Title

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Journal

Pediatrics, 148(2)

ISSN

0031-4005

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Publication Date

2021-08-01

DOI

10.1542/peds.2020-048413

Peer reviewed

Patient Portal Reminders for Pediatric Influenza Vaccinations: A Randomized Clinical Trial

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abstract

OBJECTIVES: In a large health system, we evaluated the effectiveness of electronic health record patient portal reminders in increasing pediatric influenza vaccination rates.

METHODS: We conducted an intention-to-treat randomized clinical trial of 22 046 children from 6 months to <18 years of age in 53 primary care practices. Patients (or parent and/or proxies) who were active portal users were randomly assigned to receive reminder messages framed as gains or losses or no messages. They were separately randomly assigned to receive a precommitment message before the influenza season. The primary outcome was receipt of ≥1 seasonal influenza vaccinations. Additionally, children 6 months to <3 years of age due for a second influenza vaccine were randomly assigned to receive a reminder or no reminder for the second vaccination.

RESULTS: First-dose influenza vaccination rates were 56.9% in the control group, 58.0% in the loss-frame reminders group ($P = .07$), and 58.0% in the gain-frame group ($P = .47$). Rates were 58.3% in the precommitment group versus 57.0% in the control group ($P = .11$). Adjusted risk ratios for first vaccination were 1.02 (95% confidence interval [CI]: 1.00–1.04) for loss-frame reminders, 1.01 (95% CI: 0.98–1.05) for gain-frame reminders, and 1.02 (95% CI: 1.00–1.04) for precommitment messages versus controls. Second-dose vaccination rates were 44.1% in the control group and 55.0% in the reminder group, with an adjusted risk ratio of 1.25 (95% CI: 1.07–1.45).

CONCLUSIONS: Patient portal reminders for influenza vaccines in children, whether framed as gains or losses, did not increase first-dose influenza vaccination rates but were highly effective for the second dose of the vaccine.

Full article can be found online at www.pediatrics.org/cgi/doi/10.1542/peds.2020-048413

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WHAT'S KNOWN ON THIS SUBJECT: Reminder and recall interventions by using mail, text, or telephone can increase influenza vaccination in children, but they are not widely used. Electronic health record patient portals offer a promising new channel for these interventions, but their effectiveness is untested.

WHAT THIS STUDY ADDS: Within a large health system, a randomized clinical trial of reminder messages incorporating behavioral science principles did not reveal significant increases in first-dose seasonal influenza vaccination rates in children, but it did reveal large increases in second-dose vaccination rates.

To cite: Lerner C, Albertin C, Casillas A, et al. Patient Portal Reminders for Pediatric Influenza Vaccinations: A Randomized Clinical Trial. *Pediatrics.* 2021;148(2):e2020048413

Nearly 1 in 10 children suffer from seasonal influenza annually,[1] with 7000 to 26 000 annual hospitalizations[2] and 95 to 188 deaths[3] reported in US children in the 2015–2016 through 2019–2020 seasons. Annual influenza vaccination is recommended for all US children >6 months of age.[4] However, rates for influenza vaccination remain lower than other childhood vaccinations,[5,6] ranging from 76% for children <5 years of age to 53% for adolescents in the 2019–2020 season.[7]

Reminder and recall systems have been shown to increase pediatric immunization rates. In a Cochrane review of reminder and recall for immunization in which 5 studies of childhood influenza vaccinations were included, 4 of which were in high-risk groups, researchers noted increases in childhood immunization rates using reminder methods such as letters, postcards, or telephone autodialer calls.[8] Studies of centralized reminders from state registries have revealed, at best, modest effectiveness.[9,10] Limited resources and staff remain major barriers to implementing evidence-based interventions[11] in busy primary care practices.[12,13]

Patient portals, which link providers and families via the electronic health record (EHR), offer a promising channel for reminder and recall for vaccinations. Use of the patient portal has grown in recent years, with an estimated 41% of patients joining patient portals in the 2019 Health Information National Trends Survey[14] and further growth since the coronavirus disease 2019 pandemic.[15] Patient portal reminders present several potential advantages for reminder and recall for health systems, including a low cost of implementation, a message coming from the patient's own doctor, and direct linkages to the patient's medical record. However, in a randomized clinical trial of patient reminders for influenza via the patient portal by our group during the 2018–2019 season, researchers found that generic patient portal reminders sent to pediatric and adult primary care patients were not effective in increasing influenza vaccination rates.[16] To improve on these results, in this study, we sought to use more targeted messages, including specific messaging for pediatric patients, and principles from behavioral science to enhance message persuasiveness.

Behavioral science provides insights into factors that influence human decisions, and strategies using these principles have the potential to improve health outcomes.[17,18] We incorporated evaluation of 2 such strategies in this study, the framing of messages as either gains or losses[19] and use of precommitment to increase the likelihood of vaccination. In a meta-analysis of comparisons of gain-frame versus loss-frame messages to promote vaccinations for all ages, researchers found evidence suggesting that parents may be more persuaded by loss-frame appeals.[20] The concept of commitment is based on the principle that individuals seek to maintain a consistent and continuous self-image, so precommitting to a course of action increases the likelihood of carrying it out.[21]

We also sought to evaluate reminders for the second pediatric vaccination dose. Children <9 years of age are recommended to receive a second influenza vaccination if they have not received at least 2 influenza vaccinations in previous seasons.[2] We hypothesized that reminders for the second dose of the vaccine may be particularly effective because these reminders target a group who have already demonstrated interest in receiving the influenza vaccine.

METHODS

Study Design

The study was conducted from October 1, 2019, to March 31, 2020. We evaluated 3 interventions in an intention-to-treat randomized clinical trial of 22 046 patients ages 6 months to <18 years randomly assigned within primary care practices:

1. Reminders for the first influenza vaccine. Patients were randomly assigned to 1 of 3 study arms: no reminder (n = 7391), 3 gain-frame reminders (n = 7318), or 3 loss-frame reminders (n = 7337).
2. Precommitment message. Patients were randomly assigned to 1 of 2 study arms: no precommitment message (n = 10 978) or 1 precommitment message (n = 11 068).
3. Reminders for the second influenza vaccine. Patients ages 6 to <36 months overdue for a second influenza vaccine were randomly assigned to 1 of 2 study arms: no reminder (n = 347) or 1 reminder (n = 342).

The University of California, Los Angeles, (UCLA) Institutional Review Board approved this study and issued a waiver of patient consent. This study followed the Consolidated Standards of Reporting Trials reporting guideline for randomized clinical trials.

Study Participants

P arents or guardians of patients <12 years of age can register for proxy access to their child's myUCLAhealth (Epic Systems Corporation, Verona, WI) portal. Adolescents 12 to <18 years can register for full access to the portal, and their parents or guardians can register for limited proxy access. We previously reported on the portal usage by adolescents and proxies in our health system.[22] The pediatric

study was conducted as part of a larger set of interventions that included both children and adults. For this study, we included all UCLA Health pediatric primary care patients, defined as children from the age of 6 months to <18 years with ≥2 primary care physician visits (by evaluation and management office codes) within 3 years or ≥1 primary care physician visits with a preventive service code within 1 year. We also included managed care patients assigned to UCLA Health (regardless of the number of previous visits) because their assignment established their primary care affiliation with the practice. Finally, we identified active portal users, defined as patients or proxies who signed up for and logged into the portal at least once during the previous 12 months, not including the initial portal login (Fig 1).

Study Setting

The setting was all 53 UCLA primary care practices.

Intervention

Patients randomly assigned to receive a portal message were sent a notification by e-mail or text (per patients' portal preference settings) informing them that "a message from your doctor" had been posted on the portal. For patients ≥12 years of age, messages were sent to both the patient and parent and/or proxy. Patients and proxies had to login to the portal to read the message.

The portal reminder message contents were grounded in the health belief model and principles of health literacy[23,24] as well as incorporating behavioral science principles.[17–21] The messages were in English, included the name of the patient's primary care physician, and had a below–seventh-grade reading level per Flesch-Kincaid analysis.

Gain-frame messages described the positive consequences of receiving an influenza vaccine, whereas loss-frame messages described the negative consequences of not receiving a vaccine. All messages incorporated additional behavioral science principles including scarcity[21] (eg, "time is running out"), appeal to authority ("UCLA doctors and the American Academy of Pediatrics strongly recommend"),[21] and commission[25] ("choosing to vaccinate"; Table 1). Patients in the reminder message groups received 1 message per month (October, November, and December) if their EHR indicated that they were still due for an influenza vaccine. The messages also included a questionnaire allowing patients to report whether they had received an influenza vaccine outside of the UCLA Health system.

Those in the precommitment intervention group received a message in September prompting them to answer a question to let

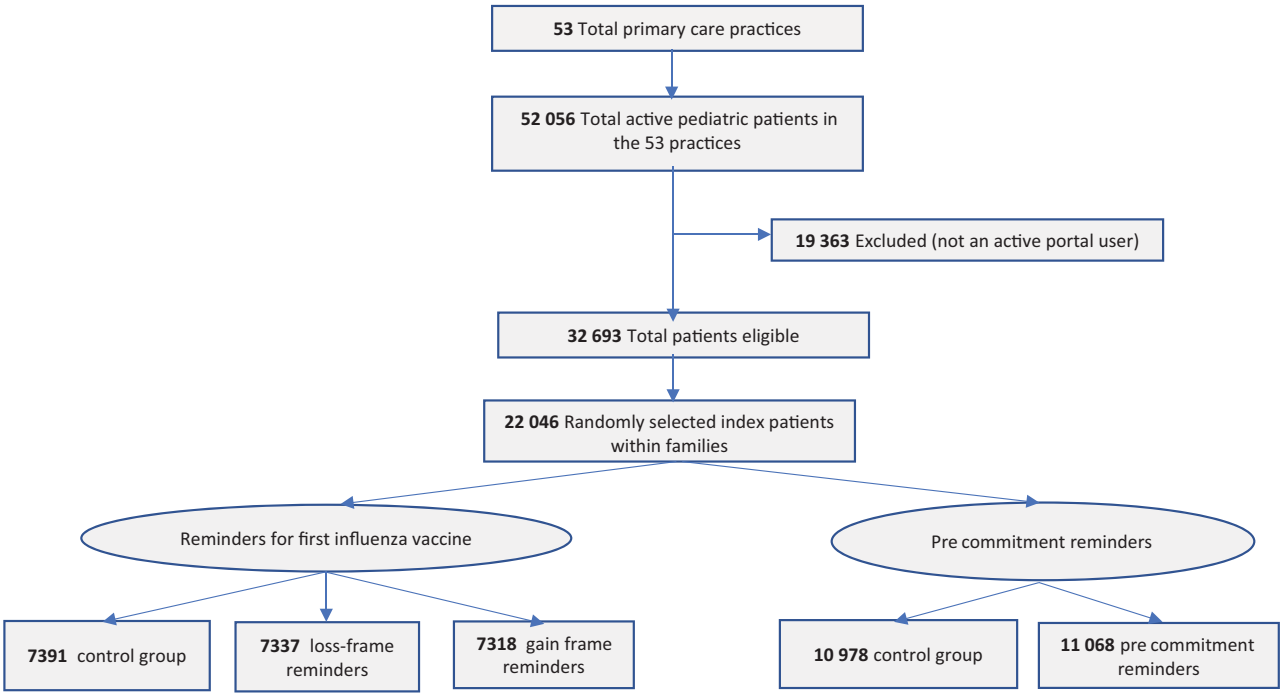

FIGURE 1
Consolidated Standards of Reporting Trials flow diagram. Patients were eligible for study participation if they were 6 months to <18 years of age at the start of intervention, a primary care patient within UCLA Health, and an active patient portal user (≥1 login during the past 12 months, other than initial account login).

