A Cluster Randomized Controlled Trial of a Modified Vaccination Clinical Reminder for

Primary Care Providers

Pompa Debroy,[1] Rekha Balu,[1,2] Russell Burnett,[1] Rebecca Johnson,[1,3] Heather Barry Kappes,[1,4]

Joseph Michael Wallace,[5,6] and Vincent C. