Targeting Behavioral Interventions Based on Baseline Motivation Increases Vaccine Uptake

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Abstract: Behavioral interventions applied to policy problems often yield varying degrees of success in different sub-populations. Understanding and planning for heterogeneous treatment effects is critical to developing nuanced theories of human behavior and offering more useful guidance to policymakers. In this research, we identify one source of heterogeneity in the effectiveness of behavioral interventions: individuals’ baseline motivation to adopt the encouraged activity. Previous studies suggest that people may not take up an activity either because (1) they have no intentions to adopt it or (2) they fail to follow through despite intending to do so. In a series of preregistered experiments (two online and one in the field; total N = 17,362), we tested two approaches to encouraging influenza vaccination, aiming to either change intentions or facilitate follow-through. The information intervention, designed to enhance intentions by targeting misconceptions, increased vaccination intentions and uptake only among those with relatively low baseline motivation. The follow-through intervention, designed to enhance the salience and convenience of getting vaccinated, increased vaccine uptake only among those with relatively high baseline motivation. This work highlights the importance of aligning the mechanisms targeted by an intervention with individuals’ baseline motivation as a fruitful way to customize behavior change interventions.

Keywords: behavioral interventions, heterogeneity, information intervention, intention-action gap, vaccination, field experiment
Behavioral interventions are widely used by policy makers around the globe. At least nine countries have established government agencies (known as “Nudge Units”) that leverage behavioral science insights to induce behavior change among citizens, and many more city governments, nonprofit organizations, academic institutions, and private companies have followed suit (1, 2). Behavioral interventions are often cost effective (3) and have been successfully used to promote a wide range of personally and socially desirable behaviors including tax payment, retirement savings, pro-environmental behaviors, and vaccination (4—11). However, intervention effectiveness varies substantially by context and population (12—14). Social scientists have begun to recognize that planning for individuals’ heterogeneous needs is essential to successful behavior change efforts (15—20). In this research, we demonstrate one predictable source of heterogeneity in the effectiveness of behavioral interventions across sub-populations in a setting that is of great interest to policymakers—vaccine uptake (21).

Our research builds on the premise that two key stages in goal pursuit involve establishing intentions to act and then turning intentions into action (22, 23). A person’s intentions to engage in an activity are a key antecedent of behavior (24, 25). Establishing intentions to act often requires a deliberative process of weighing the desirability and feasibility of the goal (26). However, established intentions alone are not enough to reach a goal (27). Commonly known as the intention-action gap, people often fail to follow through on their intentions due to forgetfulness, procrastination, or other sources of logistical or psychological frictions (28—32). Accordingly, behavioral interventions often aim to either persuade individuals to establish intentions or address inaction at the follow-through stage.

To understand for whom these two distinct approaches are more effective, we examine two interventions that either focus on intentions or follow-through as the barrier to getting
vaccinated (33, 34). To persuade individuals to establish vaccination intentions, we designed an
information intervention to change people’s beliefs about the value of getting vaccinated (see
e.g., 35). To address the intention-action gap, we designed a follow-through intervention to
increase the salience of vaccination and reduce the associated frictions (see e.g., 36).

We study whether the effectiveness of these two types of interventions varies depending
on the target population’s baseline motivation to get the flu shot. For individuals with low
baseline motivation to get vaccinated (e.g., because they underestimate the importance of
vaccination), an information intervention that addresses potential reasons for hesitancy may
increase their intentions. However, this approach may not affect individuals who already have
high motivation to get vaccinated (e.g., because they already appreciate the value of
vaccination). These individuals may fail to act despite their high baseline motivation and stand to
benefit more from a follow-through intervention. Those with low baseline motivation, however,
may be unlikely to be moved by a follow-through intervention alone.

Finding ways to get individuals vaccinated is a timely and pressing objective. In the
2019-2020 season, there were an estimated 380,000 flu-related hospitalizations and 20,000
deaths in the United States (37). Despite the benefits of getting vaccinated, both to the individual
and society at large, annual influenza vaccination rates in the United States have remained below
the national target for years (38), ranging from 37.1% to 50.2% in the past ten years (2011-2021;
39). This reluctance extends to other vaccines, leading the World Health Organization to name
vaccine hesitancy as one of the top 10 global health threats even prior to the COVID-19
pandemic (40).