TABLE 1 Text of Body of First Gain-Frame Reminder, First Loss-Frame Reminder, and Precommitment Letters

	Excerpt of message text
Gain-frame, first of 3 reminders	Time is running out to maximize the benefit of (patient's first name)'s flu vaccine. Call (his or her) doctor to set up an appointment as soon as possible, before flu season arrives. UCLA doctors and the American Academy of Pediatrics strongly recommend that all children should get the flu vaccine each year. Choosing to vaccinate (patient's first name) this season increases (his or her) chances of staying healthy and is the best way to protect (him or her) from being sick or being hospitalized from the flu. Call us to make an appointment or click here to request an appointment online.
Loss-frame, first of 3 reminders	Time is running out to maximize the benefit of (patient's first name)'s flu vaccine. Call (his or her) doctor to set up an appointment as soon as possible, before flu season arrives. UCLA doctors and the American Academy of Pediatrics strongly recommend that all children should get the flu vaccine each year. Choosing not to vaccinate (patient's first name) this season increases (his or her) chance of getting sick or being hospitalized from the flu. Call us to make an appointment or click here to request an appointment online.
Precommitment letter and question	The flu season is nearing, and we are interested in knowing your plans regarding flu vaccination for your child. Please let us know by answering the attached question. Are you planning to have your child get the flu vaccine this season? (Yes, no, or not sure) We recommend that you get your child the flu vaccine early. Take action today, such as scheduling a visit to their doctor's office or adding a reminder to your calendar.

their provider know whether they were planning to get an influenza vaccine during the upcoming influenza season (Table 1).

For the reminders for the second dose of the influenza vaccine, we included only patients 6 to <36 months old and not 3 to 8 years old, because of concern that the health system medical records might be missing influenza vaccinations from previous years administered outside of our health system. Patients 6 to <36 months of age eligible for a second influenza vaccine who had no record in the EHR of a second influenza vaccination by January were randomly assigned to 2 groups: a single reminder message sent in January or no reminder message.

Patient Characteristics

P atient factors, obtained from the EHR, included age, sex, insurance at the last primary care visit, race and ethnicity, and receipt of ≥1 influenza vaccinations during the previous 2 years.

Influenza Vaccination Data

Influenza vaccinations administered at any UCLA Health site were recorded in the EHR. In addition, UCLA Health practitioners could enter vaccination records manually for vaccines received outside UCLA Health. The UCLA Health system merges data into the EHR from external sources, including Surescripts (pharmacy benefits manager), the California Immunization Registry, and Care Everywhere (Epic's information exchange application). Patients or proxies could also enter vaccination data when they logged in to the portal or via a link included in the portal reminder letters.

Outcome and Process Measures

Primary Outcome

The primary study outcome was documentation in the EHR of ≥1 influenza immunizations, whether from internal health system sources or merged external sources, between October 1, 2019, and March 31, 2020. To eliminate bias in outcome ascertainment, the primary analysis excluded vaccination only reported by patients or proxies in response to portal reminders because the control group did not have this prompt to self-report.

Secondary Outcomes

We assessed secondary outcomes related to the receipt of ≥1 influenza vaccinations during the season: (1) vaccinations in predetermined subgroups (age, sex, insurance, and receipt of influenza vaccination in previous 2 years) and (2) vaccination rates including self-reported vaccinations.

An additional secondary outcome was the documentation in the EHR of 2 influenza immunizations by April 1, 2020, for eligible patients 6

to <36 months old that had not completed the second immunization by January.

Process Metrics

We assessed the percentage of patients who opened the portal reminder letters and source of influenza vaccination data.

Sample Size and Power Calculations

The sample size of 7349 per reminder arm for the first influenza vaccination provided 80% power to detect a 2.6% increase in vaccination rates at a 0.025 2-sided significance level. A sample size of 11 023 per precommitment arm provided 80% power to detect a 1.9% increase in vaccination rates at a 0.05 2-sided significance level. These calculations assumed a control group vaccination rate of 50% (most conservative) and a Pearson's χ^2 test.

We anticipated that the study would be underpowered to detect changes in the second vaccination rates because of small sample size, so we considered this an exploratory outcome.

Randomization and Blinding

We identified the primary care practice most recently visited and attributed the patient to that practice. W e grouped patients into family units using a matching algorithm that included each patient's telephone number, address, and insurance member number or patient guarantor identification. A statistician (S.V.) randomly selected 1 index patient per family for inclusion in the analyses. These patients were randomly assigned within practices to each of the study arms. Other study personnel were blinded to the patient allocation. The final sample comprised 22 046 (42.4%) of the 52 056 UCLA Health pediatric primary care patients.

Statistical Analysis

We report descriptive statistics for all patient characteristics in terms of frequency distributions for the full patient sample, stratifying by study arm. In the primary analysis, we compared vaccination rates between study arms using mixed-effects Poisson regression with robust SEs.[26,27] The model included fixed effects for reminder arm (no reminder versus gains-framing versus loss-framing), precommitment arm (no precommitment versus precommitment), random practice effects, and adjustment for patient characteristics (age, sex, insurance, and vaccination history). Race and ethnicity were not included as covariates in any of the analyses because of concerns about the completeness and accuracy of these data in the EHR. Differences between study arms were summarized by using risk ratios and 95% confidence intervals (CIs). Stratified analyses were performed by refitting the model within subgroups defined by patient characteristics.

For the second vaccine-dose reminder intervention, a similar modeling approach was used. In this analysis, no adjustments were made for clustering by practice, given the small sample size, and the analysis did not adjust for vaccination history because of the sample being limited to young children.

A significance level of 0.025 was used for comparing each of the reminder arms with the no-reminder arm in the primary analysis (twofold Bonferroni correction), and a significance level of 0.05 was used for all other analyses. All analyses were performed by using SAS statistical software, version 9.4 (SAS Institute, Inc, Cary, NC).

RESULTS

A total of 22 046 patients were randomly allocated to 1 of 3 groups in the first-dose vaccine reminders and 1 of 2 groups in the precommitment message reminders. For the second-dose vaccine reminders, a total of 698 patients were randomly assigned to treatment or control groups.

A total of 27.0% of patients and proxies in the first vaccine reminder group opened at least 1 reminder letter, 15.0% opened at least 2, and 9.7% opened all 3 letters. A total of 6.9% patients and proxies opened the precommitment letter.

Patient Characteristics

In Table 2, we provide demographic characteristics in each of the study arms.

First Influenza Vaccination Dose

Across all patients, the vaccination rates for ≥1 influenza vaccines, excluding self-reported vaccinations, were 56.9% in the control group (no reminders), 58.0% in the loss-frame reminders group ($P = .07$), and 58.0% in the gain-frame reminder group ($P = .47$). For the precommitment message intervention, vaccination rates were 57.0% in the control group (no reminders) and 58.3% in the precommitment message group ($P = .11$).

Adjusted risk ratios were 1.02 (95% CI: 1.00–1.04) for the loss-frame reminders, 1.01 (95% CI: 0.98–1.05) for the gain-frame reminders, and 1.02 (95% CI: 1.00–1.04) for the precommitment messages (Table 3).

Second Influenza Vaccination Dose

Among eligible 6- to <36-month-old infants, second-dose vaccination rates were 44.1% in the control (no reminder) group ($n = 347$) and 55.0% in the reminder group ($n = 342$), with an adjusted risk ratio of 1.25 (95% CI: 1.07–1.45), revealing a

TABLE 2 Demographic Characteristics of the Study Sample, Number of Patients (Percent of Category)

	All Children	No Reminders	Loss-Frame Reminders	Gain-Frame Reminders	No Precommitment	Precommitment
Total	22 046	7391	7337	7318	10 978	11 068
Age, *n* (%)						
6 to <36 mo	5640 (25.6)	1889 (25.6)	1820 (24.8)	1931 (26.4)	2857 (26.0)	2783 (25.1)
3–9 y	7817 (35.5)	2601 (35.2)	2663 (36.3)	2553 (34.9)	3878 (35.3)	3939 (35.6)
9–17 y	8589 (39.0)	2901 (39.3)	2854 (38.9)	2834 (38.7)	4243 (38.7)	4346 (39.3)
Female, *n* (%)	10 838 (49.2)	3648 (49.4)	3637 (49.6)	3553 (48.6)	5319 (48.5)	5519 (49.9)
Insurance, *n* (%)						
Private	20 208 (91.7)	6785 (91.8)	6692 (91.2)	6731 (92.0)	10 053 (91.6)	10 155 (91.8)
Public	1517 (6.9)	495 (6.7)	532 (7.3)	490 (6.7)	764 (7.0)	753 (6.8)
Other or unknown	321 (1.5)	111 (1.5)	113 (1.5)	97 (1.3)	161 (1.5)	160 (1.4)
Race, *n* (%)						
White	9098 (41.3)	3071 (41.6)	3009 (41.0)	3018 (41.2)	4563 (41.6)	4535 (41.0)
Black	868 (3.9)	281 (3.8)	272 (3.7)	315 (4.3)	414 (3.8)	454 (4.1)
Asian	2832 (12.8)	912 (12.3)	994 (13.5)	926 (12.7)	1411 (12.9)	1421 (12.8)
Other or unknown	9245 (41.9)	3126 (42.3)	3061 (41.7)	3058 (41.8)	4588 (41.8)	4657 (42.1)
Ethnicity, *n* (%)						
Not Hispanic or unknown	19 136 (86.8)	6413 (86.8)	6387 (87.1)	6336(86.6)	9522 (86.7)	9624 (86.9)
Hispanic or Latino	2910 (13.2)	978 (13.2)	950 (12.9)	982 (13.4)	1456 (13.3)	1454 (13.1)
Vaccine history, *n* (%)						
≥1 in last 2 seasons	14 044 (63.7)	4689 (63.4)	4697 (64.0)	4658 (63.7)	6930 (63.1)	7114 (64.3)
0 in last 2 seasons	8002 (36.3)	2702 (36.7)	2640 (36.0)	2660 (36.3)	4048 (36.9)	3954 (36.7)

All information was obtained from the EHRs.

large and statistically significant effect for second vaccine reminders (Table 4).

Secondary Analyses and Process Metrics

For subgroups, including age, sex, insurance and previous influenza vaccination, the intervention had small or no effects on influenza vaccination rates (Table 5).

Overall, 10 634 vaccinations (83.7%) were administered within UCLA clinics, whereas 2076 (16.3%) were administered outside UCLA and recorded in external data, such as the California Immunization Registry.

TABLE 3 Unadjusted and Adjusted Risk Ratios for First Annual Influenza Vaccination for Subgroups Versus a Reference Subgroup and for Each Study Group Versus the No Reminder Control Group

	Unadjusted Risk Ratio (95% CI)	Adjusted Risk Ratio (95% CI)
Reminders (reference = no reminder)		
Loss-frame	1.02 (0.99–1.04)	1.02 (1.00[a]–1.04)
Gain-frame	1.02 (0.98–1.06)	1.01 (0.98–1.05)
Precommitment	1.02 (1.00–1.05)	1.02 (1.00[a]–1.04)
Age		
6 to <36 mo	1 (reference)	1 (reference)
3–9 y	0.81 (0.76–0.87)	0.74 (0.69–0.79)
9–17 y	0.72 (0.63–0.81)	0.71 (0.65–0.78)
Sex		
Male	1 (reference)	1 (reference)
Female	0.99 (0.96–1.01)	1.00 (0.98–1.01)
Insurance		
Private	1 (reference)	1 (reference)
Public	0.83 (0.78–0.90)	0.87 (0.81–0.92)
Other or unknown	0.80 (0.66–0.98)	0.86 (0.74–1.01)
Vaccine history		
0 in last 2 seasons	1 (reference)	1 (reference)
≥1 in last 2 seasons	2.44 (2.25–2.64)	2.47 (2.31–2.65)

[a] Value was <1.00 before rounding.

When we included self-reported data about influenza vaccinations, the vaccination rate was 57.0% for controls versus 58.9% for the loss-frame reminder group ($P < .01$) and 58.7% for the gain-frame reminder group ($P = .15$).

