Main Manuscript for

A Mega-Study of Text-Based Nudges Encouraging Patients to Get Vaccinated at an Upcoming Doctor's Appointment

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Abstract

Many Americans fail to get life-saving vaccines each year, and the availability of a vaccine for COVID-19 makes the challenge of encouraging vaccination more urgent than ever. We present a large field experiment (N=47,306) testing 19 nudges delivered to patients via text message and designed to boost adoption of the influenza vaccine. Our findings suggest that text messages sent prior to a primary care visit can boost vaccination rates by an average of 5%. Overall, interventions performed better when they were (a) framed as reminders to get flu shots that were already reserved for the patient and (b) congruent with the sort of communications patients expected to receive from their healthcare provider (i.e., not surprising, casual, or interactive). The best-performing intervention in our study reminded patients twice to get their flu shot at their upcoming doctor's appointment and indicated it was reserved for them. This successful script could be used as a template for campaigns to encourage the adoption of life-saving vaccines, including against COVID-19.

Introduction

According to a recent poll by the Pew Research Center, only 60% of Americans plan to get a COVID-19 vaccine (1). To make matters worse, past research suggests that many who say they intend to get vaccinated will not follow through (2). Experts have estimated that to reach herd immunity, 60-90% of Americans must be inoculated against the novel coronavirus (3, 4, 5). Evidence-based strategies that can be rapidly deployed at scale to encourage vaccination are urgently needed.

Although COVID-19 differs from the flu in many ways, both are deadly respiratory diseases with an available vaccine that many Americans choose not to get. The Centers for Disease Control and Prevention recommends that every American over 6 months old receive a flu shot (6) because inoculation typically reduces the chances of contracting the flu by at least 50% (7). Yet, less than half of Americans were vaccinated during the 2019-20 influenza season (8), and an estimated 35,000 died from the flu (9).

It may be possible to move the needle on vaccination against the flu (and, hopefully, COVID-19 as well) with simple, low-cost nudges (10). For instance, we know that prompting people to consider and jot down the exact date and time when they will get a flu shot at a workplace clinic makes vaccination more likely (11); that defaulting people into vaccination appointments is effective (12); that mailings designed to leverage behavioral science insights can increase immunization (13); and that simply reminding high risk individuals to get vaccinated increases inoculation rates (14).

In this paper, we test 19 different nudges delivered to patients via text message, all designed to boost adoption of the flu vaccine.

Materials and Methods

To identify whether and how text messaging interventions could be used to boost vaccination rates at routine primary care visits, we ran a mega-study—a field experiment in which many interventions developed by different teams of scientists were tested in the

same population on the same outcome.

We conducted our study in fall 2020 in partnership with two large health systems in the Northeastern United States: Penn Medicine and Geisinger Health. We included all patients with new or routine (non-sick) primary care appointments at Penn Medicine between September 24, 2020 and December 31, 2020 and at Geisinger Health between September 28, 2020 and December 31, 2020 who met the following eligibility criteria: (1) they had a cell phone number recorded in their electronic health record, (2) they had not opted out of receiving SMS appointment reminders from their healthcare provider or asked not to be contacted for research purposes, (3) they did not have a documented allergy or adverse reaction to the flu vaccine and (4) they had not yet received a flu shot in 2020 according to their electronic health record.[1]

Twenty-six behavioral scientists worked in small teams to generate 19 different text messaging protocols. Protocols varied the contents and/or timing of up to two sets of text reminders to get a flu shot sent from the patient's healthcare provider in the three days preceding the patient's appointment. All intervention message content is included in SI Appendix.

This research was approved by the Institutional Review Board (IRB) at the University of Pennsylvania; the IRB granted a waiver of consent for this research. No identifying information about study participants was shared with the researchers.

We pre-registered our mega-study's design and analysis plan (1: https://aspredicted.org/blind.php?x=sq23yd, 2: https://aspredicted.org/blind.php?x=9zr9nu)[2] and then randomized a total of 47,306 patients to one of the 19 experimental conditions designed by team scientists (N_{min} = 2,295, N_{mean} = 2,365, N_{max} = 2,397) or a usual care control condition in which we did not send patients any text-based reminders to get a flu vaccine (N = 2,389). All patients received standard appointment reminders (the usual care).

Separately, as described in SI Appendix, we hired a separate sample of 2,214 Prolific workers to code subjective attributes (e.g., casualness) of each of the 19 text messaging protocols and, in addition, we classified each on 12 objective attributes (e.g., word count).

Results and Discussion

Patients in our study were an average of 51.9 years old (s.d. = 16.3), 43% were male, 70% were white, 47% had been vaccinated in the previous flu season, and 55% were patients at Penn Medicine. As shown in Table S8 in the Web Appendix (https://bit.ly/2YeummU), study arms were well-balanced on age, gender, race, health system and vaccination history (p-values from all F-tests > 0.05).

[1] As pre-registered, this analysis consists of data collected through December 31, 2020 (our first study endpoint). However, as noted in our pre-registration, we also plan to analyze additional data collected in 2021.

[2] Note that pre-registration 1 makes small updates to pre-registration 2, both of which were posted before any data were analyzed.

Following our pre-registration, we evaluated whether participants received a flu shot on the date of their scheduled appointment or in the three days leading up to it (i.e., when treatments had begun) using an ordinary least squares (OLS) regression and pooling data from Penn Medicine and Geisinger. The primary predictors in our regression were 19 indicator variables—one for assignment to each of our study's 19 experimental conditions (with an indicator omitted for assignment to our study's usual care control condition). Our pre-registered OLS regression included the following control variables: (1) an indicator for being a Penn Medicine patient, (2) patient age, (3) indicators for patient race/ethnicity, (4) indicators for patient gender, (5) an indicator for whether the patient received a flu shot last year, (6) indicators for the type of clinician who saw the patient, and (7) the linear and squared days separating the patient's target primary care appointment from the start of our study (September 20, 2020, when the first participants were enrolled).

In our usual care control group, 42% of patients received a flu vaccine on the day of their scheduled appointment or in the three days before it. As Figure 1 shows, 6 out of our 19 interventions (32%) produced a statistically significant boost in vaccinations (two-sided unadjusted p's < 0.05), and all of our interventions directionally increased vaccination rates. The 19 treatments boosted vaccination levels by an average of 2.1 percentage points or 5% ($p = 0.024$), and we cannot reject the null hypothesis that all 19 effects have the same true value (Chi-sq = 21.277, df = 18, $p = 0.266$)..

To account for multiple comparisons, we report not only standard errors, two-sided p-values and 95% confidence intervals, but also q-values (see Web Appendix). Since each of the six effects significant at $\alpha = 0.05$ has a q-value lower than 0.02, the expected proportion of false positives among estimates at least as extreme as the sixth largest is less than 2% (15). Using the harmonic mean method to compute the meta-analytic p-value from our study, we find that the probability of observing the 19 results depicted in Figure 1 given that they are all true nulls is < 0.0055.

The top-performing intervention in our study showed a 4.6 percentage point boost in vaccination (an 11% increase; $p < 0.01$) at the cost of sending two text messages (less than a dime). Correcting for likely inflation in the largest out of 19 estimates, we calculate a more conservative estimate of the true effect to be a 2.8 percentage point boost in vaccination or a 6.7% increase from baseline (see SI Appendix and Web Appendix). As shown in Figure S1 in the Web Appendix, the first text message in this condition, sent 72 hours before the patient's appointment, noted that "it's flu season," "a flu vaccine is available for you," and "a vaccine reminder" would be sent before the appointment. The second text in this condition, sent 24 hours before the appointment, stated simply that "this is a reminder that a flu vaccine has been reserved for your appointment." This intervention was the top-performer among both Penn Medicine and Geisinger patients.

Which attributes correlate best with intervention effectiveness? In post-hoc analyses, we found that interventions performed better when they were (a) framed as reminders to get flu shots that were already reserved for the patient ($\beta = .41$, $p = .05$) and (b) congruent with the sort of communications patients expected to receive from their healthcare provider (i.e., not surprising, casual, or interactive) ($\beta = .48$, $p < .03$). See SI Appendix and Web Appendix for details on how messages were rated and, next,

classified using principal components analysis. Notably, some of the most artful interventions (e.g., one including a joke about spreading the flu told by a dog to a cat and conveyed in picture form) were among the least effective.

In secondary analyses, we examined how treatment effects differed across different subpopulations studied (see Web Appendix). In general, we found that estimated treatment effects across conditions did not differ significantly whether we looked at patients from Penn Medicine or Geisinger, patients who identified as male or female, patients who were 65+ versus under 65 years old, patients who did or did not receive a flu shot in the 2019-2020 flu season, or patients who had appointments with physicians versus other types of clinicians (all p's > 0.375). There were some significant differences in treatment effect estimates by patient race, suggesting tailoring communications on this dimension could be valuable, but our attribute analyses yielded nearly identical results for White and non-White patients.

Overall, our findings show nudges sent via text messages to patients prior to a primary care visit and developed by behavioral scientists to encourage vaccine adoption can substantially boost vaccination rates at close to zero marginal cost. Our best-performing message, which increased adoption by an estimated 11%, reminded patients twice to get their flu shot at their upcoming doctor's appointment and mentioned that a shot was reserved for them. Although the factors influencing the adoption of vaccines for other diseases, including COVID-19, differ in important ways, this successful script could potentially be repurposed.

Acknowledgments

Research reported in this publication was supported by the National Institute On Aging of the National Institutes of Health under Award Number P30AG034532, the Bill & Melinda Gates Foundation, the Flu Lab, and the Penn Center for Precision Medicine Accelerator Fund. Support for this research was also provided in part by the AKO Foundation, John Alexander, Mark J. Leder, and Warren G. Lichtenstein. We thank Chayce Baldwin for outstanding research assistance, Joseph Simmons for valuable feedback on the manuscript, and Julian Parris for consulting with us on attribute analyses. The content is solely the responsibility of the authors and does not necessarily represent the official views of any of the listed entities.

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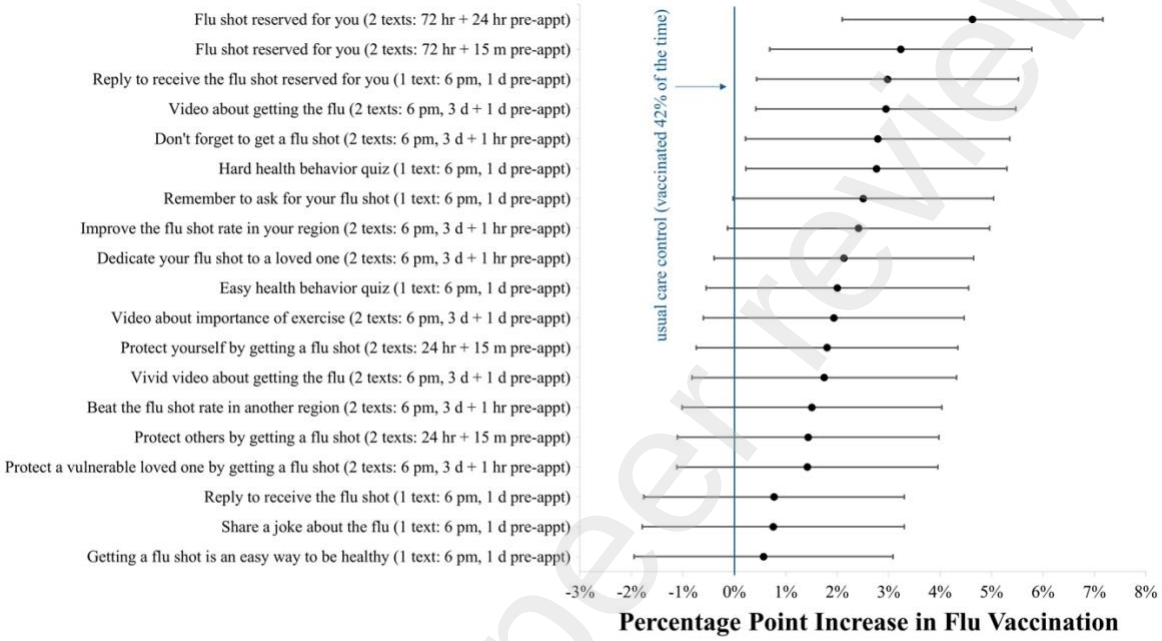
Figure

Figure 1. Regression-estimated increase in flu vaccinations induced by each of our 19 interventions compared to a usual care control at Penn Medicine and Geisinger.



Note: Whiskers depict 95% CIs. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

Supporting Information for

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Supporting Information

Extended Methods

a. Setting

We conducted our mega-study in partnership with Penn Medicine and Geisinger, two large health systems headquartered in Pennsylvania. Patients at 30 Penn Medicine primary care clinics that are part of the Clinical Practices of the University of Pennsylvania and Clinical Care Associates of Penn Medicine located in and around Philadelphia and 56 Geisinger primary care clinics located throughout Pennsylvania were eligible to be included in the mega-study.

b. Participant Eligibility, Enrollment, and Randomization

Participant enrollment. Adult patients (N = 48,688) at Penn Medicine and Geisinger were automatically enrolled in the study if they had an eligible primary care appointment scheduled during the study period. Eligible appointments were in-person, non-sick visits with the patient's primary care provider (who was a physician, resident, nurse practitioner, or physician assistant).

Patients were ineligible for this study if they:

1. Had received their 2020-2021 flu shot prior to their first eligible appointment (as documented in their medical record),
2. Had a documented allergy or adverse reaction to the flu shot,
3. Did not have a cell phone number on file, or
4. Had previously opted out of receiving appointment reminders or had asked not to be contacted for research purposes.

Patient enrollment and randomization occurred four days prior to their first eligible appointment during the study period. The earliest intervention messages were sent three days prior to patients' scheduled appointments. See the section of this document entitled *Intervention Messages* for the exact content of the messages and when messages were sent in each study condition.

A number of patients with eligible appointments were not enrolled in our study. First, a total of 670 patients were assigned to an experimental condition but did not receive any intervention messages due to technical malfunctions. These patients are excluded from analyses since they were, for all practical purposes, not a part of our study. Another 712 patients canceled their appointments on the same day they were enrolled (four days prior to their appointment), which was before messages were sent in any condition.[1] These patients are also excluded from analyses

[1] Our data provider received cancellation records from Geisinger once per day in the late morning. As a result, we did not receive sufficiently precise cancellation records to exclude Geisinger participants from our study who had cancelled appointments four days prior to a morning appointment. To adhere with our intent-to-treat principle, we did not exclude these participants in case they received an intervention message before our data provider updated their cancellation records.

since, again, they were not able to experience an intervention condition.

Patients who canceled their appointment less than four days in advance (N=10,978), did not show up their appointment (N=3,648), or converted their appointments to telemedicine visits (N=907) were included in our analyses given that they could have already received intervention messages by the time they changed their plans. If these patients rescheduled their original appointment or scheduled a new appointment during the study period (N=4,515), their intervention messages were re-started prior to their new appointment (i.e., up to three days prior to the new appointment). Patients at Penn Medicine stopped receiving messages as soon as they canceled or changed their appointment; patients at Geisinger who canceled or changed their appointments received messages for the remainder of the day.

Enrollment began on September 20, 2020 (for appointments on September 24, 2020) at Penn Medicine and September 25, 2020 (for appointments on September 29, 2020) at Geisinger.[2] Consistent with our pre-registration, this paper analyzes data collected through December 31, 2020 (our first study endpoint). However, as noted in our pre-registration, we also plan to analyze additional data collected in 2021. Specifically, following our pre-registration, we will analyze data again when 1) we have successfully recruited 4,000 people per experimental condition or 2) we reach March 31, 2021 — whichever comes first. We will also analyze all data collected through March 31, 2021, no matter what.

Power calculations. At least 2,295 patients were assigned to each study condition (average: N = 2,365.4; median: N = 2,367). Power calculations indicate that we have 90% power to detect a difference of 4.8 percentage points in vaccination rates across conditions (two-tailed $\alpha = 0.05$).

Randomization. Once enrolled, patients were randomly assigned to a study condition with stratification by (1) site (Geisinger vs. Penn Medicine), (2) age at the time of appointment (18-64 vs. 65+), and (3) vaccination receipt in the 2019-2020 flu season as recorded in medical records (yes vs. no/unknown).

c. The Interventions

The mega-study included 19 different experimental conditions designed by 26 behavioral scientists from the BCFG Scientific Team, the Penn Medicine Nudge Unit, and the Geisinger Behavioral Insights Team. The interventions were designed as eight self-contained experiments, each with its own comparison condition that could be analyzed separately. All experimental conditions were randomized simultaneously to allow us to analyze the effectiveness of different

[2] Note that there are four Penn Medicine patients with appointments on September 23rd included in our analyses. These participants were enrolled with appointments on September 24th, but rescheduled the appointments to September 23 after they had been randomized.

interventions across studies (and compared to a control condition that did not receive a flu shot nudge). Altogether, these 19 different experimental conditions and 1 holdout control condition were launched simultaneously at both Penn Medicine and Geisinger in September 2020. All experimental conditions were designed to increase flu shot vaccinations and were delivered via text message (SMS).

Patients in the holdout control condition received only the standard appointment SMS reminders from their health system, indicating the date, time, and location of their appointments. These reminders were sent two business days prior to appointments at Penn Medicine, and one week, three days, and one day prior to appointments at Geisinger.

In all 19 experimental conditions in our mega-study, patients were sent intervention text messages in addition to the standard health system appointment reminders. Interventions varied the content of the text messages patients received and could include interactive components (e.g., Y/N questions with branching messaging determined by patient responses), links to external videos and surveys, variable numbers of messages (up to two, unless patients opted in to receive additional messages), and the timing of text messages (which could be sent as early as three days prior to a scheduled appointment and as late as 15 minutes prior to the appointment). Complete information about the study stimuli in each condition is detailed in the *Intervention Messages* section of this document.

d. Statistical Analysis

Dependent variable. Our primary dependent variable is a binary measure of whether patients received a flu shot at or in the three days before their appointment (following assignment to experimental conditions), as recorded in their electronic health records.

For the primary dependent variable of whether patients received a flu shot at or before their appointment, we counted all flu shots that occurred during patients' "intervention window." We define this as the time during which patients could have received intervention messages through the date of their appointment. For patients who went to their appointment as scheduled, the intervention window began three days prior to their scheduled appointment and ended on the date of their appointment. If patients rescheduled their appointment after the start of their intervention window, the intervention window extended from three days prior to the original appointment through the date of the new appointment. Patients who canceled their appointments during their intervention window and did not reschedule were included in our analyses (the conclusion of their intervention window was defined based on the date of the canceled appointment).

Regression specifications. Following our pre-registration, we ran an ordinary least squares regression (OLS) to predict whether a given patient received a flu shot at or in the three days prior to their target appointment (a binary indicator variable).[3] The primary predictor variables in our regression were 19 indicators for assignment to each of the study's 19 experimental conditions (an indicator for the holdout control condition, which was the reference group in our regression, was omitted). Our regression controlled for the study site, individual patient characteristics including age, race, and gender, flu shot receipt in the previous flu season (2019-20), the type of provider who saw the patient, and the linear and squared number of days elapsed since the start of the study. See Table S1 in the Web Appendix (https://bit.ly/2YeummU).

We also examined whether the effects of our treatments varied for patients from Penn Medicine or Geisinger (see Table S2 in the Web Appendix), patients who identified as male or female (see Table S3 in the Web Appendix), patients who were 65+ versus under 65 years old (see Table S4 in the Web Appendix), patients who did and did not receive a flu shot in the 2019-2020 flu season (see Table S5 in the Web Appendix), patients who identified as White versus patients who identified with another race/ethnicity (see Table S6 in the Web Appendix), and patients who saw physicians at their primary care appointment versus patients who saw other clinicians (see Table S7 in the Web Appendix). For each of these subgroup analyses, in addition to running separate regressions for the subgroups, we also ran a model where we interacted the indicator for the subgroup variable of interest (e.g., an indicator for identifying as White, an indicator for identifying as male) with all of the other covariates in our model. We then tested the joint hypothesis that all the interaction terms between the subgroup variable and the 19 experimental conditions are 0. Except for the comparison between White and non-white patients, none of the F-tests were significant (Penn vs. Geisinger: F = 0.543, p = 0.945; male vs. female: F = 0.820, p = 0.686; age 18-64 vs. age > 64: F = 1.017, p = 0.437; did take the flu shot in the 2019-2020 flu season vs. did not take the flu shot in the 2019-2020 flu season: F = 1.070, p = 0.375; White vs. Non-White: F = 1.729, p = 0.025; appointment with a physician vs. other clinicians: F = 0.850, p = 0.647). This suggests that our treatment effects are fairly consistent across different subgroups.

Computation of 95% Confidence Intervals. The 95% confidence intervals are computed in the standard approach as $\hat{\beta} \pm t_{2.5\%}\hat{\sigma}_{\hat{\beta}}$ using the estimated treatment effects ($\widehat{\beta}$) and standard errors ($\hat{\sigma}_{\hat{\beta}}$) as reported in Table S1 of the Web Appendix. The standard errors are obtained from the HC1 heteroskedasticity-consistent estimate of the variance-covariance matrix of regression coefficients (2). We use heteroskedasticity-robust standard errors rather than traditional OLS standard errors because the latter do not account for the fact that random shocks in linear probability models are always heteroskedastic.

[3] See Gomila (2020) for a discussion of why linear regression is generally the best strategy to estimate causal effects of treatments on binary outcomes (1).

Computation of q-values. The q-value of a particular estimated effect is the expected proportion of false positives incurred when calling that effect significant. Whereas the p-value of an estimate is typically described as the expected proportion of estimates at least as extreme as the current one given that the true effect is null, the q-value of an estimate can be described as the expected proportion of false positives occurring among estimates given that they are at least as extreme as the current one (see Storey & Tibshirani 2003, pp. 9442 and 9444-9445)(3). We computed the q-values using the qvalue R package (4), with the default smoother for choosing tuning parameters.

Assessing possible inflation in the estimated effect of the top performing intervention. Even though a priori the estimate of each effect is unbiased, knowing that an effect is the maximum raises the concern that its expected measurement error is positive rather than zero, such that $E(\hat{\beta}) > \beta$. We therefore conduct two additional analyses on the effect size of the top performing intervention.

First, we conduct a Grubbs test (5) of the null hypothesis that the effect size of the top performing intervention follows the same Normal distribution as the effect sizes of the other 18 interventions. Second, we compute the expected value of the maximum out of $n = 19$ effects when they are all Normally distributed with mean $\mu = 0.0212$ and standard deviation $\sigma = 0.0099$, which are the sample mean and standard deviation of the 19 point estimates.

$$E[max(y_1, \ldots, y_n) \mid y_i \sim N(\mu, \sigma)] = \mu + E_{1,n}\sigma$$

Where $E_{1,n}$ is the shift due to selecting the maximum out of n standard Normally distributed values, which equals 1.84448 for $n = 19$ (6). The value of the observed maximum corrected for the upward shift equals $max(y_1, \ldots, y_n) - E_{1,n}\sigma$.

Code and data availability. The data analyzed in this paper were provided by the Geisinger and Penn Medicine health systems. We do not have legal permission to publicly post individual-level data on vaccinations that we received from our healthcare system partners because our partners consider this to be sensitive health data. Data containing individual-level health information is typically not made publicly available to protect patient privacy (as even if the data are de-identified, it is still possible to re-identify patients from de-identified data). To be as transparent as possible while protecting patient confidentiality, we have posted aggregated data and all of our analysis scripts, done with R and SAS, at https://bit.ly/2YeummU. Researchers interested in using individual-level data to replicate our results should contact Behavior Change for Good (bcfg@wharton.upenn.edu) and must sign the same data non-disclosure agreement to access the data on a protected medical server.

e. Intervention Messages

1. Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)

This intervention was designed by: Jonathan E. Bogard (UCLA Anderson School of Management), Craig R. Fox (UCLA Anderson School of Management), Matthew D. Hilchey (Rotman School of Management, University of Toronto), Dilip Soman (Rotman School of Management, University of Toronto), Jehan Sparks (UCLA Anderson School of Management), Megan Weber (UCLA Anderson School of Management), Renante Rondina (Rotman School of Management, University of Toronto), and Melanie Kim (Rotman School of Management, University of Toronto) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	72 hours prior to the appointment
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am & it's flu season. A flu vaccine is available for you. Protect yourself & your family's health! Look out for a vaccine reminder message before your appt. You can opt out of a reminder by texting back OPT OUT.
Message 2 Day/time	24 hours prior to the appointment
Message 2 content	PENNMED: John, this is a reminder that a flu vaccine has been reserved for your appt with Dr. Smith.

Please ask your doctor for the shot to make sure you receive it.[4]

[4] For Geisinger patients, this text included the addition: "Reply stop to opt out at any time."

2. Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)

This intervention was designed by: Jonathan E. Bogard (UCLA Anderson School of Management), Craig R. Fox (UCLA Anderson School of Management), Matthew D. Hilchey (Rotman School of Management, University of Toronto), Dilip Soman (Rotman School of Management, University of Toronto), Jehan Sparks (UCLA Anderson School of Management), Megan Weber (UCLA Anderson School of Management), Renante Rondina (Rotman School of Management, University of Toronto), and Melanie Kim (Rotman School of Management, University of Toronto) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	72 hours prior to the appointment
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am & it's flu season. A flu vaccine is available for you. Protect yourself & your family's health! Look out for a vaccine reminder message before your appt. You can opt out of a reminder by texting back OPT OUT.
Message 2 Day/time	15 minutes prior to the appointment
Message 2 content	PENNMED: John, this is a reminder that a flu vaccine has been reserved for your appt with Dr. Smith. Please ask your doctor for the shot to make sure you receive it.[5]

[5] For Geisinger patients, this text included the addition: "Reply stop to opt out at any time."

3. Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)

This intervention was designed by: Alison Buttenheim (University of Pennsylvania Perelman School of Medicine) and Gretchen B. Chapman (Carnegie Mellon University) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	One day prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am & it's flu season. Image: https://www.dropbox.com/s/9i6j2pfn6wn426a/Flu%20Shot%20Default%20Reservations%20OptOut.png?dl=0 A flu shot has been reserved for you to receive at your appt tomorrow. Reply Y if you want this shot held for you, N if you don't.
Reply to Message 1	*[If Y]* Your flu shot will be ready for you at your appt. *[If N]* Thank you for your response.

4. Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)

This intervention was designed by: Silvia Saccardo (Carnegie Mellon University) and Hengchen Dai (UCLA Anderson School of Management) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	Three days prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. Consider watching this 2-minute wellness video & answering 2 questions before your appt w/ Dr. Smith on 10/01 @ 11:00am.[6] Link to the video: https://player.vimeo.com/video/445590175 You're also encouraged to get a flu shot at your appt.
Message 2 Day/time	One day before the appointment at 6pm
Message 2 content	PENNMED: As a reminder, if you haven't yet, consider watching this 2-minute wellness video & answering 2 questions before your appt w/ Dr. Smith tomorrow.[7]

[6] For Geisinger patients, this text is replaced with: "It's flu season. Want to watch a 2-minute wellness video & answer 2 questions before your appt w/ Dr. Smith on 10/01 @ 11:00 AM? Reply Y to get the link." Participants only receive the link to the video if they opt in.

[7] For Geisinger patients, this text is replaced with: "GEISINGER: As a reminder, if you haven't yet, reply Y to watch a 2-minute wellness video & answer 2 questions before your appt tomorrow. Reply stop to opt out at any time." Participants only receive the link to the video if they opt in.

Link to the video: https://player.vimeo.com/video/445590175
You're also encouraged to get a flu shot at your appt.

After watching the video, participants were asked:

1. To what extent do you agree with the following statement?
   Without getting the flu vaccine, I would feel very vulnerable to the flu
   [7-point scale from Strongly disagree to Strongly agree]
2. **Do you plan to get a flu shot at your next doctor appointment?**
   [Yes/No]

5. Don’t forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)

This intervention was designed by: Jimin Nam (Harvard Business School), Leslie K. John (Harvard Business School), and Todd Rogers (Harvard Kennedy School) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	Three days prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It’s flu season. You have an appt w/ Dr. Smith on 10/01 @ 11:00am. You can get a flu shot there. You’ll receive a day-of-appointment reminder.
Message 2 Day/time	One hour prior to the appointment
Message 2 content	PENNMED: As a reminder, you have an appt w/ Dr. Smith today @ 11:00am. Don’t forget to get a flu shot.[8]

[8] For Geisinger patients, this text included the addition: “Reply stop to opt out at any time.”

6. Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)

This intervention was designed by: John Beshears (Harvard Business School), David Laibson (Harvard University), James J. Choi (Yale School of Management), and Brigitte C. Madrian (Brigham Young University) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	One day prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am. Want to take a 3 question quiz to assess the health of your habits? Text Y for Yes, N for No
Reply to Message 1	*[If the initial invitation to take the quiz generates a response of N, send.]* Got it. It's flu season, and getting a flu shot at your appt is an easy thing you can do to be healthy! Be sure to ask for your shot. *[Send if first text generates a response of Y within 2 hours:]* 1. Yesterday, did you walk at least 10,000 steps (5 miles)? Text Y for Yes, N for No. *[Send if Q1 generates a response within 2 hours:]* 2. How about your diet: Did you eat 4-6 servings of fruits & vegetables yesterday? Text Y or N.

[Send if Q2 generates a response within 2 hours:]
3. And finally, did you sleep at least 8 hours last night? Again, text back Y or N.

[Send if Q3 generates a response within 2 hours:]
That's [#] for 3. Those are tough goals to achieve. It's flu season & getting a flu shot at your upcoming appt is an easy thing you can do to be healthy!

Be sure to ask for your shot.

[If 2 hours pass with no response to the last Q sent, send:]
It's flu season & getting a flu shot at your appt is an easy thing you can do to be healthy!

Be sure to ask for your shot.

7. Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)

This intervention was designed by: Jillian Hmurovic (Wharton Risk Management and Decision Processes Center, The Wharton School, University of Pennsylvania), Dean Karlan (Kellogg School of Management, Northwestern University), Cait Lamberton (The Wharton School, University of Pennsylvania), and Caleb Warren (Eller College of Management, University of Arizona) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	One day before the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 at 11:00 AM & it's flu season. Remember to ask for your flu shot tomorrow.

8. Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)

This intervention was designed by: Modupe Akinola (Columbia Business School) and Maria Modanu (Columbia Business School) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	Three days prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am & it's flu season. Help your family & friends avoid the flu this year by getting vaccinated. Ask for your flu shot at your appt tomorrow w/ Dr. Smith. In YEAR, flu shots in YOUR REGION lagged behind the target rate of 70%. Help YOUR REGION become a leader in flu prevention and get your flu shot.
Message 2 Day/time	One hour before appointment
Message 2 content	PENNMED: As a reminder, YOUR REGION's flu shot rate in YEAR lagged behind the target rate of 70%. Get the flu shot at your appt today w/ Dr. Smith to help make YOUR REGION a leader in flu prevention and saving lives in 2020.

9. Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)

This intervention was designed by: Jimin Nam (Harvard Business School), Leslie K. John (Harvard Business School), and Todd Rogers (Harvard Kennedy School) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	Three days prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. You have an appt w/ Dr. Smith on 10/01 @ 11:00am. You can get a flu shot there. To help you remember to get your flu shot, consider dedicating it to a loved one. Text back their initials to make this dedication. They'll appear in your day-of-appointment reminder.
Reply to message 1	[Those who respond to Message 1 will receive the following message:] Thanks for your response. Your flu shot will be dedicated to [pipe Text].
Message 2 Day/time	One hour prior to the appointment
Message 2 content	[For those participants who responded to message 1:]

PENNMED: As a reminder, you have an appt w/ Dr. Smith today @ 11:00am. Don't forget to get a flu shot; it will be dedicated to [Pipe text].[9]

[For those participants who didn't respond to message 1:]

PENNMED: As a reminder, you have an appt w/ Dr. Smith today @ 11:00am. Don't forget to get a flu shot.[10]

To help you remember to get your flu shot, consider dedicating it to a loved one by texting back their initials.

[For those who respond to 2nd this message but didn't respond to the first:]

Thanks for your response. At your appointment, your flu shot will be dedicated to [pipe Text].

[9] For Geisinger patients, this text included the addition: "Reply stop to opt out at any time."
[10] For Geisinger patients, this text included the addition: "Reply stop to opt out at any time."

10. Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)

This intervention was designed by: John Beshears (Harvard Business School), David Laibson (Harvard University), James J. Choi (Yale School of Management), and Brigitte C. Madrian (Brigham Young University) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	One day prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am. Want to take a 3 question quiz to assess the health of your habits? Text Y for Yes, N for No
Reply to Message 1	*[If the initial invitation to take the quiz generates a response of N, send.]* Got it. It's flu season, and getting a flu shot at your appt is an easy thing you can do to be healthy! Be sure to ask for your shot. *[Send if first text generates a response of Y within 2 hours:]* 1. Yesterday, did you walk at least 500 feet? Text Y for Yes, N for No. *[Send if Q1 generates a response within 2 hours:]* 2. How about your diet: Did you eat at least two servings of fruits & vegetables in the last week? Text Y or N.

[Send if Q2 generates a response within 2 hours:]
3. And finally, did you sleep at least 6 hours last night? Again, text back Y or N.

[Send if Q3 generates a response within 2 hours:]
That's [#] for 3. It's flu season & getting a flu shot at your upcoming appt is an easy thing you can do to be healthy!

Be sure to ask for your shot.

[If 2 hours pass with no response to the last Q sent, send:]
It's flu season & getting a flu shot at your appt is an easy thing you can do to be healthy!

Be sure to ask for your shot.

11. Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)

This intervention was designed by: Silvia Saccardo (Carnegie Mellon University) and Hengchen Dai (UCLA Anderson School of Management) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	Three days prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. Consider watching this 2-minute wellness video & answering 2 questions before your appt w/ Dr. Smith on 10/01 @ 11:00am.[11] Link to the video: https://player.vimeo.com/video/445589923 You're also encouraged to get a flu shot at your appt.
Message 2 Day/time	One day before the appointment at 6 PM
Message 2 content	PENNMED: As a reminder, if you haven't yet, consider watching this 2-minute wellness video & answering 2 questions before your appt w/ Dr. Smith tomorrow.[12]

[11] For Geisinger patients, this text is replaced with: "It's flu season. Want to watch a 2-minute wellness video & answer 2 questions before your appt w/ Dr. Smith on 10/01 @ 11:00 AM? Reply Y to get the link." Participants only receive the link to the video if they opt in.

[12] For Geisinger patients, this text is replaced with: "GEISINGER: As a reminder, if you haven't yet, reply Y to watch a 2-minute wellness video & answer 2 questions before your appt tomorrow. Reply stop to opt out at any time." Participants only receive the link to the video if they opt in.

Link to the video: https://player.vimeo.com/video/445589923
You're also encouraged to get a flu shot at your appt.

After watching the video, participants were asked:

1. To what extent do you agree with the following statement?
   Without getting the flu vaccine, I would feel very vulnerable to the flu
   [7-point scale from Strongly disagree to Strongly agree]
2. **Do you plan to get a flu shot at your next doctor appointment?**
   [Yes/No]

12. Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)[13]

This intervention was designed by: Michelle N. Meyer (Geisinger), Amir Goren (Geisinger), Christopher Chabris (Geisinger), and Maheen Shermohammed (Geisinger) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day	24 hours prior to the appointment	24 hours prior to the appointment
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. At your appt w/ Dr. Smith on 10/01 @ 11:00 AM, be sure to ask for your flu shot. If you get it, you'll help protect yourself from the flu and the serious complications it can cause, including hospitalization. Text Y if you agree to ask for your flu shot.	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. At your appt w/ Dr. Smith on 10/01 @ 11:00 AM, be sure to ask for your flu shot. If you get it, you'll help protect yourself from the flu and avoid unnecessary exposure to COVID-19 by staying out of the hospital during the pandemic. Text Y if you agree to ask for your flu shot.
Reply to message 1	[If "Y"] Great choice! To help you remember, you'll receive another text tomorrow.	[If "Y"] Great choice! To help you remember, you'll receive another text tomorrow.

[13] Note: participants in this experimental condition were randomly assigned to receive messages that referred to COVID-19 (shown on the right) or that did not refer to COVID-19 (shown on the left).

Message 2 Day	15 minutes prior to the appointment	15 minutes prior to the appointment
Message 2 content	PENNMED: As a reminder, ask for your flu shot at your visit today to protect yourself from the flu.	PENNMED: As a reminder, ask for your flu shot at your visit today to protect yourself from the flu and avoid unnecessary exposure to COVID-19 in the hospital.

13. Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)

This intervention was designed by: Silvia Saccardo (Carnegie Mellon University) and Hengchen Dai (UCLA Anderson School of Management) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	Three days prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. Consider watching this 2-minute wellness video & answering 2 questions before your appt w/ Dr. Smith on 10/01 @ 11:00am. [14] Link to the video: https://player.vimeo.com/video/445590078 You're also encouraged to get a flu shot at your appt.
Message 2 Day/time	One day before the appointment at 6 PM
Message 2 content	PENNMED: As a reminder, if you haven't yet, consider watching this 2-minute wellness video & answering 2 questions before your appt w/ Dr. Smith tomorrow.[15]

[14] For Geisinger patients, this text is replaced with: "It's flu season. Want to watch a 2-minute wellness video & answer 2 questions before your appt w/ Dr. Smith on 10/01 @ 11:00 AM? Reply Y to get the link." Participants only receive the link to the video if they opt in.

[15] For Geisinger patients, this text is replaced with: "GEISINGER: As a reminder, if you haven't yet, reply Y to watch a 2-minute wellness video & answer 2 questions before your appt tomorrow. Reply stop to opt out at any time." Participants only receive the link to the video if they opt in.

Link to the video: https://player.vimeo.com/video/445590078
You're also encouraged to get a flu shot at your appt.

After watching the video, participants were asked:

1. To what extent do you agree with the following statement?
   Without getting the flu vaccine, I would feel very vulnerable to the flu
   [7-point scale from Strongly disagree to Strongly agree]
2. **Do you plan to get a flu shot at your next doctor appointment?**
   [Yes/No]

14. Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)

This intervention was designed by: Modupe Akinola (Columbia Business School) and Maria Modanu (Columbia Business School) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	Three days prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am & it's flu season. Help your family & friends avoid the flu this year by getting vaccinated. Ask for your flu shot at your appt tomorrow w/ Dr. Smith. In YEAR, flu shots in YOUR REGION lagged XX% behind OTHER REGION. Help YOUR REGION become a leader in flu prevention and get your flu shot.
Message 2 Day/time	One hour before appointment
Message 2 content	PENNMED: As a reminder, YOUR REGION's flu shot rate in YEAR was XX% below OTHER REGION's rate. Get the flu shot at your appt today w/ Dr. Smith to help make YOUR REGION a leader in flu prevention and saving lives in 2020.

15. Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)[16]

This intervention was designed by: Michelle N. Meyer (Geisinger), Amir Goren (Geisinger), Christopher Chabris (Geisinger), and Maheen Shermohammed (Geisinger) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day	24 hours prior to the appointment	24 hours prior to the appointment
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. At your appt w/ Dr. Smith on 10/01 @ 11:00 AM, be sure to ask for your flu shot. If you get it, you'll help protect your family and friends from the flu and the serious complications it can cause, including hospitalization. Text Y if you agree to ask for your flu shot.	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. At your appt w/ Dr. Smith on 10/01 @ 11:00 AM, be sure to ask for your flu shot. If you get it, you'll help protect family and friends from the flu and possible hospitalization. This also helps free up scarce equipment, beds, and healthcare workers to fight COVID-19. Text Y if you agree to ask for your flu shot.
Reply to message 1	[If "Y"] Great choice! To help you remember, you'll receive another text tomorrow.	[If "Y"] Great choice! To help you remember, you'll receive another text tomorrow.

[16] Note: participants in this experimental condition were randomly assigned to receive messages that referred to COVID-19 (shown on the right) or that did not refer to COVID-19 (shown on the left).

Message 2 Day	15 minutes prior to the appointment	15 minutes prior to the appointment
Message 2 content	PENNMED: As a reminder, ask for your flu shot at your visit today to protect your family and friends from the flu.	PENNMED: As a reminder, ask for your flu shot at your visit today to protect family and friends from the flu and free up scarce resources to fight COVID-19.

16. Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)

This intervention was designed by: Jimin Nam (Harvard Business School), Leslie K. John (Harvard Business School), and Todd Rogers (Harvard Kennedy School) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	Three days prior to the appointment
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. It's flu season. You have an appt w/ Dr. Smith on 10/01 @ 11:00am. You can get a flu shot there. To help you remember to get your flu shot, consider getting it to help protect a loved one who is especially vulnerable to the flu. Text back the initials of someone you hope to protect. They'll appear in your day-of-appointment reminder.
Reply to message 1	[Those who respond to Message 1 will receive the following message:] Thanks for your response. Your flu shot will help protect [Pipe Text].
Message 2 Day/time	One hour prior to the appointment
Message 2 content	[For those participants who responded to message 1:]

PENNMED: As a reminder, it's flu season & you have an appt w/ Dr. Smith today @ 11:00am. Don't forget to get a flu shot; it will help protect [Pipe text].[17]

[For those participants who didn't respond to message 1:]

PENNMED: As a reminder, you have an appt w/ Dr. Smith today @ 11:00am. Don't forget to get a flu shot.[18]

To help you remember to get your flu shot, consider getting it to help protect a vulnerable loved one by texting back their initials.

[For those who respond to 2nd this message but didn't respond to the first:]

Thanks for your response. At your appointment, your flu shot will help protect [Pipe Text].

[17] For Geisinger patients, this text included the addition: "Reply stop to opt out at any time."
[18] For Geisinger patients, this text included the addition: "Reply stop to opt out at any time."

17. Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)

This intervention was designed by: Alison Buttenheim (University of Pennsylvania Perelman School of Medicine) and Gretchen B. Chapman (Carnegie Mellon University) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	One day prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am & it's flu season. Image: https://www.dropbox.com/s/o4ffrz48d6g49nh/Flu%20Shot%20Default%20Reservations%20OptIn.png?dl=0 Flu shots will be available at your appt tomorrow. Reply Y if you would like to receive one, N if not.
Reply to Message 1	*[If Y]* A flu shot will be available at your appt. *[If N]* Thank you for your response.

18. Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)

This intervention was designed by: Jillian Hmurovic (Wharton Risk Management and Decision Processes Center, The Wharton School, University of Pennsylvania), Dean Karlan (Kellogg School of Management, Northwestern University), Cait Lamberton (The Wharton School, University of Pennsylvania), and Caleb Warren (Eller College of Management, University of Arizona) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	One day before the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 at 11:00 AM & it's flu season. To help you remember to ask for your flu shot, here's a joke about the flu. But what good is a joke you keep to yourself?[19] Share this w/ a friend, or even better, the nurse or doctor you see when you get your flu shot. Image: https://www.dropbox.com/s/dg3h85lsjycoeu7/Humor%20Image%20-%208.5%20by%2011.png?dl=0

[19] For Geisinger patients, this text is replaced with: "To help you remember to ask for your flu shot, reply Y to get a joke about the flu." Participants only receive the subsequent texts if they opt in.

19. Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)

This intervention was designed by: John Beshears (Harvard Business School), David Laibson (Harvard University), James J. Choi (Yale School of Management), and Brigitte C. Madrian (Brigham Young University) with input from Katherine L. Milkman (The Wharton School of the University of Pennsylvania), Mitesh S. Patel (Perelman School of Medicine, University of Pennsylvania), Angela L. Duckworth (School of Arts and Sciences and The Wharton School, University of Pennsylvania), and the Research Staff at the Behavior Change for Good Initiative (Heather Graci, Dena Gromet, Hung Ho, Joseph Kay, and Timothy Lee)

Message 1 Day/time	One day prior to the appointment at 6 PM
Message 1 content	John, this is a message from Penn Medicine about your upcoming appointment. Text & data rates apply. Reply stop to opt out at any time. You have an appt w/ Dr. Smith on 10/01 @ 11:00am. It's flu season & getting a flu shot at your appt is an easy thing you can do to be healthy! Be sure to ask for your shot.

Extended Methods for the Attribute Analysis

To explore underlying characteristics that are more vs. less predictive of intervention efficacy, we conducted the following exploratory (i.e., not pre-registered) steps. First, we recruited naive raters from Prolific to rate attributes on 5 subjective dimensions (see *Participants* and *Methods* below). Separately, we coded attributes on 12 objective dimensions (see *Methods* below). We then analyzed bivariate correlations between each of these 17 attributes and intervention efficacy (see *Results: Correlational Analysis* in the Web Appendix). To account for non-independence of attribute ratings, we identified a smaller number of attribute dimensions by performing principal component analysis (see *Results: Principal Components Analysis* in the Web Appendix). Specifically, considering attributes with at least a medium-sized ($r > .25$) relationship with efficacy, we used principal components analysis to capture underlying dimensions of covarying attributes and then assessed the relationship between these dimensions and efficacy in a simultaneous OLS regression predicting efficacy.

a. Participants

Participants (N = 2,214) were recruited to rate text messages through Prolific's online participant pool. To target sample demographics observed in our mega-study, prior to data collection we restricted our sample to US-based participants between the ages of 35 and 70. Participants received $0.60 in exchange for completing our short survey. We included an attention check question ("How many words are in this sentence?") in between our main survey task and our demographics questions, following best practices for online surveys outlined by Mason and Suri (2016). We dropped the following participants from our analysis: (a) 6 participants with duplicate IP addresses, (b) 72 remaining participants who incorrectly answered our attention check question, and (c) 65 remaining participants who did not fully complete our survey, leaving us with 2,071 study participants (M_{Age}=46.9; SD=9.59); 48.6% male; 84.4% White/Caucasian, 5.5% Black, 5.0% Asian,, 3.6% Hispanic, 1.3% Other, and less than 1% for each of American Indian / Alaska Native and Native Hawaiian / Other Pacific Islander.

b. Method

Subjective Ratings of Interventions. Participants were asked to complete a short survey "to gather opinions about text message content." They were provided with the study's context (see complete study stimuli in *Figure 3* in the Web Appendix).

On the next screen, one randomly selected text messaging intervention from the set of 19 was depicted.[20] Participants were asked to evaluate the text messaging intervention as if they had

[20] Consistent with our mega-study analysis, two interventions (Protect others by getting a flu shot and Protect yourself by getting a flu shot) included two versions of messages each. For each of these interventions, we included both versions then collapsed the ratings.

received it and to rate their agreement with five statements using a 5-point scale (1= "strongly disagree"; 5 = "strongly agree"). These statements, presented in randomized order, include: "Receiving this set of text messages would put me in a positive mood." (*positive mood*); "Receiving this set of text messages would put me in a negative mood." (*negative mood*); "This set of text messages seems to assume that I already intend to get my flu shot. The messages are just a reminder." (*reminder*); "This set of text messages has a casual, informal tone." (*casualness*); and "I would be surprised to get these sorts of text messages from my doctor or health system." (*surprise factor*). Participants rated one and only one intervention.

On the next screen, participants completed our attention check. They were then asked whether they got a flu shot during the a) 2019-2020 flu season and b) 2020-2021 flu season. Finally, we collected self-reported demographic information (age, gender, race, ethnicity, highest level of education achieved, and country of residence).

Coding of Objective Attributes. We examined twelve objective attributes of our text message interventions. Three attributes coded readability of the first text message in an intervention set using the editor function in Microsoft Word: *word count*, *Flesch-Kincaid grade level*, and *Flesch-Kincaid reading ease*. A fourth attribute indicated whether a given intervention condition had been designed as a control condition in the self-contained studies (*control condition*). Coding of eight additional attributes assessed the following features of all text messages in an intervention:[21] the presence of an exclamation mark (*exclamation mark*); whether the messages explicitly said a flu shot was "reserved for you" (*reserved for you*); the number of discrete text messages sent by the health system (*message count)*; the time between a patient's appointment and the last text message sent (*hours before appointment);*[22] the number of verbs using the imperative tense (excluding standard opt-out instructions, e.g., "remember to…," *imperative)*; the number of verbs using the interrogative tense (e.g., "did you…," *interrogative)*; The inclusion of an image or a link to multimedia (*multimedia)*; and whether the recipient was asked to take an action such as texting back, clicking a link, or sharing the text message with others, excluding standard opt-out instructions (*interactive).*

[21] Where intervention language slightly differed between the Geisinger and Penn Medicine channels, we used the Geisinger language for consistency, as the stimuli mocked up for our Prolific coders all used Geisinger as the use case.

[22] When the last set of messages in a text messaging intervention came at 6pm the evening before the patient's scheduled appointment, we took the average of 14 hours and 24 hours (i.e., 19 hours), assuming that their appointment would most likely be between 8am and 6pm.

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Web Appendix for

A Mega-Study of Text-Based Nudges Encouraging Patients to Get Vaccinated at an Upcoming Doctor's Appointment

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Web Appendix

1. Extended Results

The following results tables are included in this section, below:

- **Table S1.** Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake overall
- **Table S2.** Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake at each health system studied
- **Table S3.** Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by patient gender (Male vs Female)
- **Table S4.** Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by patient age (Age 18-64 vs. Age > 64)
- **Table S5.** Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by whether or not a patient received a flu vaccination in the 2019-2020 flu season.
- **Table S6.** Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by race (White vs. Non-White).
- **Table S7.** Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by the type of provider who saw the patient (Physician vs. Other Clinician).

In summary, the results of this mega-study were consistent across subgroups and robustness checks presented. A mega-study is defined as "a massive field experiment in which many different treatments are tested synchronously in one large sample using a common objectively measured outcome" (Milkman et al., 2021).

The best-performing intervention in this mega-study was the best-performer among both Penn Medicine and Geisinger patients. It is therefore recommended for implementation regardless of statistical significance (Feit & Berman, 2019; Manski & Tetenov, 2016)

Table S1. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake overall.

	Beta	SE	p-value	q-value
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.046	(0.013)	0.000	0.001
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.032	(0.013)	0.013	0.019
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.030	(0.013)	0.022	0.019
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.029	(0.013)	0.022	0.019
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.028	(0.013)	0.033	0.019
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.028	(0.013)	0.033	0.019
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.025	(0.013)	0.053	0.025
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.024	(0.013)	0.063	0.026
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.021	(0.013)	0.098	0.036
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.020	(0.013)	0.124	0.041
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.019	(0.013)	0.135	0.041
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.018	(0.013)	0.164	0.046
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.017	(0.013)	0.183	0.047
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.015	(0.013)	0.242	0.057
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.014	(0.013)	0.269	0.057
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.014	(0.013)	0.273	0.057
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.008	(0.013)	0.550	0.104
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.008	(0.013)	0.560	0.104
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.006	(0.013)	0.658	0.116
R-Squared		0.194		
Baseline Vaccination Rate		42%		
Observations		47,306		

Note: The above table reports the results of the ordinary least squares regression predicting whether patients in our study received a flu shot during their intervention window (three days prior to their scheduled appointment through the date of the appointment) with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The columns report results from this regression on the pooled Geisinger and Penn Medicine sample. The regression includes the following control variables: 1) patient age (as of the date of their target doctor's appointment), 2) indicators for patient race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown; white non-Hispanic omitted), 3) indicators for a patient's gender (male, other/unknown; female omitted), 4) an indicator for whether the patient received a flu shot in the 2019-20 flu season according to their medical records, 5) indicators for the type of provider who saw the patient (attending/faculty physician, resident, or physician assistant; nurse practitioner omitted), 6) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020), and 7) an indicator for being a Penn Medicine patient (rather than a Geisinger Health patient). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

Table S2. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake at each health system studied.

	Geisinger		Penn Medicine	
	Beta	**SE**	**Beta**	**SE**
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.058**	(0.018)	0.037*	(0.018)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.040*	(0.019)	0.026	(0.018)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.040*	(0.019)	0.021	(0.018)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.031+	(0.018)	0.028	(0.018)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.037*	(0.019)	0.021	(0.018)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.032+	(0.019)	0.024	(0.018)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.034+	(0.019)	0.019	(0.018)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.020	(0.019)	0.027	(0.018)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.035+	(0.018)	0.010	(0.018)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.034+	(0.019)	0.008	(0.018)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.032+	(0.018)	0.008	(0.018)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.036+	(0.019)	0.005	(0.018)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.012	(0.019)	0.023	(0.018)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.029	(0.018)	0.004	(0.018)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.008	(0.018)	0.019	(0.018)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.017	(0.018)	0.013	(0.018)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.016	(0.018)	-0.001	(0.018)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.022	(0.018)	-0.005	(0.018)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.003	(0.018)	0.009	(0.018)
R-Squared	0.207		0.162	
Baseline Vaccination Rate	33%		49%	
Observations	21,495		25,811	

*** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.10

Note: The above table reports the results of two ordinary least squares regressions predicting whether patients in our study received a flu shot during their intervention window (three days prior to their scheduled appointment through the date of the appointment) with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The first two columns report results from the Geisinger sample only and the final two columns report results from the Penn Medicine sample only. Both regressions include the following control variables: 1) patient age (as of the date of their target doctor's appointment), 2) indicators for patient race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown; white non-Hispanic omitted), 3) indicators for a patient's gender (male, other/unknown; female omitted), 4) an indicator for whether the patient received a flu shot in the 2019-20 flu season according to their medical records, 5) indicators for the type of provider who saw the patient (attending/faculty physician, resident, or physician assistant; nurse practitioner omitted), and 6) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

Table S3. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by patient gender (Male vs Female).

	Male		Female	
	Beta	**SE**	**Beta**	**SE**
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.060**	(0.019)	0.036*	(0.017)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.049*	(0.020)	0.020	(0.017)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.024	(0.020)	0.034+	(0.017)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.010	(0.020)	0.042*	(0.017)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.043	(0.020)	0.017	(0.018)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.019	(0.020)	0.033+	(0.017)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.023	(0.019)	0.026	(0.017)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.029	(0.020)	0.020	(0.017)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.013	(0.019)	0.028	(0.017)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.027	(0.020)	0.015	(0.017)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.018	(0.019)	0.020	(0.017)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.020	(0.019)	0.017	(0.017)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.019	(0.020)	0.017	(0.018)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.003	(0.019)	0.025	(0.017)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.027	(0.019)	0.005	(0.018)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.023	(0.019)	0.007	(0.017)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.019	(0.019)	-0.001	(0.017)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.018	(0.020)	0.000	(0.017)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.012	(0.019)	0.001	(0.017)
R-Squared	0.200		0.192	
Baseline Vaccination Rate	43%		41%	
Observations	20,427		26,879	

*** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.10

Note: The above table reports the results of two ordinary least squares regressions predicting whether patients in our study received a flu shot during their intervention window (three days prior to their scheduled appointment through the date of the appointment) with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The first two columns report results from the sample of patients who identified as male, and the final two columns report results from the sample of patients who identified as female. Both regressions include the following control variables: 1) patient age (as of the date of their target doctor's appointment), 2) indicators for patient race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown; white non-Hispanic omitted), 3) an indicator for whether the patient received a flu shot in the 2019-20 flu season according to their medical records, 4) indicators for the type of provider who saw the patient (attending/faculty physician, resident, or physician assistant; nurse practitioner omitted), 5) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020), and 6) an indicator for being a Penn Medicine patient (rather than a Geisinger Health patient). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

Table S4. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by patient age (Age 18-64 vs. Age > 64).

	Age 18-64		Age > 64	
	Beta	**SE**	**Beta**	**SE**
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.050***	(0.015)	0.039	(0.027)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.031*	(0.015)	0.044+	(0.026)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.023	(0.015)	0.054*	(0.026)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.028+	(0.015)	0.038	(0.026)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.023	(0.015)	0.047	(0.027)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.026+	(0.015)	0.040	(0.026)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.020	(0.015)	0.047+	(0.026)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.017	(0.015)	0.05+	(0.026)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.023	(0.015)	0.019	(0.026)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.033*	(0.015)	-0.015	(0.027)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.021	(0.015)	0.023	(0.027)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.024	(0.015)	0.007	(0.027)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.014	(0.015)	0.042	(0.027)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.020	(0.015)	0.005	(0.027)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.020	(0.015)	0.001	(0.027)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.013	(0.015)	0.020	(0.027)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.007	(0.015)	0.019	(0.026)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.016	(0.015)	-0.010	(0.027)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.001	(0.015)	0.024	(0.026)
R-Squared	0.171		0.194	
Baseline Vaccination Rate	38%		56%	
Observations	36,157		11,149	

*** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.10

Note: The above table reports the results of two ordinary least squares regressions predicting whether patients in our study received a flu shot during their intervention window (three days prior to their scheduled appointment through the date of the appointment) with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The first two columns report results from the sample of patients who were between 18 and 64 years old at the time of our study, and the final two columns report results from the sample of patients who were 65 years old or above at the time of our study. Both regressions include the following control variables: 1) indicators for patient race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown; white non-Hispanic omitted), 2) indicators for a patient's gender (male, other/unknown; female omitted), 3) an indicator for whether the patient received a flu shot in the 2019-20 flu season according to their medical records, 4) indicators for the type of provider who saw the patient (attending/faculty physician, resident, or physician assistant; nurse practitioner omitted), 5) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020), and 6) an indicator for being a Penn Medicine patient (rather than a Geisinger Health patient). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

Table S5. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by whether or not a patient received a flu vaccination in the 2019-2020 flu season.

	Received Flushot in the 2019-20 Flu Season		Did Not Receive Flushot in the 2019-2020 Flu Season	
	Beta	**SE**	**Beta**	**SE**
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.061**	(0.020)	0.032+	(0.017)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.051**	(0.020)	0.016	(0.017)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.046*	(0.020)	0.014	(0.017)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.051**	(0.019)	0.010	(0.017)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.021	(0.020)	0.034+	(0.017)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.057**	(0.020)	0.001	(0.017)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.049*	(0.020)	0.003	(0.017)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.040*	(0.020)	0.011	(0.017)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.045*	(0.020)	-0.001	(0.017)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.027	(0.020)	0.014	(0.017)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.050*	(0.020)	-0.007	(0.017)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.027	(0.020)	0.009	(0.017)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.017	(0.020)	0.016	(0.017)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.034+	(0.020)	-0.004	(0.017)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.025	(0.020)	0.003	(0.017)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.036+	(0.020)	-0.005	(0.017)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.024	(0.020)	-0.008	(0.017)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.020	(0.020)	-0.002	(0.017)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.033+	(0.020)	-0.018	(0.017)
R-Squared	0.082		0.075	
Baseline Vaccination Rate	60%		26%	
Observations	22,197		25,109	

*** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.10

Note: The above table reports the results of two ordinary least squares regressions predicting whether patients in our study received a flu shot during their intervention window (three days prior to their scheduled appointment through the date of the appointment) with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The first two columns report results from the sample of patients who received a flu shot in the 2019-2020 flu season, and the final two columns report results from the sample of patients who did not receive a flu shot in the 2019-2020 flu season. Both regressions include the following control variables: 1) patient age (as of the date of their target doctor's appointment), 2) indicators for patient race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown; white non-Hispanic omitted), 3) indicators for a patient's gender (male, other/unknown; female omitted), 4) indicators for the type of provider who saw the patient (attending/faculty physician, resident, or physician assistant; nurse practitioner omitted), 5) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020), and 6) an indicator for being a Penn Medicine patient (rather than a Geisinger Health patient). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

Table S6. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by race (White vs. Non-White).

	White		Non-White	
	Beta	**SE**	**Beta**	**SE**
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.064***	(0.015)	0.009	(0.024)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.039*	(0.016)	0.018	(0.024)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.049**	(0.015)	-0.016	(0.024)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.048**	(0.015)	-0.010	(0.024)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.042**	(0.016)	-0.004	(0.024)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.030+	(0.015)	0.026	(0.024)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.031*	(0.015)	0.015	(0.023)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.025	(0.015)	0.028	(0.024)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.031*	(0.015)	0.001	(0.024)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.048**	(0.016)	-0.043+	(0.024)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.042**	(0.015)	-0.027	(0.024)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.033*	(0.015)	-0.014	(0.024)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.024	(0.016)	0.009	(0.024)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.027+	(0.015)	-0.005	(0.024)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.025	(0.016)	-0.005	(0.024)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.018	(0.015)	0.014	(0.024)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.030*	(0.015)	-0.040+	(0.023)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.016	(0.016)	-0.010	(0.024)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.015	(0.015)	-0.012	(0.024)
R-Squared	0.203		0.168	
Baseline Vaccination Rate	42%		42%	
Observations	33,317		13,989	

*** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.10

Note: The above table reports the results of two ordinary least squares regressions predicting whether patients in our study received a flu shot during their intervention window (three days prior to their scheduled appointment through the date of the appointment) with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The first two columns report results from the sample of patients who identify as White (Non-Hispanic) and the second two columns report results from the sample of patients who identify as racial minorities or do not indicate their race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown). Both regressions include the following control variables: 1) patient age (as of the date of their target doctor's appointment), 2) indicators for a patient's gender (male, other/unknown; female omitted), 3) an indicator for whether the patient received a flu shot in the 2019-20 flu season according to their medical records, 4) indicators for the type of provider who saw the patient (attending/faculty physician, resident, or physician assistant; nurse practitioner omitted), 5) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020), and 6) an indicator for being a Penn Medicine patient (rather than a Geisinger Health patient). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

Table S7. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake by the type of provider who saw the patient (Physician vs. Other Clinician).

	Physician		Other Clinician	
	Beta	**SE**	**Beta**	**SE**
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.053***	(0.015)	0.025	(0.027)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.034*	(0.015)	0.027	(0.028)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.032*	(0.015)	0.023	(0.027)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.026+	(0.015)	0.044	(0.027)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.028+	(0.015)	0.027	(0.028)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.028+	(0.015)	0.029	(0.028)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.035*	(0.015)	-0.007	(0.028)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.021	(0.015)	0.037	(0.028)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.020	(0.015)	0.025	(0.027)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.016	(0.015)	0.035	(0.027)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.022	(0.015)	0.011	(0.027)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.011	(0.015)	0.043	(0.028)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.022	(0.015)	0.007	(0.028)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.010	(0.015)	0.034	(0.027)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.007	(0.015)	0.042	(0.028)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.019	(0.015)	0.000	(0.028)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.012	(0.015)	-0.005	(0.027)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.008	(0.015)	0.006	(0.028)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.009	(0.015)	-0.002	(0.027)
R-Squared	0.199		0.169	
Baseline Vaccination Rate	43%		37%	
Observations	36,665		10,641	

*** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.10

Note: The above table reports the results of two ordinary least squares regressions predicting whether patients in our study received a flu shot during their intervention window (three days prior to their scheduled appointment through the date of the appointment) with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The first two columns report results from the sample of patients who had primary care appointments with physicians and the second two columns report results from the sample of patients who had primary care appointments with other clinicians (residents, physicians assistants, or nurse practitioners). Both regressions include the following control variables: 1) patient age (as of the date of their target doctor's appointment), 2) indicators for patient race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown; white non-Hispanic omitted), 3) indicators for a patient's gender (male, other/unknown; female omitted), 4) an indicator for whether the patient received a flu shot in the 2019-20 flu season according to their medical records, 5) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020), and 6) an indicator for being a Penn Medicine patient (rather than a Geisinger Health patient). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

2. Participant Characteristics and Balance Checks

Patients in our study were an average of 51.9 years old (SD=16.3), 43% were male, 70% were white, 47% had been vaccinated in the previous flu season, and 55% were patients at Penn Medicine.

To ensure our study arms were well-balanced, we regressed the treatment groups on each balance variable (specifically: an indicator for being a patient at Geisinger, patient age as of the date of their target doctor's appointment, an indicator for a patient's gender, indicators for the patient's race, indicators for whether the patient received a flu shot in previous flu seasons, indicators for the type of clinician who saw the patient, and the number of days since the start of the study) using pooled ordinary least squares regressions with robust standard errors to correct for heteroscedasticity. F-tests were then conducted for the beta coefficients from the regressions to compare the overall significance across treatment groups. As shown in Table S8, study arms were well-balanced on age, gender, race, health system, and vaccination history (p-values from all F-tests > 0.05).

Table S8. Summary of patient characteristics overall, at different health systems, and in our control versus intervention groups. F-Test p-values are based on pairwise comparisons of the 19 study conditions to the control group in our mega-study to compare the overall significance across treatment groups using the regression models described above. Additionally, to summarize across all categories of race and clinician overseeing the appointment, we analyzed these balance variables using design-based F-tests.

	Full Sample	Geisinger	Penn Medicine	Control	Intervention Groups (Pooled)	F-Test p-value
Penn Medicine Patient	55%	0%	100%	55%	55%	0.999
Age (years)	51.9	50.2	53.4	51.6	51.9	0.980
Female	57%	57%	57%	56%	57%	0.530
Race						
White	70%	90%	54%	69%	71%	
Black Non-Hispanic	19%	4%	32%	21%	19%	
Hispanic	4%	4%	4%	5%	4%	0.409
Asian	2%	1%	4%	2%	2%	
Other	3%	0%	6%	4%	3%	
Received Flu Shot Before						
2019-20 Flu Season	47%	45%	49%	47%	47%	0.999
2018-19 Flu Season	42%	37%	46%	42%	42%	0.728
2017-18 Flu Season	36%	31%	40%	37%	36%	0.736
2016-17 Flu Season	32%	29%	35%	33%	32%	0.296
2015-16 Flu Season	30%	27%	32%	31%	30%	0.231
Clinician Overseeing Appt						
Attending/Faculty Physician	78%	80%	75%	77%	78%	
Resident	5%	2%	7%	5%	5%	
Physician's Assistant	9%	15%	4%	9%	9%	0.786
Nurse Practitioner	9%	3%	14%	9%	9%	
Days since 9/20/20 at Time of Appt	44.8	46.9	43.1	45.2	44.8	0.990
Overall N	47,306	21,495	25,811	2,389	44,917	

3. Additional Analyses

To ensure the robustness of our main results, we re-ran our analysis without any control variables (Table S9) and found that the treatment effect estimates on our 19 interventions in an uncontrolled regression are extremely similar to those in our primary analysis ($r = 0.98$; $p < 0.001$). In addition, we examined the effects of our experimental conditions on patients' likelihood of showing up to their scheduled appointments (Table S10). Our top-performing intervention does boost the rate at which patients show up for their appointments, and we see a moderate (but insignificant) correlation between the estimated impact of our interventions on flu vaccine take up and showing up for an appointment ($r = 0.34$; $p = 0.15$). Our interventions may work in part by increasing the likelihood that patients will attend their appointments.

Table S9. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake overall, without any control variables.

	Beta	**SE**
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.049***	(0.014)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.036*	(0.014)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.032*	(0.014)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.038**	(0.014)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.036*	(0.014)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.034*	(0.014)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.031*	(0.014)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.026+	(0.014)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.024+	(0.014)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.026+	(0.014)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.023	(0.014)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.024+	(0.014)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.022	(0.015)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.017	(0.014)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.017	(0.014)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.021	(0.014)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.007	(0.014)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.007	(0.014)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.010	(0.014)
R-Squared	0.001	
Baseline Vaccination Rate	42%	
Observations	47,306	

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$

Note: The above table reports the results of an ordinary least squares regression predicting whether patients in our study received a flu shot during their intervention window (three days prior to their scheduled appointment through the date of the appointment) with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. No additional control variables were included in the regression. Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

Table S10. Regression-estimated impact of each of our study's 19 intervention conditions on likelihood of showing up at the scheduled appointment.

	Beta	SE
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.023*	(0.012)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.002	(0.012)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.004	(0.012)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	-0.004	(0.012)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.021+	(0.012)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.016	(0.012)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.011	(0.012)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.025*	(0.012)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.013	(0.012)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.005	(0.012)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.015	(0.012)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.016	(0.012)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.024*	(0.012)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.006	(0.012)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.002	(0.012)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.004	(0.012)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	-0.021+	(0.012)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.003	(0.012)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.017	(0.012)
R-Squared	0.067	
Baseline Show-up Rate	77%	
Observations	47,306	

*** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.10

Note: The above table reports the results of the ordinary least squares regression predicting whether patients in our study showed up at their scheduled appointment with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The columns report results from this regression on the pooled Geisinger and Penn Medicine sample. The regression includes the following control variables: 1) patient age (as of the date of their target doctor's appointment), 2) indicators for patient race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown; white non-Hispanic omitted), 3) indicators for a patient's gender (male, other/unknown; female omitted), 4) an indicator for whether the patient received a flu shot in the 2019-20 flu season according to their medical records, 5) indicators for the type of provider who saw the patient (attending/faculty physician, resident, or physician assistant; nurse practitioner omitted), 6) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020), and 7) an indicator for being a Penn Medicine patient (rather than a Geisinger Health patient). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

We conducted pairwise Wald tests to determine whether there were significant differences in the regression coefficients between experimental conditions. Table S11 shows that in addition to the usual care control condition, the top performing experimental condition significantly outperformed over half of the other experimental conditions.

We performed several additional Wald tests. First, we tested that the average treatment effect across all 19 interventions was different from zero. The average effect was 0.02127 (SE = 0.00939, p = 0.02357). Second, we tested the null hypothesis that all 19 effects have the same true value (Chi-sq = 21.277, df = 18, p = 0.266). Third, we tested the contrast between the average effect of the top 6 interventions and the average effect of the bottom 13. The difference was 0.01605 (SE = 0.00453, p = 0.00040). Fourth, we tested the difference between the effect of the top performing intervention and the average effect of the other 18 interventions. The difference was 0.02644 (SE = 0.00939, p = 0.00486). Note, the third and fourth tests involve hypotheses that are formulated only after the treatment effects were estimated and ranked. Consequently the true differences are likely smaller than the estimated differences reported here. As described in SI Appendix, we assess the risk of inflation using a Grubbs test and computing a corrected value for the estimate of the top performing intervention. The null hypothesis that the top performing effect comes from the same Normal distribution as the other effects is rejected at p = 0.05218. This suggests that the top performer is indeed different from the others. The expected upward shift due to selecting the maximum out of 19 estimates equals 0.0183. This results in an expected maximum value of 0.0395 which is still smaller than the actual observed value of 0.0463. Alternatively, correcting the observed maximum for the upward shift results in a revised estimate of 0.0280 which is still larger than the observed mean of 0.0212.

Table S11. The percentage of other conditions that each experimental condition outperformed on flu vaccine uptake at $p < 0.05$.

Experimental Condition	% of conditions outperformed (p <.05)	List of conditions outperformed (p <.05)
1. Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	58%	#10-20
2. Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	11%	#19-20
3. Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	5%	#20
4. Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	5%	#20
5. Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	5%	#20
6. Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	5%	#20
7. Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0%	
8. Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0%	
9. Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0%	
10. Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0%	
11. Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0%	
12. Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0%	
13. Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0%	
14. Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0%	
15. Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0%	
16. Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0%	
17. Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0%	
18. Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0%	
19. Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0%	
20. Usual care control	0%	

Note: The percentage of conditions outperformed ($p < 0.05$) was obtained from conducting pairwise Wald tests to assess whether paired regression coefficients significantly differed from one another in Table S1. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

As a robustness check (Table S12), we re-ran our primary analysis excluding vaccinations that were received in the three days prior to patients' appointments, and only included vaccines received on the day of the target appointment in our outcome variable.

Table S12. Regression-estimated impact of each of our study's 19 intervention conditions on flu vaccine uptake on the day of the patient's target doctor's appointment.

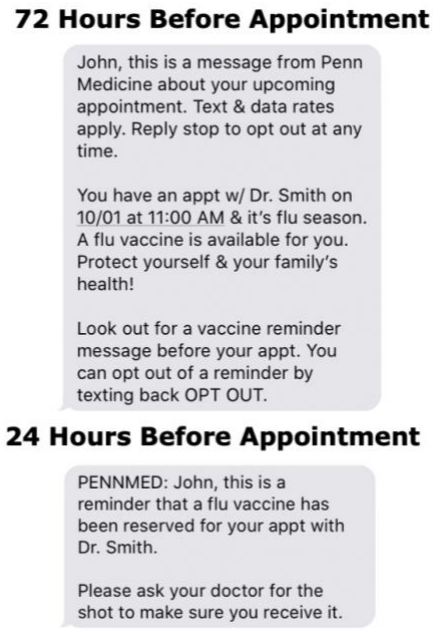
	Beta	SE
Flu shot reserved for you (2 texts: 72 hr + 24 hr pre-appt)	0.047***	(0.013)
Flu shot reserved for you (2 texts: 72 hr + 15 m pre-appt)	0.033*	(0.013)
Reply to receive the flu shot reserved for you (1 text: 6 pm, 1 d pre-appt)	0.031*	(0.013)
Video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.032*	(0.013)
Don't forget to get a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.029*	(0.013)
Hard health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.027*	(0.013)
Remember to ask for your flu shot (1 text: 6 pm, 1 d pre-appt)	0.028*	(0.013)
Improve the flu shot rate in your region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.028*	(0.013)
Dedicate your flu shot to a loved one (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.022+	(0.013)
Easy health behavior quiz (1 text: 6 pm, 1 d pre-appt)	0.018	(0.013)
Video about importance of exercise (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.020	(0.013)
Protect yourself by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.015	(0.013)
Vivid video about getting the flu (2 texts: 6 pm, 3 d + 1 d pre-appt)	0.020	(0.013)
Beat the flu shot rate in another region (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.016	(0.013)
Protect others by getting a flu shot (2 texts: 24 hr + 15 m pre-appt)	0.018	(0.013)
Protect a vulnerable loved one by getting a flu shot (2 texts: 6 pm, 3 d + 1 hr pre-appt)	0.017	(0.013)
Reply to receive the flu shot (1 text: 6 pm, 1 d pre-appt)	0.009	(0.013)
Share a joke about the flu (1 text: 6 pm, 1 d pre-appt)	0.010	(0.013)
Getting a flu shot is an easy way to be healthy (1 text: 6 pm, 1 d pre-appt)	0.007	(0.013)
R-Squared	0.182	
Baseline Vaccination Rate	42%	
Observations	47,306	

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$

Note: The above table reports the results of the ordinary least squares regression predicting whether patients in our study received a flu shot on the day of their scheduled appointment with 19 indicators for experimental condition as the primary predictors. The reference group is the usual care control condition. The columns report results from this regression on the pooled Geisinger and Penn Medicine sample. The regression includes the following control variables: 1) patient age (as of the date of their target doctor's appointment), 2) indicators for patient race/ethnicity (Black non-Hispanic, Hispanic, Asian, other/unknown; white non-Hispanic omitted), 3) indicators for a patient's gender (male, other/unknown; female omitted), 4) an indicator for whether the patient received a flu shot in the 2019-20 flu season according to their medical records, 5) indicators for the type of provider who saw the patient (attending/faculty physician, resident, or physician assistant; nurse practitioner omitted), 6) the linear and squared number of days separating the patient's target primary care appointment from the start of our study (that is, September 20, 2020), and 7) an indicator for being a Penn Medicine patient (rather than a Geisinger Health patient). Robust standard errors are shown in parentheses. As indicated in parentheses, some messages were sent at 6 pm, one and/or three days before an appointment, while others were sent a pre-determined number of hours before an appointment (e.g., 72 hours).

4. Screenshot of the Text Messages from the Top Performing Intervention

Figure S1. Text messages sent to patients in our top-performing intervention.



5. Attribute Analysis

To explore underlying characteristics that are more vs. less predictive of intervention efficacy, we conducted the following exploratory (i.e., not pre-registered) steps. First, we recruited naive raters from Prolific to rate attributes on 5 subjective dimensions (see *Participants* and *Methods* below). Separately, we coded attributes on 12 objective dimensions (see *Methods* below). We then analyzed bivariate correlations between each of these 17 attributes and intervention efficacy (see *Results: Correlational Analysis* below). To account for non-independence of attribute ratings, we identified a smaller number of attribute dimensions by performing principal component analysis (see *Results: Principal Components Analysis* below). Specifically, considering attributes with at least a medium-sized ($r > .25$) relationship with efficacy, we used principal components analysis to capture underlying dimensions of covarying attributes and then assessed the relationship between these dimensions and efficacy in a simultaneous OLS regression predicting efficacy.

5a. Participants

Participants (N = 2,214) were recruited to rate text messages through Prolific's online participant pool. To target sample demographics observed in our mega-study, prior to data collection we restricted our sample to US-based participants between the ages of 35 and 70. Participants received $0.60 in exchange for completing our short survey. We included an attention check question ("How many words are in this sentence?") in between our main survey task and our demographics questions, following best practices for online surveys outlined by Mason and Suri (2016). We dropped the following participants from our analysis: (a) 6 participants with duplicate IP addresses, (b) 72 remaining participants who incorrectly answered our attention check question, and (c) 65 remaining participants who did not fully complete our survey, leaving us with 2,071 study participants (M_{Age}=46.9; SD=9.59); 48.6% male; 84.4% White/Caucasian, 5.5% Black, 5.0% Asian,, 3.6% Hispanic, 1.3% Other, and less than 1% for each of American Indian / Alaska Native and Native Hawaiian / Other Pacific Islander.

