binary indicator, *Bundling,* which equal one if a patient received one of the bundling messages and zero if the patient received the *Simple-Enhance Protection* message. As shown in Column 2 in Table 2, receiving a message about bundling the flu shot and the bivalent booster did not significantly affect people's likelihood of getting the bivalent booster within four weeks, relative to just receiving a simple message that only encouraged the uptake of the bivalent booster (p = 0.335).

Table 2: Differences Between RCT1 Text Messages in Booster Uptake Based on Field Experiment

	Booster Uptake	
	(1)	(2)
Bundle-Booster and Flu Shot	-0.004	
	(0.003)	
Bundle		-0.003
		(0.003)
Control Variables	Yes	Yes
N	37305	56010
R^2	0.017	0.018
Conditions Included	Bundle-Tagging Flu Shot Bundle-Booster and Flu Shot	All Message Conditions
Reference Condition	Bundle-Tagging Flu Shot	Simple-Enhance Protection

Legend: The table reports ordinary least squares (OLS) regressions predicting booster uptake within four weeks. *Bundle-Booster and Flu Shot* is coded as 1 when participants received the *Bundle-Booster Flu Shot* message and 0 otherwise. *Bundle* is coded as 1 when participants received one of the two vaccine bundling messages (*Bundle-Tagging Flu Shot*, *Bundle-Booster Flu Shot*) and 0 otherwise. Control variables include pre-registered covariates of gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, other/mixed, with people whose race was unknown to us and whose ethnicity was not Hispanic as the reference group), as well as indicators for the 33 time slots (i.e., 3 times across 11 days) that patients were randomly assigned to. Robust standard errors are reported in parentheses. $^{+}$p<0.10; *p<0.05; **p<0.01; ***p<0.001 (all two-sided).

1.6 Results of RCT2

RCT2 has two main research questions. The first one pertains the effect of changing people' beliefs about the bivalent booster by providing relevant information. Answering this question requires that we compare the three messages containing an information provision intervention—the *Info-Uniqueness* message, the *Info-Eligibility Clarification* message, and the *Info-Severity* message—with the *Simple-No Info* message. The second question pertains the effect of eliciting the consistency principle by complimenting people on their completion of the COVID-19 vaccine primary series. Answering this question requires that we compare the *Consistency* message and the *Consistency & Info-Uniqueness* message with the *Simple-No Info* message.

Following the pre-registration, we began with a comparison of three information-provision messages to determine whether we should collapse them into one condition. We predicted *Booster Uptake* as a function of an indicator of the *Info-Uniqueness* Message and an indicator for the *Info-Severity* message (with the *Info-Eligibility Clarification* message as the

reference group). This regression only included observations from these three information-provision conditions. As shown in Table 3 Column 1, uptake rates of the bivalent booster did not significantly differ between the *Info-Uniqueness* message and the *Info-Eligibility Clarification* message (p = 0.275), or between the *Info-Severity* message and the *Info-Eligibility Clarification* message (p = 0.390). A post-regression Wald test indicates that the *Info-Uniqueness* message led to a marginally significantly higher booster uptake rate than the *Info-Severity* message (p = 0.051). A joint significance F-test fails to reject the null hypothesis that the three information-provision message conditions had the same true value (p = 0.148). As a result, we collapse the three information-provision message conditions in our analysis next.

In an OLS regression that included all patients in the analysis sample of RCT2, we predicted *Booster Uptake* with (1) a binary indicator, *Information Provision,* which equal one if a patient received one of the three information-provision messages and zero if the patient received the *Simple-No Info* message; (2) a binary indicator for getting the *Consistency* message; and (3) a binary indicator for getting the *Consistency & Info-Uniqueness* message. The *Simple-No Info* message was the reference group in this regression. The results are reported in Table 3 Column 2. The coefficient on *Information Provision* suggests that receiving additional information about bivalent boosters in RCT2 did not significantly change booster uptake (p = 0.424). Leveraging the psychological principle of consistency by complimenting people on their completion of primary vaccine series did not improve booster uptake, either, regardless of whether the consistency principle was used by itself (p = 0.582) or when it was combined the language about the difference between the bivalent boosters and earlier doses (p = 0.865).

Table 3: Differences Between RCT2 Text Messages in Booster Uptake Based on Field Experiment

	Booster Uptake	
	(1)	(2)
Info-Uniqueness	0.004	
	(0.003)	
Info-Severity	-0.003	
	(0.003)	
Information Provision		0.002
		(0.003)
Consistency		-0.002
		(0.003)
Consistency and Info-Uniqueness		0.001
		(0.003)
Control Variables	Yes	Yes
N	56029	111964
R^2	0.016	0.017
Wald Test	Info-Uniqueness vs. Info-Severity p = 0.051	Narrow Link Only
F-test	p = 0.148	
Conditions Included	Info-Uniqueness Info-Eligibility Info-Severity	All Message Conditions
Reference Condition	Info-Eligibility	Simple-No Info

Legend: The table reports ordinary least squares (OLS) regressions predicting booster uptake within four weeks. The predictor variables are binary indicators of the messages. *Information Provision* is coded as 1 when participants received one of the three information-provision messages (*Info-Uniqueness*, *Info-Severity*, *Info-Eligibility Clarification*) and 0 otherwise. Control variables include pre-registered covariates of gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, other/mixed, with people whose race was unknown to us and whose ethnicity was not Hispanic as the reference group), as well as indicators for the 33 time slots (i.e., 3 times across 11 days) that patients were randomly assigned to. Robust standard errors are reported in parentheses. $^{+}p<0.10$; $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$ (all two-sided).

1.7 Results of RCT3

RCT3 was set to explore the value of simultaneously elevating intentions (by highlighting doctors' strong recommendations) and facilitating action (by providing links to appointment scheduling websites and prompting people to claim their dose right away). Following the pre-registration, we compared booster uptake rates between (1) the combination of *Ownership w/ Narrow Link* and *Ownership w/ Broad Link* messages that only prompted people to get the bivalent booster and presented the links to do so, without explaining why this action would be valuable, (2) the *Doctor Recommendation Only* message that aimed at elevating patients' intentions to get the booster but did not provide links to appointment scheduling websites, and (3) the combination of the *Doctor Recommendation & Ownership w/ Narrow Link* and *Doctor Recommendation & Ownership w/ Broad Link* messages that aimed at simultaneously elevating intentions and facilitating immediate action. We constructed a binary indicator, *Facilitating Action Only*, which equals one for *Ownership w/ Narrow Link* and *Ownership w/ Broad Link* messages and zero otherwise. We constructed a binary indicator, *Doctor Recommendation & Facilitating Action*, which equals one for *Doctor Recommendation & Ownership w/ Narrow Link* and *Doctor Recommendation & Ownership w/ Broad Link* messages and zero otherwise.

In an OLS regression that involved all five message conditions in RCT3, we predicted *Booster Uptake* with the indicator of *Facilitating Action Only* and the indicator of *Doctor Recommendation & Facilitating Action*, with the *Doctor Recommendation Only* message as the reference group. The results of this regression are shown in Column 1 of Table 4. The coefficient on *Doctor Recommendation & Facilitating Action* captures the regression-estimated effect of adding language to facilitate action on top of highlighting doctor recommendation (vs. only presenting doctor recommendation), which is not statistically significant ($p = 0.323$). Comparing the coefficient on *Facilitating Action Only* with the coefficient on *Doctor Recommendation & Facilitating Action* via a Wald test allows us to estimate the effect of adding language to elevate booster intentions on top of facilitating immediate action (vs. only facilitating action), which is also not statistically significant ($p = 0.704$).

Another question of interest is whether it is better to provide people with a link to one or two vaccination venues or a link to a variety of vaccination venues. The former is less flexible but can reduce the time and decision costs of location selection especially if there are many locations to choose from. Following the pre-registration, we compared the two conditions that contained only "narrow" links to UCLA and CVS (*Ownership w/ Narrow Link* and *Doctor Recommendation & Ownership w/ Narrow Link*) with the two conditions that replaced the CVS link with a "broad" link to www.vaccines.org (*Ownership w/ Broad Link* and *Doctor Recommendation & Ownership w/ Broad Link*). In an OLS regression involving all five message conditions in RCT3, we predicted *Booster Uptake* with the binary indicator of *Narrow Link Only* and the binary indicator of *Containing Broad Link. Narrow Link Only* equals one for the *Ownership w/ Narrow Link* and *Doctor Recommendation & Ownership w/ Narrow Link* conditions and zero otherwise. *Containing Broad Link* equals one for *Ownership w/ Broad Link* and *Doctor Recommendation & Ownership w/ Broad Link conditions* and zero otherwise. Comparing *Narrow Link Only* with *Containing Broad Link* via a Wald test, we observe some evidence that the two messages with "narrow" links on average led to higher booster uptake rates than the two messages that contained a "broad" link ($B = 0.005$, $SE = 0.002$, $p = 0.039$; Column 2 of Table 4).

Table 4: Differences Between RCT3 Text Messages in Booster Uptake Based on Field Experiment

	Booster Uptake	
	(1)	(2)
Facilitating Action Only	0.003	
	(0.003)	
Doctor Recommendation and Facilitating Action	0.004	
	(0.003)	
Narrow Link Only		0.006*
		(0.003)
Containing Broad Link		0.001
		(0.003)
Control Variables	Yes	Yes
N	93200	93200
R^2	0.017	0.017
Wald Test	Doctor Recommendation and Facilitating Action vs. Facilitating Action Only: p = 0.704	Narrow Link Only vs. Containing Broad Link: B = 0.005, SE = 0.002, p = 0.039
Conditions Included	All Message Conditions	All Message Conditions
Reference Condition	Doctor Recommendation Only	Doctor Recommendation Only

Legend: The table reports ordinary least squares (OLS) regressions predicting booster uptake within four weeks. *Facilitating Action Only* is coded as 1 when participants received the *Ownership w/ Narrow Link* or *Ownership w/ Broad Link* message and 0 otherwise. *Doctor Recommendation Only* is coded as 1 when participants received the *Doctor Recommendation Only* message. *Doctor Recommendation and Facilitating Action* is coded as 1 when participants received the *Doctor Recommendation Ownership w/ Narrow Link* or the *Doctor Recommendation Ownership w/ Broad Link* message. *Narrow Link Only* is coded as 1 when participants received the *Ownership w/ Narrow Link* or *Doctor Recommendation Ownership w/ Narrow Link* message. *Containing Broad Link* is coded as 1 when participants received the *Ownership w/ Broad Link* or *Doctor Recommendation Ownership w/ Broad Link* message. Control variables include pre-registered covariates of gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, other/mixed, with people whose race was unknown to us and whose ethnicity was not Hispanic as the reference group), as well as indicators for the 33 time slots (i.e., 3 times across 11 days) that patients were randomly assigned to. Robust standard errors are reported in parentheses. $^{+}$p<0.10; *p<0.05; **p<0.01; ***p<0.001 (all two-sided).

1.8 Results of the Megastudy Analysis

In our pre-registration (https://clinicaltrials.gov/ct2/show/record/NCT05586204), we indicated that in addition to examining the research questions that individual RCTs were designed to test, we would also report results across the three RCTs in a megastudy fashion following Milkman et al. (2021). Thus, we ran an OLS regression with heteroskedasticity-robust standard errors to predict *Booster Uptake* as a function of the 14 indicators for random assignment to each of the 14 message arms (with the holdout condition as the reference group). The regression coefficients are reported in Column 1 of Table 5 and also plotted in Figure 1 in the Main Text. All but one message arm produced a statistically significant increase in booster uptake at the two-sided 5% significance level, compared to the holdout condition. To estimate the average effect of receiving a text reminder across three RCTs, we ran another OLS regression to predict *Booster Uptake* as a function of the *Text Reminder* indicator, which equals one for any of the message arms and zero for the holdout condition. As shown in Column 2 of Table 5, the average effect of receiving a reminder was to increase booster uptake within four weeks by 1.09 percentage points ($p < .001$).

Further, we conducted two comparisons to estimate the effect of adding the ownership language. First, we compared the four text messages containing the "claim your dose" language with all the other messages that contains links. We ran an OLS regression to predict *Booster Uptake* as a function of a binary indicator, *Containing Ownership*, which equals one for the four conditions that included the "claim your dose" language and zero for other message conditions

that contained links. As shown in Column 3 of Table 5, booster uptake rate was statistically significantly higher by 0.77 percentage points in the four ownership conditions combined than in other conditions that contained links ($p < 0.001$).

Second, we compared the two text messages that only contained the "claim your dose" language without highlighting doctor recommendations (i.e., *Ownership w/ Narrow Link* and *Ownership w/ Broad Link*) with the simple reminders in the first and second RCTs (i.e., *Simple-Enhance Protection* and *Simple-No Info*). Note that *Ownership w/ Narrow Link* and *Simple-Enhance Protection* have the same (narrow) links, and *Ownership w/ Broad Link* and *Simple-No Info* have the same (broad) links. As shown in Column 4 of Table 5, the significant coefficient on *Containing Ownership w/o Doctor Rec* suggests that booster uptake rate was statistically significantly higher by 0.75 percentage points in *Ownership w/ Narrow Link* and *Ownership w/ Broad Link* conditions combined than in *Simple-Enhance Protection* and *Simple-No Info* conditions combined ($p = 0.002$).

Altogether, we observe suggestive evidence for the positive impact of adding the "claim your dose" ownership language, consistent with the findings of Dai et al. (2021) where similar language was shown to encourage the uptake of the primary COVID-19 vaccine series.

Table 5: Megastudy Approach to Compare Conditions Across Three RCTs with the Holdout Condition

	Booster Uptake			
	(1)	(2)	(3)	(4)
Simple-Enhance Protection	0.007**			
	(0.003)			
Bundle-Tagging Flu Shot	0.006*			
	(0.003)			
Bundle-Booster and Flu Shot	0.002			
	(0.003)			
Simple-No Info	0.009**			
	(0.003)			
Info-Uniqueness	0.015***			
	(0.003)			
Info-Eligibility Clarification	0.011***			
	(0.003)			
Info-Severity	0.008**			
	(0.003)			
Consistency	0.007**			
	(0.003)			
Consistency and Info-Uniqueness	0.010***			
	(0.003)			
Ownership w/ Narrow Link	0.019***			
	(0.003)			
Ownership w/ Broad Link	0.012***			
	(0.003)			
Doctor Recommendation Only	0.013***			
	(0.003)			
Doctor Rec and Ownership w/ Narrow Link	0.018***			
	(0.003)			
Doctor Rec and Ownership w/ Broad Link	0.015***			
	(0.003)			
Text Reminder		0.011***		
		(0.002)		
Containing Ownership			0.008***	
			(0.001)	
Containing Ownership w/o Doctor Rec				0.008**
				(0.002)
Control Variables	Yes	Yes	Yes	Yes

N	317175	317175	242571	74771
R^2	0.017	0.016	0.017	0.017
Conditions Included	All Conditions	All Conditions	All Message Conditions with Links	Ownership w/ Narrow Link Ownership w/ Broad Link Simple-Enhance Protection Simple-No Info
Reference Condition	Holdout Condition	Holdout Condition	Messages w/o Ownership Framing	Simple-Enhance Protection Simple-No Info

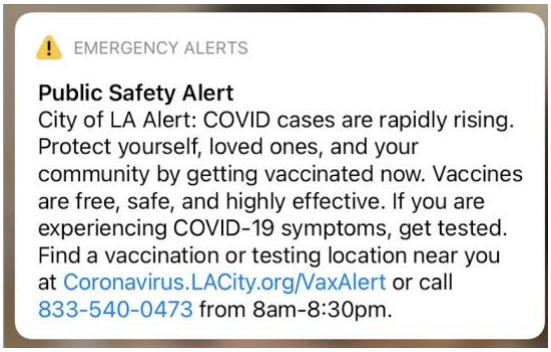
Legend: The table reports ordinary least squares (OLS) regressions predicting booster uptake within four weeks. The key predictors in Column 1 are binary indicators of the 14 message conditions. In Column 2, *Text Reminder* is coded as 1 when participants received any text message and and 0 otherwise. In Column 3, *Containing Ownership* is coded as 1 when participants received any message with the ownership language and 0 otherwise. In Column 4, *Containing Ownership w/o Doctor Rec* is coded as 1 when participants received the *Ownership w/ Narrow Link* or the *Ownership w/ Broad Link* message and 0 when participants received the *Simple-Enhance Protection* or the *Simple-No Info* message. Control variables include pre-registered covariates of gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, other/mixed, with people whose race was unknown to us and whose ethnicity was not Hispanic as the reference group), as well as indicators for the 33 time slots (i.e., 3 times across 11 days) that patients were randomly assigned to. Robust standard errors are reported in parentheses. $^{+}$p<0.10; *p<0.05; **p<0.01; ***p<0.001 (all two-sided).

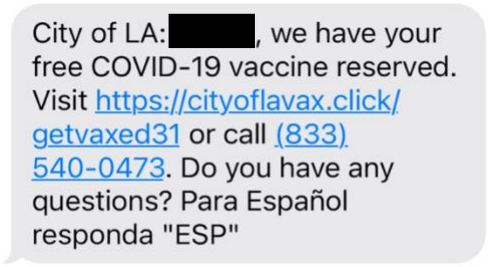
1.9 Effect Size Comparison with Previous Field Work in the Same Population

One of the outcome measures in Saccardo et al. (2023) is comparable to ours: the take-up of the first COVID-19 vaccine dose anywhere in California within four weeks. Using this outcome measure, Saccardo et al. (2023) estimated that receiving (vs. not receiving) a reminder in their first randomized controlled trial on average increased the first COVID-19 vaccine dose uptake by 1.0 percentage point, and that adding ownership language increased the first dose uptake by 0.60 percentage points (relative to the reminders without such language). These effect sizes are similar to what we observed here: receiving one reminder on average increased booster uptake within four weeks by 1.09 percentage points, and the addition of ownership framing is estimated to have increased the booster uptake rate by 0.77 percentage points, relative to the messages without this language.

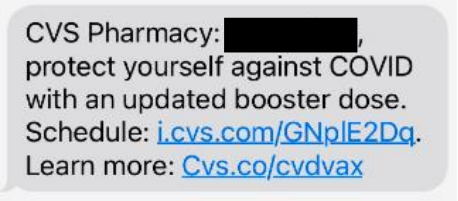
Section 2: Examples of Practices Related to COVID-19 Vaccinations

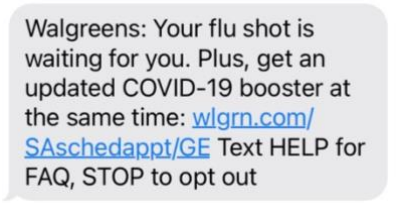
1. Messages from the City of Los Angeles in 2021 to promote COVID-19 vaccinations



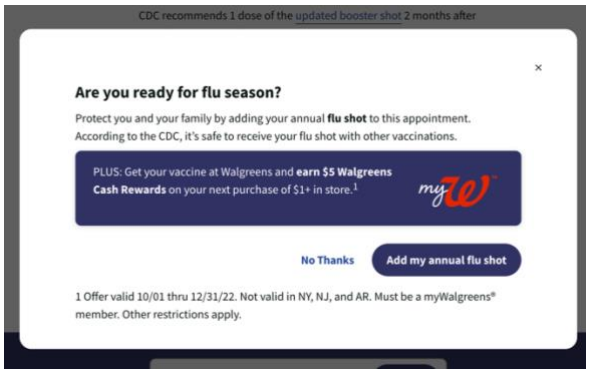


2. Messages from Walgreen and CVS to promote the uptake of bivalent booster and/or flu shot





3. Screenshots showing that Walgreen and CVS websites encouraged customers to add flu shot to bivalent booster appointments



Section 3: Prediction Surveys with Behavioral Scientists and Lay People

Methods

We invited attendees of two conferences, the 2022 Annual Behavioral Economics and Health Symposium (November 10, 2022) and the 2022 Society of Judgment and Decision Making annual meeting (November 10-13, 2022), to participate in a brief prediction survey. Respondents were presented with a brief background about the first RCT at UCLA Health and asked to select which one of the three text messages tested in the first RCT would lead the largest number of patients to receive the COVID-19 bivalent booster. They were also asked to indicate their discipline and current status.

In addition, we recruited Prolific workers living the United States in early November 2022 to make the same prediction. Specifically, we used Prolific's screening database to identify English-fluent adults in the United States who had completed at least one dose of the COVID-19 vaccine. At the start of the survey, we asked participants whether they had completed the COVID-19 primary vaccine series and when they received the last dose of the COVID-19 vaccine. Participants also reported whether they already received the flu shot. Next, participants were presented with a brief background about the first RCT at UCLA Health and asked to select

which one of the three text messages tested there would lead the largest number of patients to receive the COVID-19 bivalent booster. Finally, they provided their demographics.

These two prediction surveys as well as all the surveys mentioned in the SI are available at https://osf.io/qhw95/?view_only=2d0c071d4a494c569b68fcd5bcacf410.

Results

A total of 40 behavioral scientists responded to our survey during the two aforementioned conferences, comprising 47.5% faculty members and 45% post-docs, PhD students, or other academic positions. In this sample, 85% were behavioral scientists, and 7.5% were economists. Regarding which message would yield the highest booster uptake rate, 60% of experts predicted that the *Bundle-Booster & Flu Shot* message would be the most effective, 25% selected the *Bundle-Tagging Flu Shot* message, and the remaining 15% chose the *Simple-Enhance Protection* message. This distribution was statistically significantly different from the expected pattern had experts believed that the three messages would perform equally and picked randomly ($p = 0.0012$). The proportion that selected the *Bundle-Booster & Flu Shot* message was significantly higher than the chance level of 33.3% ($p = 0.0003$). The proportion that selected either of the two bundling messages (i.e., either *Bundle-Booster & Flu Shot* or *Bundle-Tagging Flu Shot*) was significantly higher than the chance level of 66.6% ($p = 0.014$).

Among the 498 Prolific respondents who made a prediction, the average age was 37.13 (SD = 14.18), with 45.58% identifying as male, 72.49% identifying as White (excluding Hispanic participants), and 4.42% identifying as Hispanic. Regarding which message would yield the highest booster uptake rate, 70.48% of respondents predicted that the *Bundle-Booster & Flu Shot* message would be the most effective, 22.49% selected the *Bundle-Tagging Flu Shot* message, and the remaining 7.03% chose the *Simple-Enhance Protection* message. This distribution was statistically significantly different from the expected pattern under chance ($p < 0.0001$). The proportion that picked the *Bundle-Booster & Flu Shot* message was significantly higher than the chance level of 33.3% ($p < 0.0001$). The proportion that selected either of the two bundling messages (i.e., either *Bundle-Booster & Flu Shot* or *Bundle-Tagging Flu Shot*) was significantly higher than the chance level of 66.6% ($p < 0.0001$).

We observe the same pattern when we focus on the 363 respondents who reported that they completed the COVID-19 primary vaccine series and did not receive any COVID-19 vaccine dose in September, October, or November 2022—that is, people who met the basic eligibility for the COVID-19 bivalent booster at the time of our study. Further, among this sample, we observe the same pattern among the subset of participants who had not yet obtained the flu shot at the time of our study (n = 261) as well as among those who had already obtained the flu shot (n = 102).

Section 4: Online Experiment Assessing Vaccine Bundling Messages

In mid-November 2022, we conducted a pre-registered online experiment to examine the vaccine bundling interventions implemented in our first RCT (https://aspredicted.org/L17_JW2). We were primarily interested in the perceived persuasiveness of these messages as well as how they may affect people's perceptions of the ease of getting two vaccines at once.

Methods

We aimed to recruit adults living in the United States who were eligible for the COVID-19 bivalent booster but had not yet received it. We used Prolific's screening database to identify participants in the United States who had received at least one dose of the COVID-19 vaccine and were fluent in English. At the beginning of the survey, we asked participants whether they had completed the COVID-19 primary vaccine series, when they received their last dose of the COVID-19 vaccine, and whether they had already received the flu shot for the 2022-2023 flu season.

We asked participants to imagine that their healthcare provider sent them a text message about the bivalent COVID-19 booster. Participants were randomly assigned to read one of the three messages tested in our first RCT, with minor modifications to fit the context (e.g., replacing "UCLA Health" with "Our clinics"). After reading their assigned message, participants answered two pre-registered primary outcome measures in a randomized order. Specifically, participants rated how persuasive they thought the message was (from 1 = Not at all persuasive to 7 = Very persuasive; *Perceived Persuasiveness*) and the extent to which the message would make them feel that it was convenient to get the flu shot at the same time as the bivalent COVID-19 booster ((from 1 = Not at all to 7 = Extremely; *Perceived Convenience*).

Then participants reported how likely they would be to get the bivalent COVID-19 booster (*Booster Intentions*). If participants had not yet obtained the flu vaccine for that season, they also rated how likely they would get the flu shot (*Flu Shot Intentions*). The response scale for both questions ranged from 1 = Not at all likely to 7 = Very likely. Participants were also asked how valuable it would be to get the bivalent COVID-19 booster (*Booster Value*). Participants responded to a few additional questions about the bivalent booster or flu shot. At the end of the survey, participants reported their demographics and COVID-19 vaccination history, among other background information.

Due to Prolific's requirements, we could not screen participants out based on their responses once they start the survey. However, our pre-registered analyses reported below only include participants who met the basic eligibility requirements for the COVID-19 bivalent booster. A total of 625 participants had completed the COVID-19 primary vaccine series at the time of our study, did not obtain any vaccine dose in September, October, or November 2022, and responded to our pre-registered outcome measures. Unless otherwise noted, our analyses focus on this pre-registered sample.[3] These participants had an average age of 34.52 years old (SD=12.48), 49.76% were male, 67.36% were White (excluding Hispanic participants), and 6.72% were Hispanic.

Results

Following our pre-registration, we began by examining whether the two vaccine bundling messages worked differently from each other, in order to decide whether we should collapse them into one condition to be compared with the *Simple-Enhance Protection* message. In OLS regressions that only included participants assigned to the two vaccine bundling messages, we predicted *Perceived Persuasiveness* and *Perceived Convenience* with an indicator for the *Bundle-Booster & Flu Shot* message (with the reference group being the *Bundle-Tagging Flu Shot* message). These regressions, as well as all other introduced below, included pre-registered covariates of gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, and race/ethnicity (Hispanic, White non-Hispanic, Black non-

[3] The results are robust to using all workers who responded to our pre-registered primary outcome measures (N = 862).

Hispanic, Asian non-Hispanic, with people whose race was other or mixed or unknown to use and whose ethnicity was not Hispanic as the reference group). Since only one person did not report demographics, we did not include an indicator for missing demographics.

As shown in Table 6 Columns 1 and 3, the two bundling messages did not significantly differ in *Perceived Persuasiveness* (B = 0.238, SE = 0.149, p = 0.111) and *Perceived Convenience* (B = -0.131, SE = 0.155, p = 0.397). Thus, we combined the two vaccine bundling messages in our analyses going forward.

In OLS regressions that included all participants in the sample, we predicted *Perceived Persuasiveness* and *Perceived Convenience* with a binary variable, *Bundling,* which equals one if participants read one of the two vaccine bundling messages and zero if participants read the *Simple-Enhance Protection* message. Column 2 of Table 6 shows that the two vaccine bundling messages were perceived as significantly more persuasive than the simple message (B = 0.428, SE = 0.126, p = 0.001). Column 4 of Table 6 shows that getting the flu shot and the bivalent COVID-19 booster simultaneously seemed more convenient when participants read one of the vaccine bundling messages than when if they read the simple message (B = 1.592, SE = 0.152, p < 0.001).

Table 6: Differences Between RCT1 Text Messages in Persuasiveness and Convenience Perceptions Based on Online Experiment

	Perceived Persuasiveness		Convenience	
	(1)	(2)	(3)	(4)
Bundle-Booster and Flu Shot	0.238		-0.131	
	(0.149)		(0.155)	
Bundle		0.428***		1.592***
		(0.126)		(0.152)
Control Variables	Yes	Yes	Yes	Yes
N	414	625	414	625
R^2	0.030	0.037	0.031	0.185
Conditions Included	Bundle-Tagging Flu Shot Bundle-Booster and Flu Shot	All Conditions	Bundle-Tagging Flu Shot Bundle-Booster and Flu Shot	All Conditions

Legend: The table reports ordinary least squares (OLS) regressions predicting the perceived persuasiveness of a message (Columns 1-2) and the perceived easiness of getting the flu shot at the same time as the bivalent booster Columns 3-4). *Bundle-Booster and Flu Shot* is coded as 1 when participants received the *Bundle-Booster Flu Shot* message and 0 otherwise. *Bundle* is coded as 1 when participants received one of the two vaccine bundling messages (*Bundle-Tagging Flu Shot*, *Bundle-Booster Flu Shot*) and 0 otherwise. Control variables include pre-registered covariates of gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, and race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, with people whose race was other or mixed or unknown to use and whose ethnicity was not Hispanic as the reference group). Robust standard errors are reported in parentheses. $^{+}$p<0.10; *p<0.05; **p<0.01; ***p<0.001 (all two-sided).

In addition, using the same regression specification described above, we explored whether the perceived value of getting the bivalent booster as well as intentions to get the booster and the flu shot differed between the two vaccine bundling messages and the simple message. Participants viewed it as more valuable to get the bivalent booster if they were prompted to think about getting the flu shot at the same time than if they read the simple message (B = 0.378, SE = 0.140, p = 0.007). This suggests that reminding people of the opportunity to bundle both vaccines may prompt them to recognize an added benefit of getting the booster—that is, they can also use the time to get the flu shot.

Intentions to get the bivalent booster were directionally but not statistically significantly higher in the two vaccine bundling conditions than in the simple message condition (B = 0.216, SE = 0.155, p = 0.166). However, in our robustness check analyses that include all participants (including those who received a dose of the COVID-19 vaccine in the past two months and thus seemed to have already received the bivalent booster), we observed that participants reported

significantly higher intentions to get the bivalent booster after reading one of the two vaccine bundling messages than after reading the simple message (B = 0.315, SE = 0.133, p = 0.018).[4]

Section 5: Online Survey Exploring Beliefs Associated with Vaccination Intentions

In mid-September 2022, we conducted an online survey to investigate the factors that predict the general public's intentions to receive the COVID-19 bivalent booster.

Methods

We recruited 533 adults from Prolific (n=349) and Amazon Mechanical Turk (n=184) who had completed the COVID-19 primary vaccine series, lived in the United States, and passed an attention check (for MTurk only). They were on average 37.57 years old (SD=13.44), 40.71% were male, 48.78% were White (excluding Hispanic participants), and 13.13% were Hispanic. To select participants on Prolific, we used Prolific's screening system to identify people who had received at least one dose of the COVID-19 vaccine, and then confirmed participants' vaccination status at the start of the survey. On MTurk, only participants who reported having completed the primary vaccine series were allowed to take the survey, and participants were unaware of our selection criterion when they provided their vaccination status.

At the beginning of the survey, we informed participants that the Food and Drug Administration (FDA) had authorized for use the new bivalent COVID-19 boosters developed by Pfizer and Moderna. We then asked participants a series of questions about their intentions to get the booster, their beliefs about the coronavirus and the bivalent booster, and their demographics. The following measures are particularly important to shaping the design of our text messages and thus are highlighted below.

- *Perceived Eligibility*: Participants indicated whether they thought they were eligible to get the bivalent booster, with 1 equaling "Yes, I believe I am eligible", 2 equaling "I am not sure", and 3 equaling "No, I don't believe I am eligible."
- *Booster Intentions*: Participants reported whether they intended to get the bivalent booster, with 1 indicating "I have already gotten the COVID-19 bivalent booster", 2 indicating "I plan to get the COVID-19 bivalent booster but I have not done it yet", 3 indicating "I am not sure if I will get the COVID-19 bivalent booster", and 4 indicating "I do not plan to get the COVID-19 bivalent booster."
- *Infection Likelihood* and *Booster Effectiveness for Infections*: Participants reported their likelihood of getting infected with the coronavirus if they did not receive the COVID-19 bivalent booster (*Infection Likelihood without Booster*) and if they did receive the COVID-19 bivalent booster (*Infection Likelihood with Booster*) (from 0% = I certainly won't get infected with COVID-19 to 100% = I certainly will get infected with COVID-19). For each participant, we subtracted *Infection Likelihood with Booster* from *Infection Likelihood without Booster* to capture their belief in the effectiveness of the COVID-19 booster in reducing their chance of getting infected with the coronavirus (*Booster Effectiveness for Infections*), which in theory could range from -100% to 100%.
- *Long COVID Likelihood* and *Booster Effectiveness for Long COVID*: After introducing Long COVID-19, which we defined as a range of health problems that can last weeks or

[4] Participants who already received the bivalent booster may have responded to our question based on what they would do after getting the message from their healthcare provider if they had not yet received the booster.

even months after COVID-19 infections, we asked participants to report their likelihood of getting Long COVID-19 if they unfortunately became infected with COVID-19. Participants reported the likelihood under two circumstances: One was when they did not receive the COVID-19 bivalent booster (*Long COVID Likelihood without Booster*), and the other was when they did receive the COVID-19 bivalent booster (*Long COVID Likelihood with Booster*) (from 0% = I certainly wouldn't develop Long COVID to 100% = I certainly would develop Long COVID). To measure *Booster Effectiveness for Long COVID,* we subtracted *Long COVID Likelihood with Booster* from *Long COVID Likelihood without Booster*.

- *Infection Severity* and *Booster Effectiveness for Severe Symptoms*: Participants also reported how ill they thought they would be if they unfortunately got infected with COVID-19 (from 0 = No symptoms to 10 = Severely ill/hospitalized), and they did so for two circumstances. One circumstance was when they did not receive the COVID-19 bivalent booster (*Infection Severity without Booster*) and the other was when they did receive the COVID-19 bivalent booster (*Infection Severity with Booster*). The difference between these two measures was *Booster Effectiveness for Infection Severity.*
- *Comparative Efficacy over Original Booster*: Participants rated the extent to which they agreed with the statement, "I believe the bivalent COVID-19 boosters are much more effective than the original COVID-19 boosters in protecting people against the dominant Omicron variants (BA.4 and BA.5)" (from 0 = Strongly disagree to 10 = Strongly agree).
- *Guideline Confusion*: Participants rated the extent to which they agreed with the statement, "I think the current public health guidelines about who should get the bivalent booster are confusing" (from 0 = Strongly disagree to 10 = Strongly agree).
- *Perceived Doctor Recommendation*: Participants predicted, "What percentage of doctors do you think are recommending their eligible patients to get the bivalent COVID-19 booster?" (from 0% to 100%).

Results

Across the 533 workers, 10.13% reported having already received the bivalent booster, 54.03% reported that they planned to get it but had not done so yet, 27.95% were unsure about getting the bivalent booster, and the remaining 7.88% did not plan to get it.

To inform the design of text messages, we compared beliefs about the coronavirus and the bivalent booster across participants based on whether they planned to get the booster (including those who already got it and those who had not received it), were uncertain, or did not plan to get the booster. Table 7 displays the mean and standard deviation of the key measures (highlighted above) for the three sub-groups of participants. We report the p-values of statistical tests that compare people who planned to get the booster with those who felt uncertain or did not plan to get it. Compared to those uncertain or not intending to get the bivalent booster, people who planned to get the booster:

- Were more likely to realize that they were eligible for the bivalent booster.[5] In fact, people who indicated uncertainty about booster intentions were less aware of their eligibility (M =

[5] At the time of our study, CDC guidelines indicated that adults who had completed the COVID-19 primary vaccine series and had not received a vaccine dose within two months were eligible for the bivalent booster. The guidelines also stated that people who had recently contracted COVID-19 may consider delaying getting a vaccine dose for three months (https://www.cdc.gov/coronavirus/2019-ncov/vaccines/stay-up-to-date.html). Our fining about the difference in eligibility awareness between

1.50, SD = 0.50), compared to both participants who intended to get the bivalent booster (M = 1.20, SD = 0.43, $t(489) = 6.78$, $p < 0.0001$) and those who did not intend to get the booster (M = 1.26, SD = 0.50, $t(189) = 2.82$, $p < 0.0001$). A closer look at the data suggests that among people who intended to get the booster, a large portion (80.99%) knew they were eligible; and a similarly large (73.81%) of participants who did not plan to get the booster knew they were eligible. In contrast, only 49.66% of people with uncertain booster intentions knew they were eligible, and the remaining 50.34% said they did not know if they were eligible.

- Believed that if they did not get the bivalent booster, they would have a greater likelihood of getting infected with COVID-19, a higher likelihood of developing Long COVID, and more severe COVID-19 symptoms
- Believed more strongly in the bivalent booster's effectiveness in reducing the likelihood of getting infected with COVID-19, the chance of developing Long COVID, and the severity of COVID-19 symptoms
- Believed more strongly that the bivalent boosters offered greater protection over the dominant Omicron variants than the original boosters
- Expressed less confusion about public health guidelines on bivalent boosters
- Believed that a greater percentage of doctors recommended the bivalent boosters

Based on these results, we developed text messages to address different factors associated with booster uptake intentions. Specifically, our messages (1) emphasized the enhanced efficacy of bivalent boosters over original vaccines in fighting against the dominant Omicron variants (*Uniqueness*), (2) clarified potential confusion about who were eligible for and could benefit from the bivalent boosters (*Eligibility Clarification*), (3) highlighted the chance of developing Long COVID and severe COVID-19 symptoms as well as the effectiveness of bivalent boosters in reducing the risk (*Severity*), and (4) communicated doctors' strong recommendations (*Doctor Recommendation Only*, *Doctor Rec & Ownership w/ Narrow Link, Doctor Rec & Ownership w/ Broad Link*). In addition, all messages either clearly informed patients that they were eligible for the bivalent booster or at least implied so.

subgroups of participants holds, even when we exclude those who had received the bivalent booster, contracted COVID-19 in the past 90 days, or received a vaccine dose within the past two months.