DISCUSSION

In this study, we found no significant increases in vaccination rates after portal reminders for the first influenza vaccine, with vaccination rates of 56.9% in the control group (no reminders), 58.0% in the loss-frame portal reminders group ($P = .07$), and 58.0% in the gain-frame reminder group ($P = .47$). Additionally, a portal-based precommitment survey, intended to capitalize on the principle that individuals seek a consistent and continuous self-image, did not significantly increase vaccination rates, with 57.0% receiving ≥1 vaccines in the control group and 58.3% in the precommitment group ($P = .11$). In our previous work, we found limited effectiveness of a generic influenza vaccine reminder.[16] In this study, despite the implementation of a message

TABLE 4 Second Influenza Vaccination Rates Among Children Age 3 to <36 Months Overdue for Second-Dose Influenza Vaccines

	Rate, %	Unadjusted Risk Ratio (95% CI)[a]	Adjusted Risk Ratio (95% CI)[b]
Reminder (n = 342)	55.0	1.25 (1.07–1.45)	1.24 (1.07–1.45)
No reminder (n = 347)	44.1	1 (reference)	1 (reference)

[a] Reminders were sent to patients in intervention group if they were overdue for second influenza vaccination in January.

[b] CIs were not adjusted for clustering by practice because of small sample size, and adjusted model does not include history of influenza vaccination in previous 2 years.

targeted specifically at pediatric patients and the use of additional behavioral science concepts to enhance message effectiveness, the portal reminders for the first influenza vaccine had no significant impact on immunization rates. Some have speculated that loss-frame messages may be more persuasive in the context of childhood vaccinations because they may possibly arouse emotions of guilt or regret in the parent,[20] but we found no significant effect, regardless of framing.

Likewise, the precommitment message did not increase vaccination rates. Plausible reasons for the lack of efficacy include the low percentage (6.9%) of patients and proxies that read the precommitment message and the private nature of the precommitment responses. Commitments that are made publicly, for example, may be more effective, because the individual seeks to avoid reputational damage,[28] a dimension we were unable to incorporate in our intervention.

In a commentary accompanying the article of our previous portal message intervention, the authors applied the Green and Kreuter precede-proceed model for health behavior change to suggest that portal messages may be ineffective if they do not sufficiently address predisposing factors (eg, vaccine hesitancy), enabling factors (eg, access barriers), and reinforcing factors (eg, incentives to pursue vaccination).[29] These factors may have limited the effectiveness of the interventions presented here as well. With our interventions, we did not directly address vaccine hesitancy. With recent nationally representative samples of US parents, researchers found high levels of hesitancy for influenza vaccines, ranging from 20% to 25%.[30,31] Addressing hesitancy directly may be critical in increasing influenza vaccination rates. With our findings, we suggest that efforts that focus solely on optimizing and reframing the portal message itself are probably not sufficient to increase message effectiveness.

In contrast to the modest efficacy of vaccine reminders for the first influenza vaccine, the reminders for children overdue for a second dose of the vaccine were highly effective, with second-dose vaccine rates of 44.1% in the control group and 55.0% in the reminder group, with an adjusted risk ratio of 1.25 (95% CI: 1.07–1.45). These messages were sent to a group of parents who were unlikely to be vaccine-hesitant or have insurmountable access barriers, given that their children had already received the first dose of the vaccine. The contrast between the effectiveness of first-dose and second-dose reminders suggests that vaccine hesitancy played an important role in reducing the effectiveness of the first-dose reminders. Second-dose reminders possibly also addressed health

TABLE 5 Influenza Vaccination Rates by Study Group Overall (Primary Outcome) and by Patient Subgroup at the End of the Study Period Excluding Self-Reported Vaccinations