5b. Method

Subjective Ratings of Interventions. Participants were asked to complete a short survey "to gather opinions about text message content." They were provided with the study's context (see complete study stimuli in *Figure 3*).

On the next screen, one randomly selected text messaging intervention from the set of 19 was depicted.[1] Participants were asked to evaluate the text messaging intervention as if they had received it and to rate their agreement with five statements using a 5-point scale (1= "strongly disagree"; 5 = "strongly agree"). These statements, presented in randomized order, include: "Receiving this set of text messages would put me in a positive mood." (*positive mood*); "Receiving this set of text messages would put me in a negative mood." (*negative mood*); "This set of text messages seems to assume that I already intend to get my flu shot. The messages are just a reminder." (*reminder*); "This set of text messages has a casual, informal tone." (*casualness*); and "I would be surprised to get these sorts of text messages from my doctor or health system." (*surprise factor*). Participants rated one and only one intervention.

On the next screen, participants completed our attention check. They were then asked whether they got a flu shot during the a) 2019-2020 flu season and b) 2020-2021 flu season. Finally, we collected self-reported demographic information (age, gender, race, ethnicity, highest level of education achieved, and country of residence).

Coding of Objective Attributes. We examined twelve objective attributes of our text message interventions. Three attributes coded readability of the first text message in an intervention set using the editor function in Microsoft Word: *word count, Flesch-Kincaid grade level,* and *Flesch-Kincaid reading ease.* A fourth attribute indicated whether a given intervention condition had been designed as a control condition in the self-contained studies (*control condition*). Coding of eight additional attributes assessed the following features of all text messages in an intervention:[2] the presence of an exclamation mark (*exclamation mark*); whether the messages explicitly said a flu shot was "reserved for you" (*reserved for you*); the number of discrete text messages sent by the health system (*message count)*; the time between a patient's appointment and the last text message sent (*hours before appointment);*[3] the number of verbs using the imperative tense (excluding standard opt-out instructions, e.g., "remember to…," *imperative)*; the number of verbs using the interrogative tense (e.g., "did you…," *interrogative)*; The inclusion of an image or a link to multimedia (*multimedia)*; and whether the recipient was asked to take an action such as texting back, clicking a link, or sharing the text message with others, excluding standard opt-out instructions (*interactive).*

5c. Results

[1] Consistent with our mega-study analysis, two interventions (Protect others by getting a flu shot and Protect yourself by getting a flu shot) included two versions of messages each. For each of these interventions, we included both versions then collapsed the ratings.

[2] Where intervention language slightly differed \between the Geisinger and Penn Medicine channels, we used the Geisinger language for consistency, as the stimuli mocked up for our Prolific coders all used Geisinger as the use case.

[3] When the last set of messages in a text messaging intervention came at 6pm the evening before the patient's scheduled appointment, we took the average of 14 hours and 24 hours (i.e., 19 hours), assuming that their appointment would most likely be between 8am and 6pm.

Summary Statistics. We obtained an average of 98.6 raters per intervention (min=92, median=99, max=103). To check for reliability of raters across interventions, we calculated the intraclass correlation coefficients for each of our subjective attribute measures (shown in Table S13).

Table S13. Intraclass Correlation Coefficients

Rating	ICC(1,k)[1]
Positive mood	0.79
Negative mood	0.80
Reminder	0.89
Casualness	0.77
Surprise Factor	0.93

Note. [1]For our ICC(1,k) analysis, the underlying "k" varied between 92-103, given the number of raters per attribute varied by stimulus.

Correlational Analysis. Correlations between intervention efficacy (i.e., the coefficient estimating the impact of a given intervention on flu shot uptake in our pooled sample, shown in Table S1) and attribute ratings are shown in Table S14.

Table S14. Paired correlations between the ratings of intervention attributes as well as our estimate of intervention efficacy, for our 19 text messaging interventions

	on Efficacy	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Subjective attributes																		
1. Surprise factor	-0.373	-																
2. Reminder	0.304	-0.010	-															
3. Casualness	-0.300	0.414†	0.343	-														
4. Positive mood	-0.172	-0.083	0.379	0.522*	-													
5. Negative mood	-0.127	0.432†	-0.558*	-0.359	-0.850***	-												
Objective attributes																		
6. Reserved for you	0.672**	-0.338	0.406†	0.005	0.320	-0.469*	-											
7. Interactive	-0.318	0.493*	-0.167	0.343	0.022	0.201	-0.268	-										
8. Control Condition	0.249	-0.447†	0.060	-0.192	0.067	-0.224	0.016	-0.655**	-									
9. Multimedia	-0.189	0.180	-0.288	0.174	0.383	-0.148	0.016	0.519*	-0.218	-								
10. Exclamation mark	0.181	-0.216	0.048	0.218	-0.147	0.032	0.268	-0.095	-0.049	-0.519*	-							
11. Imperative	0.141	0.464*	-0.311	-0.302	-0.798***	0.858***	-0.159	0.070	-0.249	-0.331	0.244	-						
12. Flesch-Kincaid reading ease	-0.115	-0.042	-0.125	0.247	0.427†	-0.269	0.291	-0.154	0.004	-0.088	0.263	-0.207	-					
13. Hours before appointment	0.108	-0.086	-0.310	0.322	0.214	-0.100	0.133	0.184	0.165	0.542*	0.009	-0.238	0.188	-				
14. Message count	0.065	0.452†	-0.176	0.096	-0.533*	0.608**	-0.241	0.634**	-0.486*	-0.052	0.309	0.646**	-0.138	0.045	-			
15. Word count	-0.063	0.177	0.037	-0.308	-0.210	0.241	0.125	-0.112	-0.203	-0.455†	0.149	0.409†	0.018	-0.697***	-0.062	-		
16. Interrogative	0.050	0.414†	-0.259	0.288	-0.395†	0.508*	-0.224	0.394†	-0.258	0.020	0.319	0.524*	0.083	0.412†	0.828***	-0.418†	-	
17. Flesch-Kincaid grade level	0.028	0.267	-0.047	-0.027	-0.495*	0.447†	-0.312	0.296	-0.166	0.050	-0.027	0.432†	-0.874***	-0.081	0.329	0.090	0.161	-

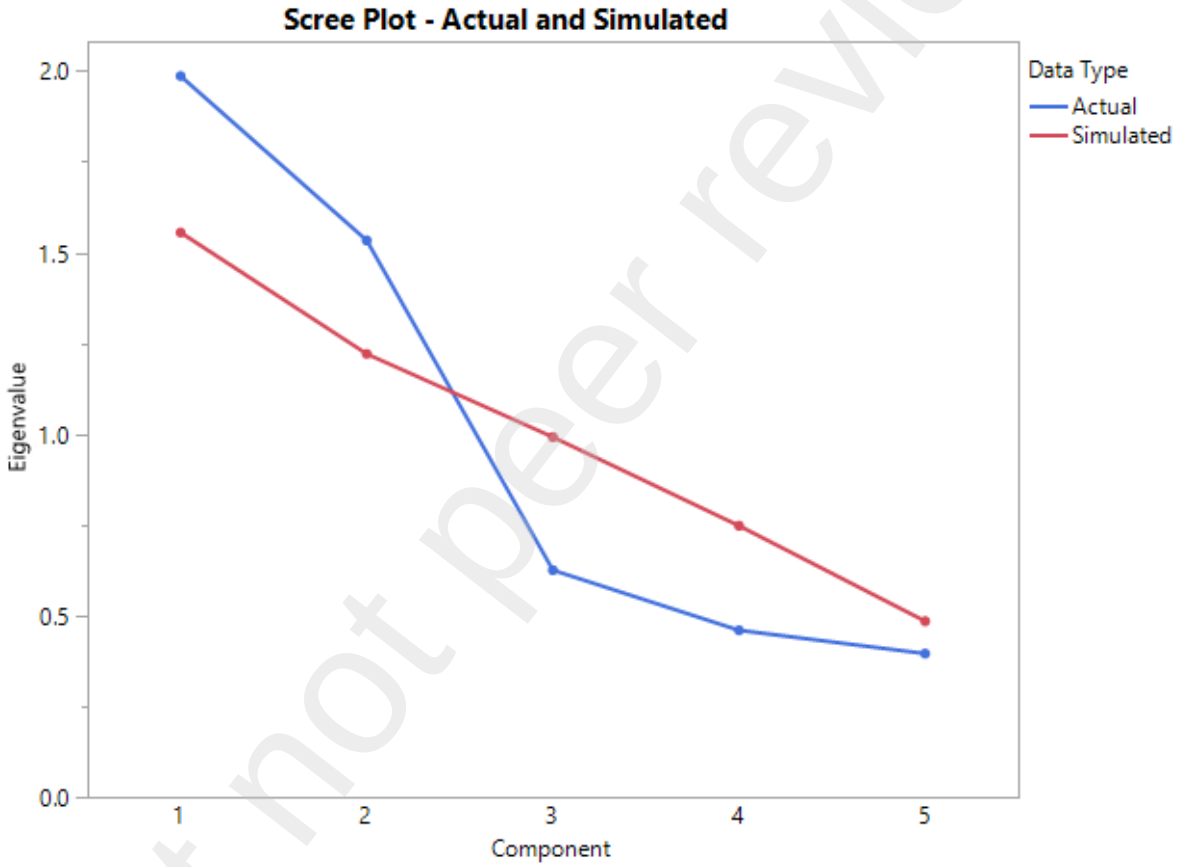
*** p <0.001, ** p < 0.01, * p < 0.05, † p < 0.10

Principal Components Analysis. Because intervention attributes were not linearly independent (see correlations in Table S14), we used principal components analysis to extract dimensions of correlated attributes among a subset of the attributes coded. Specifically, given our limited degrees of freedom, we set a cutoff of attributes with medium sized (i.e., $r > 0.25$) associations with efficacy in Table S14: *surprise factor, interactive, casualness, reminder,* and *reserved for you*.

As shown in Figure S2, a scree plot and parallel analysis (i.e., the scree plot of simulated data from 10,001 reshufflings of the same data) indicated a two-component solution. Specifically, the

slope of the scree plot levels off after two dimensions and, in addition, the cross-over point is between two and three dimensions. The first and second components explained 38.90% and 31.51% of the variance in the ratings, respectively.

Figure S2. Parallel analysis of components identified from top five attributes by effect size. The blue line represents the actual data; the red line represents simulated data from 10,001 reshufflings.



The loadings from the principal components analysis with an oblique promax rotation of this subset of five attributes are shown in Table S15. We interpreted Component 1 as incongruence with typical health provider messaging (i.e., surprising, interactive, casual) and Component 2 as reminders to get flu shots that were already reserved for the patient. These components were largely independent (r = - 0.03, p = 0.90). Bivariate associations with intervention efficacy were substantial for both Component 1 ("*incongruence*") (r = - 0.49, p = 0.03) and Component 2 ("*reserved reminder*") (r = 0.43, p = 0.07), respectively.

Table S15. Loadings of top five correlated attributes on each component

	Component 1 "Incongruence"	Component 2 "Reserved Reminders"
Surprise factor	**0.83**	-0.12
Interactive	**0.76**	-0.24
Casualness	**0.73**	0.47
Reminder	0.09	**0.88**
Reserved for you	-0.37	**0.72**

Note: Component loadings ≥ 0.60 are shown in bold.

As shown in Table S16, in a simultaneous OLS regression model predicting intervention effectiveness (using coefficient estimates drawn from Table S1), both *incongruence* (**β** = - 0.48, $p = 0.024$) and *reserved reminders* (**β** = 0.41, $p = 0.046$) were each significant predictors. *Incongruence* negatively predicted flu shot uptake; *reserved reminders* positively predicted flu shot uptake.

Table S16. Regression-estimated effect of principal components 1 (*incongruence*) and 2 (*reserved reminders*) on intervention effectiveness.

	β	SE	β (standardized)
Incongruence	-0.005*	(0.002)	-0.48*
Reserved Reminders	0.004*	(0.002)	0.41*
R-Squared	0.41		
Adjusted R-Squared	0.34		
Observations	19		

* $p < 0.05$

Note: The above table reports the results of the ordinary least squares regression predicting intervention efficacy with the two components identified above -- Incongruence and Reserved Reminders -- as the predictors. Each intervention was given a component loading based on our prior PCA. Intervention efficacy was measured on the pooled Geisinger and Penn Medicine sample (see Table S1). Robust standard errors are shown in parentheses.

We also separately explored whether and how these two components predicted intervention effectiveness for White patients and Non-White patients, using coefficient estimates drawn from Table S6. Neither OLS regression model was powered to find significant results, but we found results were nearly identical for White and Non-White patients.