Table 7: Comparisons of COVID-19- and Booster-related Beliefs and Perceptions by Booster Intentions

Booster Intentions	No		Uncertain		Yes		Compare "Yes" vs. "Uncertain"/"No"
	Mean	SD	Mean	SD	Mean	SD	p-value of two-sided t-test, Cohen's d
Perceived Eligibility	1.26	0.45	1.50	0.50	1.20	0.43	$p < 0.0001$, $d = 0.55$
Infection Likelihood without Booster	30.62	19.53	34.64	19.43	45.92	23.62	$p < 0.0001$, $d = 0.55$
Booster Effectiveness for Infections	1.14	15.03	9.30	15.76	20.60	20.27	$p < 0.0001$, $d = 0.70$
Long COVID Likelihood without Booster	22.14	20.69	33.82	22.61	42.47	25.06	$p < 0.0001$, $d = 0.46$
Booster Effectiveness for Long COVID	3.33	11.73	11.83	17.18	24.28	22.47	$p < 0.0001$, $d = 0.70$
Infection Severity without Booster	3.67	2.20	4.27	1.68	5.34	1.82	$p < 0.0001$, $d = 0.66$
Booster Effectiveness for Infection Severity	0.64	1.32	1.48	1.41	2.80	1.82	$p < 0.0001$, $d = 0.88$
Comparative Efficacy over Original Booster	4.83	2.50	5.58	1.71	6.11	2.35	$p = 0.0006$, $d = 0.31$
Guideline Confusion	5.38	2.55	5.22	2.21	3.72	2.79	$p < 0.0001$, $d = 0.59$
Perceived Doctor Recommendation	68.60	21.32	70.14	20.80	82.58	16.58	$p < 0.0001$, $d = 0.70$

Legend: The table reports the mean value and standard deviation for a series of measures of perceptions and beliefs about COVID-19 and the bivalent booster, for participants who chose either "I have already gotten the COVID-19 bivalent booster" or "I plan to get the COVID-19 bivalent booster but I have not done it yet" (*Yes*), participants who chose either "I am not sure if I will get the COVID-19 bivalent booster" (*Uncertain*), and participants who chose "I do not plan to get the COVID-19 bivalent booster" (*No*). The original scale of *Infection Likelihood without Booster*, *Long COVID Likelihood without Booster*, and *Perceived Doctor Recommendation* was 0% to 100%, and we multiply the raw values by 100 for ease of presentation. The original scale of *Booster Effectiveness for Infections* and *Booster Effectiveness for Long COVID* was -100% to 100%, and we multiply the raw values by 100 for ease of presentation. The last column reports the p-value of two-sided two-sample *t*-test that compares each variable between "Yes" participants and "Uncertain" or "No" participants, along with the corresponding Cohen's *d*. Degree of freedom is 531 for the two-sided two-sample *t*-test for all variables.

Section 6: Online Experiment Comparing Information Provision Interventions

In October 2022 while our RCTs were ongoing, we conducted a pre-registered online experiment to examine the information provision interventions implemented in our second RCT (https://aspredicted.org/MYX_HZH). We sought to test how these interventions affect people's intentions to get the booster and their perceived persuasiveness of these messages.

Methods

We recruited adults from MTurk who were living in the United States, were eligible for the COVID-19 bivalent booster, and had not yet received it. Our data collection spanned four consecutive days. In the first three days of data collection, per our pre-registration, participants were asked at the start of the survey (1) whether they had completed the primary COVID-19 vaccine series and (2) whether they had gotten a COVID-19 vaccine in the past 2 months. We screened out people who had not completed the primary series (because they were not eligible for the bivalent booster) as well as those that obtained a dose within two months (because they either were not eligible for the bivalent booster at the time of the study or they had already received it). Participants were unaware of our selection criteria. The data collection was getting slow during the third day, and the rate at which people reported getting a COVID-19 vaccine dose within the past two months was higher than our expectations. We thought workers may not notice the time window of past two months. Thus, we changed the screening process during the final day of data collection to directly ask people whether they had received the bivalent booster. This question was presented at the end of the survey, along with a question asking them whether they had completed the primary COVID-19 vaccine series (we guaranteed participants that their responses would not affect their payment). Our analysis excludes people who had not completed the primary series or who already received the bivalent booster.

We asked participants to imagine that their healthcare provider sent them a text message about the bivalent COVID-19 boosters. Participants were randomly assigned to read one of the six messages tested in our second RCT with minor modifications to suit the context. All messages explained to patients that "our clinics have limited booster appointment available", and encouraged patients to book an appointment at a pharmacy nearby, which mimicked the text messages used in our second RCT from the fourth day on.

After reviewing the assigned message, participants rated how persuasive they thought the message was (from 1 = Not at all persuasive to 7 = Very persuasive) and how likely they would be to get the bivalent COVID-19 booster (from 1 = Not at all likely to 7 = Very likely). *Persuasiveness* and *Booster Intentions* were our pre-registered dependent variables, and their order was randomized.

Next, participants responded to a series of questions assessing their beliefs about the bivalent COVID-19 booster. In the end, participants reported demographics and their COVID-19 vaccination history, among other background information.

A total of 1,774 participants met our aforementioned selection criteria, responded to our pre-registered outcome measures, and were thus included in our analysis.[6] They were an average of 42.06 years old (SD=23.89), 47.69% were male, 73.56% were White (excluding Hispanic participants), and 4.28% were Hispanic.

Results

As pre-registered, this study has two main research questions. One question pertains the effect of changing people' beliefs about the bivalent booster by providing relevant information. Answering this question requires us to compare the three messages containing an information provision intervention—the *Info-Uniqueness* message, the *Info-Eligibility Clarification* message, and the *Info-Severity* message—with the *Simple-No Info* message. The other question pertains the effect of eliciting the consistency principle by complimenting people on their completion of the COVID-19 vaccine primary series. Answering this question requires us to compare the *Consistency* message and the *Consistency & Info-Uniqueness* message with the *Simple-No Info* message.

Following our pre-registration, we began by comparing the three information-provision messages to determine whether we should collapse them into one condition. We predicted *Perceived Persuasiveness* and *Booster Intentions* using OLS regressions, with an indicator of the *Info-Uniqueness* Message and an indicator for the *Info-Severity* message (with the *Info-Eligibility Clarification* message as the reference group). These regressions only included observations from these three information-provision conditions. These regressions and all other

[6] We had initially pre-registered to collect 3,600 responses and test another version of the text messages that did not mention the limited booster appointments at the clinics (while keeping everything else in the messages the same). However, after the first day of data collection, we realized that the rate at which people met our selection criteria was much lower than our expectation. Out of 1,185 workers who responded, only 560 (47%) had completed the COVID-19 vaccine primary series and had not received any COVID-19 vaccine dose within the past two months. This made it challenging for us to recruit 3,600 participants, which required nearly 8,000 MTurk workers to respond to our survey. Additionally, the version of text messages that did not mention the limited booster appointments at clinics may seem odd to participants, as they may wonder why their healthcare providers would encourage them to get the booster at a local pharmacy instead of at clinics. For these reasons, we dropped this version of text messages from the second day of data collection onwards and aimed to recruit 1,800 eligible participants to react to the version of text messages that mentioned limited booster appointments at clinics, just as the text messages in our RCTs did.

introduced below controlled for pre-registered covariates of gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, with people whose race was other or mixed or unknown to use and whose ethnicity was not Hispanic as the reference group), and an indicator for missing demographics.