	No Reminders	Loss-Frame Reminders	P[b]	Gain-Frame Reminders	P[a]	No Precommitment	Precommitment	P[b]
All children	56.9	58.0	.072	58.0	.471	57.0	58.3	.110
Age								
6 to <36 mo	71.3	69.0	.258	72.2	.894	70.1	71.6	.098
3–9 y	55.7	58.5	.023	57.8	.108	56.8	57.9	.648
9–17 y	48.6	50.6	.138	48.5	.988	48.3	50.2	.541
Sex								
Female	56.4	58.2	.106	57.5	.498	56.8	57.9	.136
Male	57.5	57.9	.240	58.4	.536	57.2	58.7	.269
Insurance								
Private	57.9	59.3	.060	59.1	.478	58.0	59.5	.073
Public	44.8	45.3	.479	45.7	.375	45.7	44.9	.515
Other or unknown	51.4	44.2	.838	46.4	.953	47.2	47.5	.281
Vaccine history								
≥1 in last 2 seasons	73.6	74.6	.119	73.6	.851	73.6	74.2	.472
0 in last 2 seasons	28.1	28.7	.942	30.7	.221	28.5	29.8	.081

[a] The primary outcome is for first annual influenza vaccine and excluded self-reported vaccinations to avoid ascertainment bias because intervention groups but not the control group received prompts to self-report in the reminder messages.

[b] P values are for differences between the intervention group and the respective no reminders control group.

literacy gaps for parents who, perhaps, did not know about the need for a second influenza vaccine. In a study of text message reminders for the second influenza vaccine in a low-income minority population, researchers found increases in rates of the second dose of the influenza vaccination, particularly for text messages that specifically addressed health literacy.[32]

Our study has several limitations. As a single health system intervention, it potentially lacks generalizability to other health care systems, particularly those serving larger underserved populations or populations with limited English proficiency. An inherent limitation of portal-based interventions is that they are targeted at only active portal users, narrowing their impact and, potentially, leading to disparities if portal usage varies by demographic group. A notable finding of our study was the low rates of reading of the portal messages, which may be due, in part, to the particular implementation of our intervention but may also reflect a more pervasive challenge for portal interventions. Optimizing portal message reading is an area ripe for further work and may include innovations such as more seamless integration of texting and more robust usability testing.

CONCLUSIONS

In a large health system, patient portal reminders for influenza vaccines in children were ineffective for the first influenza vaccine but highly effective for the second dose of the vaccine. To increase overall pediatric immunization rates, in future strategies using the patient portal, researchers likely need to directly address influenza vaccine hesitancy or include efforts that address other barriers to vaccination.

ACKNOWLEDGMENTS

We are grateful for the expert contributions of the UCLA Health Information Services and Solutions team, in particular, Alexander E. Kurpinski, Ashley E. Turner, Deidre L. Keeves, Desmond Kelly, Eric M. Cheng, and Michael A. Pfeffer.

ABBREVIATIONS

CI: confidence interval
EHR: electronic health record
UCLA: University of California, Los Angeles

This trial has been registered at www.clinicaltrials.gov (identifier NCT04110314).
DOI: https://doi.org/10.1542/peds.2020-048413

Accepted for publication Feb 18, 2021

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FUNDING: Supported by the National Institutes of Health National Institute of Allergy and Infectious Diseases grant 1R01AI135029-02 (Dr Szilagyi: principal investigator) and National Institutes of Health National Center for Advancing Translational Sciences grant UL1TR00188. Funded by the National Institutes of Health (NIH).

POTENTIAL CONFLICT OF INTEREST: Dr Humiston disclosed the following conflicts of interest: her employer receives grant money for work sponsored by the Pediatric Infectious Diseases Society Foundation, a not-for-profit organization. The Pediatric Infectious Diseases Society is funded for the project through unrestricted joint educational grants from Sanofi Pasteur US, Merck & Co., Inc., Pfizer, Inc., GlaxoSmithKline, and Seqirus USA, Inc. She is a consultant to Sanofi Pasteur, 2 universities with federally funded grants (University of Rochester and University of California, Los Angeles), and several not-for-profit organizations (the American Academy of Pediatrics and its chapters, Immunization Action Coalition, and Immunize Kansas Coalition); the other authors have indicated they have no potential conflicts of interest to disclose.

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