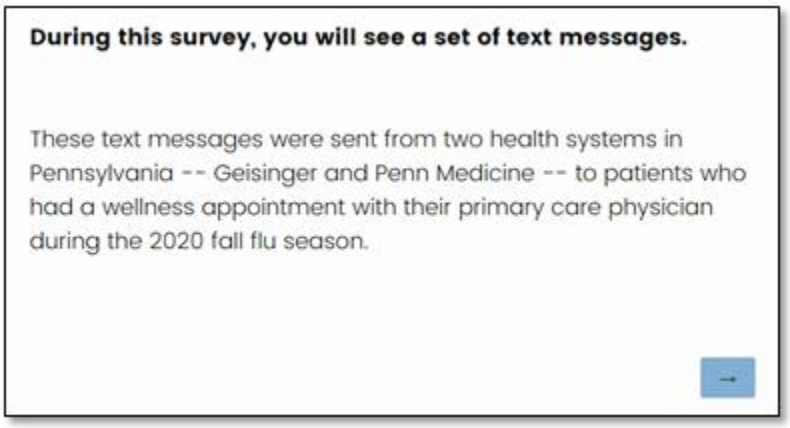
Table S17. Regression-estimated effect of principal components 1 (*incongruence*) and 2 (*reserved reminders*) on intervention effectiveness for White patients.

	β	SE	β (standardized)
Incongruence	-0.005	(0.003)	-0.35
Reserved Reminders	0.004	(0.003)	0.28
R-Squared		0.21	
Adjusted R-Squared		0.11	
Observations		19	

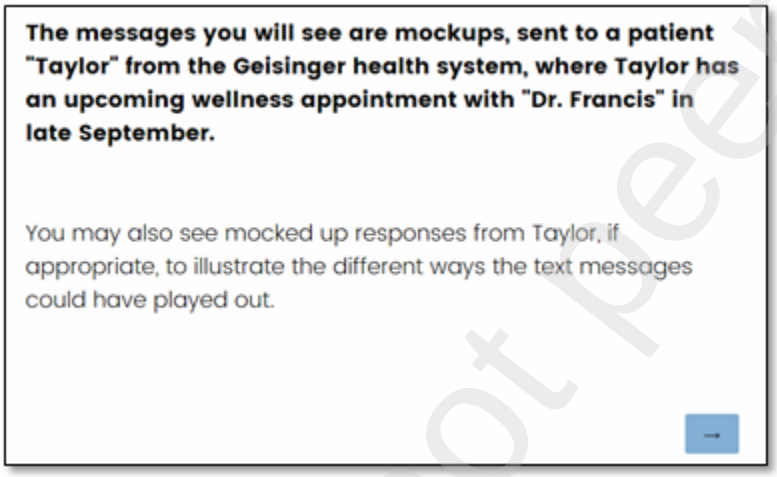
Table S18. Regression-estimated effect of principal components 1 (*incongruence*) and 2 (*reserved reminders*) on intervention effectiveness for Non-White patients.

	β	SE	β (standardized)
Incongruence	-0.006	(0.005)	-0.29
Reserved Reminders	0.004	(0.005)	0.18
R-Squared		0.12	
Adjusted R-Squared		0.01	
Observations		19	

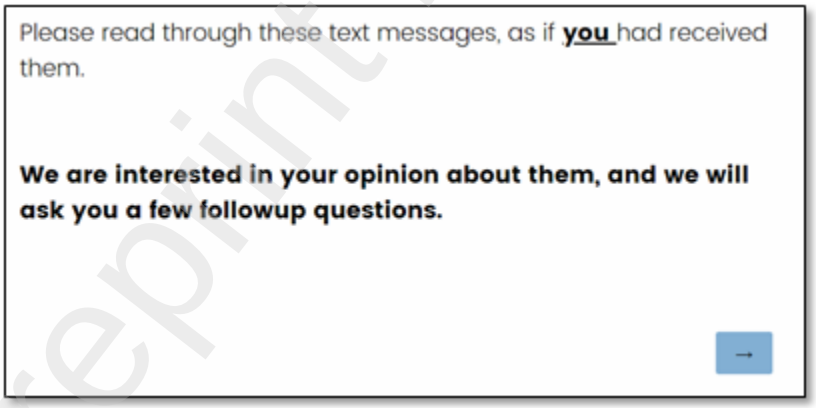
Figure S3. Screenshots of survey for coding of subjective attributes.
Screen 1 (all text messaging interventions)



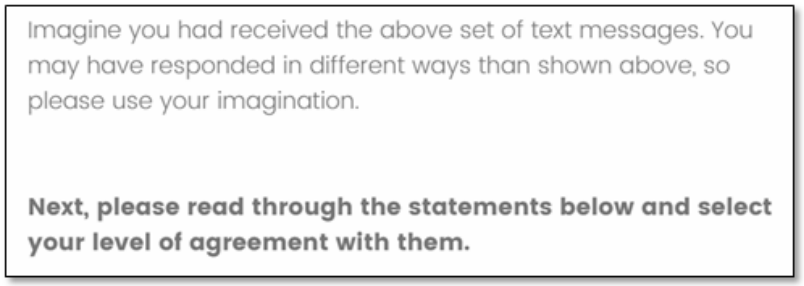
Screen 2 (all text messaging interventions)



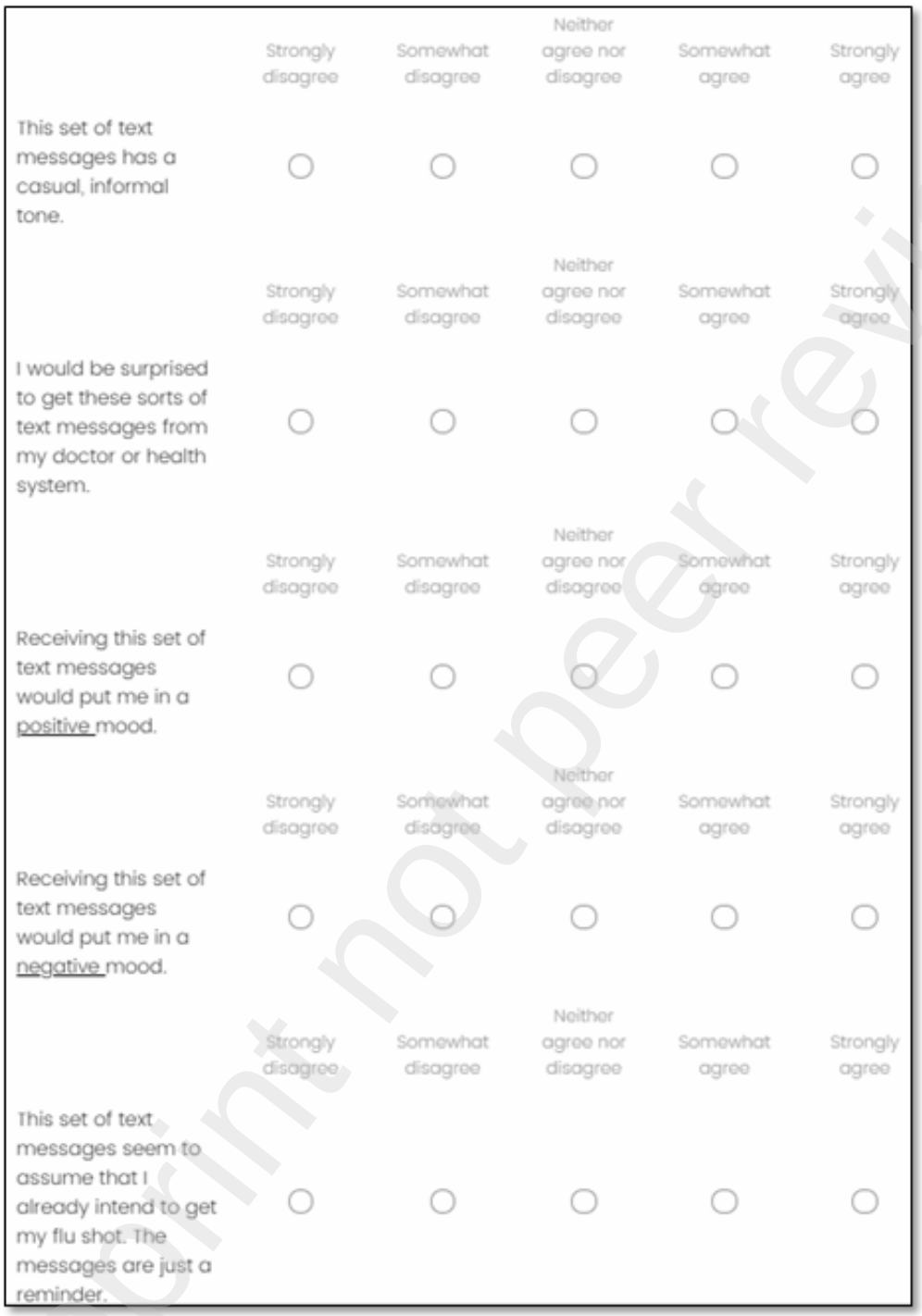
Screen 3 (all text messaging interventions)



Screen 4a (each participant received a randomly selected text messaging intervention, but the instructions and question set were the same for all participants)

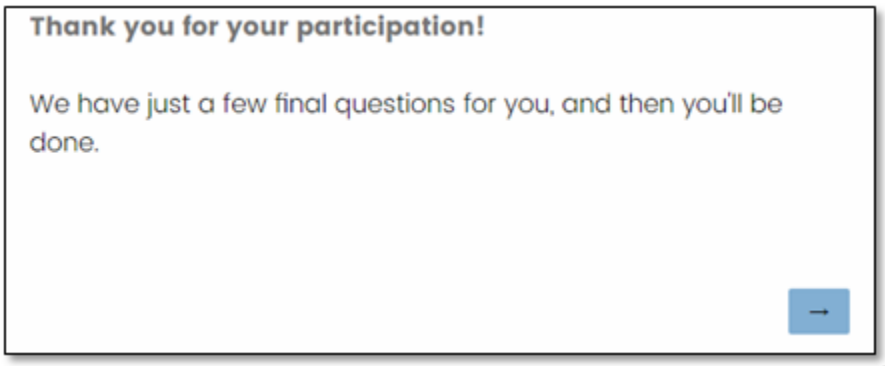


Screen 4b (each participant received a randomly selected text messaging intervention, but the instructions and question set were the same for all participants)

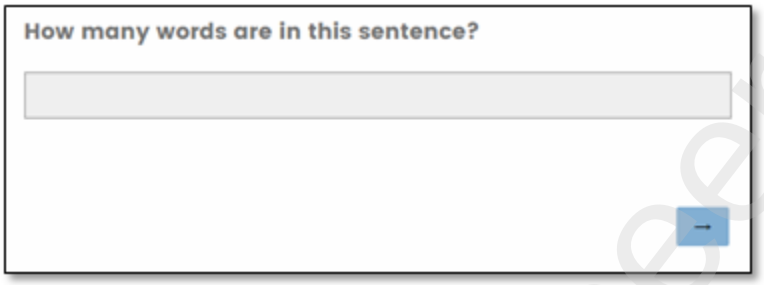


	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
This set of text messages has a casual, informal tone.	○	○	○	○	○
I would be surprised to get these sorts of text messages from my doctor or health system.	○	○	○	○	○
Receiving this set of text messages would put me in a positive mood.	○	○	○	○	○
Receiving this set of text messages would put me in a negative mood.	○	○	○	○	○
This set of text messages seem to assume that I already intend to get my flu shot. The messages are just a reminder.	○	○	○	○	○

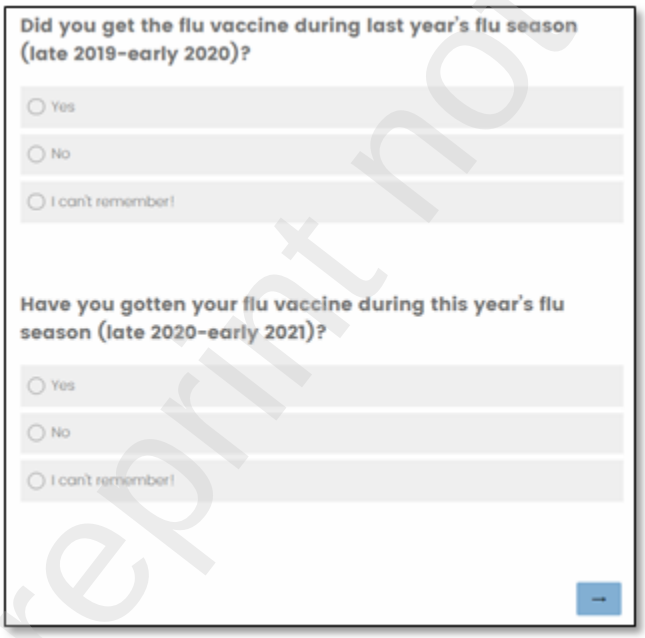
Screen 5 (all text messaging interventions)



Screen 6 (all text messaging interventions)



Screen 7 (all text messaging interventions)



6. References for the Web Appendix

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