Across online and field experiments (total N = 17,362), we found that the effect of
different intervention approaches designed to encourage vaccine uptake depended on
individuals’ baseline motivation, as proxied by their influenza vaccination history. Among people with low baseline motivation (i.e., those who did not get their flu shot in the prior season as far as we could measure), receiving information about the flu and the flu vaccine shifted related beliefs and increased vaccination intentions by 6.5-12.8 percentage points (or 24.1%-48.5%) across our online and field studies; it also boosted vaccine uptake in the field by 3.8 percentage points (or 16.5%). This first intervention approach, however, yielded no detectable effects among those with high baseline motivation to vaccinate (i.e., those who got their flu shot in the prior season). Conversely, an intervention that encouraged people to follow through on vaccination intentions by increasing the salience and ease of vaccination boosted vaccine uptake by 3.8 percentage points (or 7.8%) in the field among those with high baseline motivation to vaccinate. This second intervention approach had no detectable benefits among those with low baseline motivation.

Altogether, our findings suggest that information interventions can shift intentions and actions for people who have low motivation to act, whereas follow-through interventions can close the intention-action gap for those with higher baseline motivation. More broadly, these findings highlight the importance of assessing individuals’ baseline motivation and addressing their specific source of inaction (e.g., to address misconceptions about the benefits of an activity or to reduce friction associated with taking up the activity). Beyond vaccine uptake, baseline motivation is a critical individual-level factor that is at play for many behavioral challenges, such as energy conservation, retirement savings, and voter turnout. Our work provides behavioral scientists and policymakers with one framework to help account for individual-level heterogeneity when implementing and customizing behavior change interventions.
Online Experiments

Methods

We conducted two preregistered large-scale online experiments in September and October of 2020 (Experiment 1, https://aspredicted.org/blind.php?x=TGD_ZWN; Experiment 2, https://aspredicted.org/blind.php?x=KEJ_VPB) to test the effect of an information intervention on influenza vaccination intentions. Using the Amazon Mechanical Turk and Prolific Academic platforms, we recruited 5,136 adults in the United States who had not yet received their flu vaccine for the 2020-2021 flu season. Participants in Online Experiment 1 and a subset of participants in Online Experiment 2 were randomly assigned to watch either a 2-minute video designed to address misperceptions about the flu and increase flu vaccination intentions (“Flu Video Condition”; \( n = 1,739 \)) or a 2-minute control video about the challenges of chronic illness and benefits of regular exercise that did not mention the flu (“Control Video Condition”; \( n = 863 \)). The analyses reported in the main text focus on these participants (total \( N = 2,602 \), \( M_{\text{age}} = 38.4 \) years, \( SD_{\text{age}} = 12.5 \), 71% White, 52% female, and 37% vaccinated in the previous flu season). Online Experiment 2 also had 2,534 participants who were randomly assigned to watch the first or second half of either the flu video or the control video, or to not watch any video, in order to study a different question that was not the focus of this paper. Results are robust when including those people (see Supplementary Information (SI) Section 1.4.2). Figure 1 depicts the basic design of the online experiments, and SI Sections 1.1.1 and 1.1.2 present a detailed design description.

The flu video was designed based on the results of a representative sample survey we conducted in July 2020 (before the start of the 2020-2021 flu season) with 484 adults in the United States recruited from Prolific Academic. We found that, relative to people who planned to
get the flu shot in the upcoming flu season, those who did not plan to do so underestimated the prevalence of the flu, the severity of flu symptoms, and the effectiveness of the vaccine (see SI Section 3 for details about this survey). Based on these findings and in line with prior research that has sought to change vaccination intentions by altering risk appraisals of a disease and confidence in a vaccine (33, 41), we structured our flu video to inform people about the risks and consequences of contracting the flu and about the effectiveness of inoculation.

We created two variations of the flu video: In one version, we provided the information from the perspective of doctors and public health experts and highlighted that the statistics came from research (the “scientific” version; https://tinyurl.com/4npcehep). In another version, we presented essentially the same information about the flu and the vaccine from the perspective of two adults who recently became sick with the flu along with their personal stories (the “vivid” version; https://tinyurl.com/2mz4z273). Participants in the Flu Video Condition were randomly assigned to watch one of these two versions. We varied how the information was presented because the effect of narratives and anecdotal evidence is an understudied yet burgeoning research topic (35, 42—43). The results did not statistically significantly differ between these two sub-conditions in our preregistered primary outcome measures (SI Section 1.5); therefore, as preregistered, we pooled participants from these sub-conditions to form the “Flu Video Condition” for the analyses reported in the main text.

The video in the Control Video Condition discussed the problem of chronic illness and the importance of regular exercise but did not discuss the flu. It had a similar length, style, and structure as the scientific version of the flu video, emphasizing statistics from research and opinions from medical and public health experts (https://tinyurl.com/bdfhk66a).
After watching their assigned video, participants indicated their intentions to get a flu shot in the current (2020-2021) flu season (“Will you get the flu shot during this flu season?”, responding “Yes” or “No”) and reported their beliefs and perceptions regarding the flu and its vaccine. Specifically, participants first reported their perceived likelihood of getting the flu with and without inoculation (“Please think about how likely you are to catch the flu during a flu season under 2 different circumstances: (1) If you do not get the flu vaccine, how likely are you to catch the flu in a flu season? and (2) If you get the flu vaccine, how likely are you to catch the flu in a flu season?”). Participants responded on a scale from 0% (*I certainly won’t catch the flu*) to 100% (*I certainly will catch the flu*), and in the analysis, we multiplied the responses by 100 so they ranged from 0 to 100. Then, participants reported their perceived vulnerability to the flu (“Without getting the flu vaccine, I would feel very vulnerable to the flu”), anticipated regret if they did not get the vaccine (“I would regret not getting a flu shot if I end up getting sick”), fear
of catching the flu (“I am scared of catching the flu”), and worry about transmitting the flu (“The possibility of passing the flu to other people worries me”), all on a scale from 1 (strongly disagree) to 7 (strongly agree). Finally, to capture the perceived effectiveness of the flu vaccine, we subtracted the perceived likelihood of getting the flu with the vaccine from the perceived likelihood of getting the flu without the vaccine. The values of this variable ranged from -100 to 100, where higher positive values convey stronger beliefs that the flu shot can prevent the flu and lower negative values convey stronger beliefs that the flu shot actually causes the flu. The full list of measures captured in the online experiments can be found in SI Section 1.1.1.

Following our preregistration, we examined whether the effects of watching a flu (vs. control) video on vaccination beliefs and intentions depended on participants’ self-reported vaccination status in the previous (2019-2020) flu season. We used this variable as a proxy for participants’ baseline motivation to get vaccinated, as past vaccination behavior is one of the strongest and most reliable predictors of current vaccination intentions (41, 44). Indeed, our aforementioned representative sample survey (N = 484) shows that when asked in July 2020 (the summer before the 2020-2021 flu season), people who received the flu vaccine in the previous flu season were much more likely to plan to get vaccinated in the current year (97%) than those who did not receive it in the previous flu season (32%; p < .001). Based on these findings, we assume those in our online experiments who received the flu shot in the last flu season had a relatively high baseline motivation to get vaccinated in the current flu season, and we assume those who did not receive the flu shot in the last flu season had a relatively low baseline motivation to get vaccinated.
Results

In the Main Text, we report pooled data from our two online experiments for simplicity. All analyses rely on ordinary least-squares (OLS) regressions with heteroskedasticity-robust standard errors and control for covariates that were preregistered for Experiment 2 (age, race, gender, vaccination status from the prior season, whether participants had children under the age of 18, survey platform, and survey date fixed effects). We obtain similar results when analyzing the two online experiments separately (SI Sections 1.3 and 1.4; in these robustness checks, we only control for covariates that were preregistered for the respective experiment).

We found a significant main effect of watching the flu video on vaccination intentions. Those in the Flu Video Condition were 8 percentage points (pp) more likely to plan to get vaccinated in the current flu season than those in the Control Video Condition ($b = .080, SE = .016, p < .001$). This difference amounted to a 16% increase in vaccination intentions, since 50 percent of participants exposed to the control video reported planning to get the flu vaccine. As shown in Figure 2, this effect was entirely driven by the substantial increase in vaccination intentions among participants who reported not getting the influenza vaccine in the prior flu season (i.e., participants who presumably had relatively low baseline motivation to get the vaccine). Specifically, within this sub-sample of participants, those in the Flu Video Condition were 12.8 pp (or 48.5%) more likely to plan to get vaccinated than those in the Control Video Condition ($b = .128, SE = .024, p < .001$). Among those who reported getting the influenza vaccine in the prior flu season (i.e., those who presumably had relatively high baseline motivation to vaccinate), watching the flu video made virtually no difference to vaccination intentions ($b = -.010, SE = .016, p = .56$), which reflects a ceiling effect, given that 94.7 percent of participants in the Control Video Condition already intended to get a flu shot. The flu video
had a significantly smaller effect among participants who received a flu shot in the previous flu season than among those who did not ($b = -0.134, SE = 0.029, p < .001$).

![Figure 2: This figure plots the raw percentage of people who indicated an intention to receive the flu shot in the current season in each condition of the two online experiments combined, broken down by people’s baseline motivation (proxied by whether they reported receiving the flu shot in the previous flu season). Error bars represent the 1 +/- SE. Regression estimated differences between the Flu Video Condition and the Control Video Condition are reported in text boxes. The horizontal bars represent the significance levels of the regression-estimated simple effects: n.s., $p > .05$; *, $p < .05$; **, $p < .01$; ***, $p < .001$.](image)

Furthermore, the flu video changed all of the beliefs and perceptions measured about the flu and the flu vaccine (see SI Section 1.2 for detailed analyses). Among these measures, perceived vulnerability to the flu ($M = 4.01, SD = 1.98$) and perceived effectiveness of the vaccine ($M = 21.06, SD = 25.26$) were of particular interest, given that the flu video aimed to convey the risks of contracting the flu as the focal problem and the effectiveness of inoculation as a proposed solution. Focusing first on perceived vulnerability to the flu, the flu video
intervention had a significant, positive main effect ($b = .381, SE = .072, p < .001$) as well as a marginally significant negative interaction with having received a flu shot in the previous flu season ($b = -.283, SE = .145, p = .062$). Specifically, watching the flu video (vs. the control video) increased perceived vulnerability to the flu for participants who had not received a flu shot in the previous flu season ($b = .488, SE = .092, p < .001$), but had a much smaller and nonsignificant impact among those who had received a flu shot in the previous flu season ($b = .175, SE = .112, p = .11$). A similar pattern emerged in perceived effectiveness of the vaccine:

The flu video (relative to the control video) on average increased perceived effectiveness of the vaccine ($b = 3.69, SE = 1.04, p < .001$), but this effect was qualified by a significant interaction between the information intervention and having received a flu shot in the previous flu season ($b = -6.55, SE = 2.05, p = .002$). Specifically, watching the flu (vs. control) video significantly increased perceived effectiveness of the vaccine among participants who had not received a flu shot in the prior flu season ($b = 6.12, SE = 1.37, p < .001$), but yielded no detectable influence among participants who had been vaccinated against flu in the prior season ($b = -.820, SE = 1.51, p = .57$).

Altogether, the online experiments show that the video-based information intervention was differentially effective at boosting individuals’ perceived vulnerability to the flu, perceived effectiveness of the vaccine, and flu vaccination intentions based on individuals’ baseline motivation to get vaccinated as indicated by their vaccination status from the prior flu season. These findings provide initial evidence that an information intervention can change important beliefs held about a focal behavior as well as intentions to act, particularly among people with low baseline motivation. One potential limitation of these online experiments is that vaccination intentions among individuals with high baseline motivation may be too high to move (i.e., due to
ceiling effects). In the next section, we report on a field experiment that does not have this limitation. This field experiment tests the effect of an information intervention on vaccine intentions and uptake. On top of that, it also examines the effects of a follow-through intervention on vaccination behavior.

Field Experiment Capturing Vaccination Intentions and Behavior

Methods

We conducted a preregistered field experiment (initial preregistration: https://aspredicted.org/CZT_AVM; updated preregistration: https://aspredicted.org/MIZ_QYY) in fall 2020 as part of a megastudy organized by the Behavior Change For Good Initiative (BCFG; 45). A megastudy is a large-scale field experiment involving a number of nested studies that are developed by different research teams and are simultaneously conducted (46). Our field experiment is one of the sub-studies in the megastudy that BCFG organized in partnership with two health systems in the United States: Penn Medicine and Geisinger Health (megastudy initial preregistration: https://aspredicted.org/blind.php?x=9zr9nu; updated preregistration: https://aspredicted.org/blind.php?x=sq23yd; See SI Section 2.1 for descriptions of how this megastudy was set up and the role of our research team). The megastudy was approved by the Institutional Review Board (IRB) at the University of Pennsylvania; the IRB granted a waiver of consent for this research.

Participants were eligible for the experiment if they (1) had a new or routine (non-sick) primary care appointment between September 24, 2020, and March 31, 2021, at Penn Medicine or between September 28, 2020, and March 31, 2021, at Geisinger Health, (2) had a cell phone number in their electronic health record, (3) had not opted out of receiving text messages for
appointment reminders or for being contacted for research purposes, (4) had no documented allergic or otherwise adverse reactions to the flu vaccine, and (5) had not already received a flu vaccination in 2020 according to their electronic health record. Random assignment to each study arm in the megastudy was stratified by health system (Penn Medicine vs. Geisinger Health), age (18 to 64 years vs. 65 years and older), and prior influenza vaccination status in the 2019-2020 season (yes vs. no/unknown) based on participants’ electronic health records at our collaborating health systems. A total of 14,760 patients were assigned to study conditions relevant to our preregistered sub-study ($M_{age} = 50.6$ years, $SD_{age} = 16.1$, 70% White, 55% female, 53.5% Penn Medicine patients, 40% vaccinated in the previous flu season). As shown in SI Section 2.1.1, study conditions were well-balanced on age, race, gender, health system, provider type, days separating the earliest enrollment date and a patient’s appointment date, and vaccination history ($p$-values from all $F$ tests $> .20$).

Patients in our field experiment were randomly assigned to either receive two text messages (“Follow-Through Condition”; $n = 11,018$) or not (“Holdout Condition”; $n = 3,742$). In the Follow-Through Condition, two text messages encouraged patients to get the flu shot at their upcoming doctor’s appointment (see Figure 3 for the exact text). The messages were sent 3 days and 1 day before this appointment, respectively. These text messages served as a follow-through intervention on vaccine uptake because they were designed to address three barriers to actions. First, they aimed to combat forgetfulness by reminding people it was flu season. Second, they were intended to reduce the friction associated with deciding when and where to get the shot by creating a vaccination plan for patients (i.e., encouraging people to get the vaccine at their doctor visit; 47). Third, these messages were designed to enhance the perceived ease of getting the shot,
since patients were told that they could simply bundle their vaccinations with their doctor’s appointment.

The text messages also contained a link to a wellness video, which was used to implement the information intervention. Patients in the Follow-Through Condition were randomly assigned to receive a link to one of three videos, which were the same full-length videos used in the online experiments. That is, they either received a link to a control video about exercise (‘‘Control Follow-Through Condition,’’ \( n = 3,685 \)), a link to a scientific version of the flu video (\( n = 3,710 \)), or a link to the vivid version of the flu video (\( n = 3,623 \)). As preregistered, the latter two groups were combined (\( n = 7,333 \)) to form our ‘‘Information & Follow-Through Condition.’’ The text messages were identical across conditions, with the only difference being a nondescript URL of the video link. Patients could not determine the content of the video before clicking on the link, and only saw the condition-specific video content after they clicked the link.

After patients were presented with the video, which was embedded in a survey, they were asked about their intentions to get the flu shot at their doctor’s appointment (‘‘Do you plan to get a flu shot at your upcoming doctor appointment?’’ responding with ‘‘Yes’’ or ‘‘No’’). They were also asked to indicate their perceived vulnerability to the flu (‘‘To what extent do you agree with the following statement? Without getting the flu vaccine, I would feel very vulnerable to the flu,’’ responding on a 7-point scale from 1 = strongly disagree to 7 = strongly agree). Patients could choose not to finish watching the video or not to respond to our survey questions. The field experiment study design and funnel of patients at each stage are visualized in Figure 3.
Figure 3: This figure visualizes the design of the field experiment and the funnel of patients at each stage. It also displays the samples used in each of the main analyses.