As shown in Table 8 Column 1, both the *Info-Uniqueness* message (B = 0.414, SE = 0.133, p = 0.002) and the *Info-Severity* Messages (B = 0.383, SE = 0.133, p = 0.004) were perceived as significantly more persuasive than the *Eligibility Clarification* message. A Wald test indicates that there was no detectable difference in *Perceived Persuasiveness* between the *Info-Uniqueness* message and the *Info-Severity* message (p = 0.814). A joint significance F-test was significant (p = 0.003), rejecting the null hypothesis that the three information-provision messages had the same true value.

In terms of *Booster Intentions* (Table 8 Column 4), the *Info-Uniqueness* message led people to report higher intentions to get the bivalent booster than the *Info-Eligibility Clarification* message (B = 0.321, SE = 0.164, p = 0.05). The *Info-Severity* message did not significantly differ from either the *Info-Uniqueness* message (p = 0.314) or the *Info-Eligibility Clarification* message (p = 0.339). A joint significance F-test of the coefficient on *Info-Uniqueness* and the coefficient on *Info-Severity* is not significant (p = 0.147), failing to reject the null hypothesis that the three message conditions had the same true value. In light of the inconclusive evidence for whether or not the three information-provision messages differed from each other in *Booster Intentions*, we compare these messages both jointly and separately with the *Simple-No Info* message in our next analyses.

In the OLS regressions that included all participants, we predicted *Perceived* Persuasiveness and *Booster Intentions* with (1) a binary indicator, *Information Provision,* which equals one if a patient received one of the three information-provision messages and zero if the patient received the *Simple-No Info* message; (2) a binary indicator for getting the *Consistency* message; and (3) a binary indicator for getting the *Consistency & Info-Uniqueness* message. The *Simple-No Info* message was the reference group in these regressions. The results are reported in Table 8 Columns 2 and 5.

Compared to the *Simple-No Info* message, the three information-provision messages combined were viewed as significantly more persuasive (B = 0.661, SE = 0.110, p < 0.001) and yielded significantly higher intentions to receive the bivalent booster (B = 0.409, SE = 0.134, p = 0.002). Compared to the simple message, complimenting people on their completion of primary vaccine series significantly increased the persuasiveness of the message (B = 0.326, SE = 0.133, p = 0.014) and enhanced booster intentions (B = 0.385, SE = 0.164, p = 0.019). Combining the consistency principle with information about the uniqueness of the bivalent booster also led to higher perceived persuasiveness (B = 0.913, SE = 0.135, p < 0.001) and booster intentions (B = 0.417, SE = 0.168, p = 0.013) than the simple message.

In another specification, we predicted *Perceived Persuasiveness* and *Booster Intentions* with five binary indicators of the five treatment messages (with the *Simple-No Info* message as the reference group). As shown in Table 8 Column 3, all five treatment messages were viewed as significantly more persuasive than the *Simple-No Info* message (B ranged from 0.325 to 0.912, SE ranged from 0.132 to 0.137, all p-values < 0.015). Further, as shown in Table 8 Column 6, *Info-Uniqueness*, *Info-Severity*, *Consistency*, and *Consistency & Info-Uniqueness* messages all led participants to report significantly higher intentions to get the bivalent booster, compared to the *Simple-No Info* message (B ranged from 0.385 to 0.560, SE ranged from 0.162 to 0.168, p-

values < 0.02). The *Info-Eligibility Clarification* message led to directionally but not significantly higher booster intentions than the *Simple-No Info* message (p = 0.131).

To summarize, this online experiment shows that people view all of our treatment messages tested in the second RCT as more persuasive than the corresponding simple message, and that all treatment messages except one statistically significantly enhanced people's reported intentions to get the bivalent booster.[7]

Table 8: Differences Between RCT2 Text Messages in Persuasiveness and Booster Intentions Based on Online Experiment

	Perceived Persuasiveness			Booster Intentions		
	(1)	(2)	(3)	(4)	(5)	(6)
Info-Uniqueness	0.414**		0.801***	0.321+		0.560***
	(0.135)		(0.134)	(0.165)		(0.162)
Info-Severity	0.383**		0.775***	0.158		0.404*
	(0.133)		(0.132)	(0.166)		(0.163)
Information Provision		0.661***			0.409**	
		(0.110)			(0.134)	
Info-Eligibility Clarification			0.392**			0.251
			(0.137)			(0.167)
Consistency		0.326*	0.325*		0.385*	0.385*
		(0.133)	(0.133)		(0.164)	(0.164)
Consistency and Info-Uniqueness		0.913***	0.912***		0.417*	0.416*
		(0.135)	(0.135)		(0.168)	(0.168)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
N	895	1774	1774	895	1774	1774
R^2	0.026	0.047	0.053	0.007	0.009	0.011
Conditions Included	Info-Uniqueness Info-Eligibility Info-Severity	All Conditions	All Conditions	Info-Uniqueness	All Conditions	All Conditions

Legend: The table reports ordinary least squares (OLS) regressions predicting the perceived persuasiveness of a message (Columns 1-3) and participants' intentions to get the bivalent booster after reading the message (Columns 4-6). The predictor variables are binary indicators of the messages. *Information Provision* is coded as 1 when participants received one of the three information-provision messages (*Info-Uniqueness*, *Info-Severity*, *Info-Eligibility Clarification*) and 0 otherwise. Control variables include pre-registered covariates of gender (male, female, with people whose gender was "other" or unknown to us as the reference group), age, race/ethnicity (Hispanic, White non-Hispanic, Black non-Hispanic, Asian non-Hispanic, with people whose race was other or mixed or unknown to use and whose ethnicity was not Hispanic as the reference group), and an indicator for missing demographics. Robust standard errors are reported in parentheses. $^{+}$p<0.10; *p<0.05; **p<0.01; ***p<0.001 (all two-sided).

[7] Unexpectedly, on the last day of data collection (the only day when people reported whether they had already received the bivalent booster at the end of the survey, and we used this question to filter people out of analyses), the proportion of people who reported getting the booster was significantly higher in one condition (the *Consistency & Uniqueness* condition) than in several other conditions. We view this as happening by chance because, in theory, the *Consistency & Uniqueness* message could not change whether people had already received the booster. We conducted two robustness checks: (1) we included all participants who responded to our primary outcome measures on the last day of collection, regardless of whether their vaccination history; and (2) we only examined participants who took our study during the first three days of data collection, when we screened out people who failed our selection criteria at the beginning of the survey and then randomized eligible participants into conditions. All of the key results hold.