263 Results

264 All analyses in the Main Text about the field experiment follow our preregistration. We pool data from two health systems and use OLS regressions with heteroskedasticity-robust standard errors. We control for preregistered covariates that were made available to us, which include patient age, race, gender, health system, flu shot in the prior season, provider type, as well as the linear and squared days separating a patient’s scheduled doctor’s appointment from the start of the field experiment. We examine heterogeneous treatment effects by whether
patients’ electronic health record indicated that they received the flu shot in the prior flu season, which is our proxy for patients’ baseline motivation to get vaccinated.

**Effect of the information intervention on vaccination intentions**

In this and the next section, we focus on the effects of the information intervention (i.e., the flu vs. control video nested in the Follow-Through Condition) on vaccination intentions and actual vaccine uptake among those who clicked the link in the follow-through text messages to watch the wellness video. As explained earlier, the text messages were identical across conditions and patients could not anticipate the content of the video without clicking on the link, so condition assignment could not have affected whether patients clicked on the link in at least one of the text messages (i.e., click-through rates). Thus, we believe that the small, marginally significant difference in click-through rates between Information & Follow-Through Condition (42%) and Control Follow-Through Condition (40%; \( p = .062 \)) occurred by chance and that we maintain internal validity when examining the effect of watching the flu (vs. control) video among patients who clicked on the link. Also, attrition rates from opening the link to responding to the post-video vaccination intention measure were statistically indistinguishable between Information & Follow-Through Condition (22.6%) and Control Follow-Through Condition (21.7%; \( p = .589 \)), which furthers confirms that our analysis about patients who clicked on the link in the follow-through text messages is internally valid.

Focusing only on patients who clicked on the link (and thus were exposed to either the control video or flu video), there was a significant main effect of the flu video treatment on vaccination intentions: Exposure to the flu video increased patients’ likelihood of planning to get a flu shot at their upcoming doctor’s appointment by 4.9 pp (or 9.8% relatively speaking) when compared to patients who were exposed to the control video (\( b = .049, SE = .015, p < .001 \)). As
shown in Figure 4, this main effect was driven by an increase in vaccination intentions among
those whose electronic health records indicated they had not been vaccinated in the prior year.
Within this subgroup of patients, those exposed to the flu video were 6.5 pp (or 24.1%) more
likely to plan to get vaccinated than those exposed to the control video ($b = .065, SE = .021, p =
.003$). Among those whose medical records indicated that they received their flu vaccine in the
previous flu season, there was no significant difference in vaccination intentions induced by
exposure to the flu video relative to the control video ($b = .032, SE = .020, p = .104$). The
interaction between the type of video exposure and known prior vaccination status was not
statistically significant ($b = -0.034, SE = .030, p = .25$).

Figure 4: This figure plots the raw percentage of patients who planned to receive the flu vaccine at their
upcoming doctor’s appointment among those who clicked on the video link in the Control Follow-
Through and Information & Follow-Through Conditions of the field experiment, broken down by
patients’ baseline motivation proxied by whether they received the flu shot in the previous flu season
according to their electronic health record. Error bars represent the 1 +/- SE. Regression estimated
differences between the Information & Follow-Through arm and the Control Follow-Through arm are
Further, the information intervention differentially affected patients’ perceived vulnerability to the flu, depending on prior vaccination history. Among patients who clicked through, there was a significant main effect of exposure to the flu video (vs. control video) on perceived vulnerability to the flu. Importantly, the flu video increased perceived vulnerability more strongly among patients who had not received a flu vaccine the year before (b = 0.492, SE = .094, p < .001) than among those who had been vaccinated the prior year (b = 0.179, SE = .101, p = .076; interaction, b = -.313, SE = .138, p = .023).

So far, we have shown that both in online and field settings, our video-based information intervention effectively boosted perceived vulnerability to the flu and increased vaccination intentions among those with low preexisting motivation to get the vaccine (as suggested by no record of flu vaccine receipt in the prior year), but had a limited impact on those with high preexisting motivation (as suggested by record of vaccine receipt in the prior year). Next, we examine the effect of the information intervention on actual vaccine uptake.

**Effect of the information intervention on vaccine uptake**

To investigate how the information intervention affected actual vaccine uptake, we again focus only on patients who opened their assigned wellness video and compare people exposed to the flu video to those exposed to the control video. Our preregistered primary measure of vaccine uptake is whether patients received a flu shot on the date of their scheduled doctor’s appointment or in the 3 days leading up to it (i.e., after the follow-through messages were sent) according to their electronic health records. Watching the flu (vs. control) video on average led to a marginally significant 2.2 pp (or 5.4%) increase in vaccination rates at or before an upcoming
doctor’s appointment ($b = .022$, $SE = .013$, $p = .089$). As shown in Figure 5, the increase was driven by patients who had not received a flu shot in the prior flu season, who were 3.8 pp (or 16.5%) more likely to get vaccinated after opening the flu video than after opening the control video ($b = .038$, $SE = .017$, $p = .024$). Among patients who had received a flu shot the prior flu season, vaccination rates were virtually unaffected by exposure to the flu video versus the control video ($b = .005$, $SE = .019$, $p = .801$). Although negative in sign, the interaction between the type of video exposure and having received a vaccine the prior year was not statistically significant in predicting vaccine uptake ($b = -0.035$, $SE = .026$, $p = .183$).

Figure 5: This figure plots the raw percentage of patients who received an influenza vaccine at their doctor’s appointment or in the three days leading up to it among those who opened the link to the video. It shows patients by condition – the Control Follow-Through Condition and Information & Follow-Through Condition, broken down by whether they had received a flu shot in the prior flu season (a proxy for baseline motivation to vaccinate in the current year). Error bars represent the 1 +/- SE. Regression estimated differences between the Information & Follow-Through and the Control Follow-Through arm.
Altogether, our field and online experiments suggest that an information intervention is most helpful for individuals who have low motivation to act. Next, results from our follow-through intervention in the field experiment will illuminate one way to change behavior among those with strong preexisting motivation to act.

**Effect of the follow-through intervention on vaccine uptake**

In this section, we examine how an intervention to encourage follow through on vaccination affected vaccine uptake. We report on intent-to-treat analyses comparing the vaccine uptake of patients assigned to receive text messages in the Follow-Through Condition (regardless of whether they clicked the link to a wellness video in the text) to those in the Holdout Condition of our experiment. Here, we again focus on the preregistered primary measure of vaccine uptake—whether patients got their flu shot at or before their doctor’s appointment.

We first compare patients who received the text messages containing a link to the control video (i.e., those in the Control Follow-Through Condition, who received the text messages but were not exposed to the information intervention about the flu) with those in the Holdout Condition who did not receive any study-related text messages. On average, vaccination rates at or before patients’ doctor visits were directionally but not significantly higher in the Control Follow-Through Condition than in the Holdout Condition ($b = .014, SE = .009, p = .133$). Importantly, there was a significant, positive interaction between receiving the text messages containing a link to the control video (vs. no messages) and prior receipt of flu vaccine in predicting vaccine uptake ($b = .043, SE = .019, p = .027$). As shown in Figure 6, for patients who had received a flu vaccine the year before, receiving the Control Follow-Through treatment

are reported in text boxes. The horizontal bars represent the significance levels of the regression-estimated simple effects: n.s., $p > .05$; *, $p < .05$; **, $p < .01$; ***, $p < .001$. 

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increased vaccination rates by 3.8 pp (or 7.8%) relative to the Holdout Condition ($b = .038$, $SE = .016$, $p = .018$). Since the Control Follow-Through Condition did not provide any additional information about the flu or the vaccine relative to the Holdout Condition, and watching the control video indeed did not change flu vaccination intentions relative to not watching anything in our online Experiment 2 (see SI Section 1.4.3), we believe the Control Follow-Through treatment intervention should have primarily brought this increase in vaccine uptake by encouraging follow-through (rather than changing intentions). By contrast, this treatment made virtually no difference among patients who had not received a flu shot in the prior flu season ($b = -.002$, $SE = .011$, $p = .886$). Thus, our results suggest that our follow-through intervention effectively closed the intention-action gap among those with intentions already in place, as captured through their previous flu vaccination behavior.

Figure 6: This figure plots the raw percentage of patients who received the vaccine at their doctor’s appointment or in the three days leading up to it in the Control Follow-Through Condition and the Holdout Condition of the field experiment, broken down by people’s baseline motivation proxied by whether they received the flu shot in the previous flu season according to their electronic health records.
If we compare the combined Follow-Through Conditions (i.e., the Control Follow-Through Condition and the Information & Follow-Through Condition) with the Holdout Condition, our results are similar to those reported above (see SI Section 2.2.4). However, the comparison between the Information & Follow-Through Condition and the Holdout Condition does not isolate the effect of the text-based follow-through intervention on getting vaccinated because some patients in the Information & Follow-Through Condition received additional information about the flu and the flu vaccine by watching the flu video. Thus, we have focused on the comparison between the Control Follow-Through Condition and the Holdout Condition, which as discussed above shows that the text-based follow-through intervention successfully boosted vaccine uptake, primarily among those whose vaccination history suggested they had high motivation to get vaccinated.

**General Discussion**

Understanding how behavioral interventions vary in impact across subpopulations is of utmost importance (Bryan et al., 2021). Building on the notion that the path to behavior change has multiple stages (Ajzen, 1991; Chang et al., 2019; Gollwitzer, 1990; Sheeran & Webb, 2016), we examine two common types of interventions that aim to either change intentions or address follow-through barriers, and then demonstrate heterogeneity in their treatment effects. Our findings suggest that intervention efficacy depends on the alignment between an intervention’s mechanism and an individual’s preexisting motivation to act. Our *information* intervention
effectively updated participants’ attitudes and beliefs about the risk of catching the flu and the 
effectiveness of the vaccine, and it increased both vaccination intentions and actual vaccine 
uptake for those whose vaccination history suggested they would have a lower baseline 
propensity to inoculate. Conversely, those whose vaccination histories suggested they already 
intended to vaccinate were more responsive to our follow-through intervention, which was 
designed to close the intention-action gap by making flu vaccination salient, presenting a specific 
plan to reduce decision-making friction, and increasing the ease of vaccination. Altogether, this 
evidence suggests that the effectiveness of an intervention may depend on an individual’s current 
stage on the path from intentions to behavior, which can be captured by understanding the 
individual’s baseline motivation to act (as summarized in Figure 7).

![Figure 7: This figure visualizes the proposed path from determining an individual’s baseline motivation (by measuring their past behavior) to effectively provoking behavior change.](image)

This research has a number of limitations that suggest promising directions for future 
research. First, our proxy for individuals’ baseline level of motivation to get vaccinated in our 
field experiment was imprecise. Since our field partners did not have access to records of flu 
vaccinations that patients obtained outside of their healthcare systems (unless patients updated
their healthcare providers about their external flu shots), some patients who got their flu shot in
the previous flu season (and should have been classified as having high baseline motivation) may
be classified incorrectly as having low baseline motivation. Thus, our results in the field may
have underestimated the magnitude of differential treatment effects of interventions between
patients classified as having high versus low baseline motivation.

Second, although our studies were preregistered and our findings were consistent across
online and field settings, the heterogeneous treatment effects we detected were not the primary a
priori predictions we designed our studies to examine. Future research is needed to replicate
these findings. Further, it is important to note that patients in our field experiment who were
exposed to the information treatment also received the text messages designed to facilitate
follow-through. A full factorial design would illuminate whether information interventions are
only effective in changing behavior among individuals with low baseline motivation when paired
with follow-through interventions. Finally, our results were obtained exclusively in studies of
influenza vaccine uptake. Although vaccine uptake is an important and timely area of focus for
those who seek to develop behavior change interventions, there are many other domains to which
our framework can be applied. Future work would ideally test the predictions of our framework
outside of the vaccination context and explore other ways of measuring baseline motivation.

Overall, our research demonstrates the importance of aligning the targeted mechanism of
an intervention with the barriers to individual action. In the context of vaccination, we show that
information interventions are most valuable for those whose past inoculation history suggests
they may require persuasion, while follow-through nudges are most valuable for those whose
inoculation history suggests persuasion is likely unnecessary. As practitioners and policy makers
increasingly turn to behavioral science to improve individual and societal well-being, our
findings point to one fruitful approach to customizing interventions and thus improving their capacity for tackling pressing policy challenges.

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References


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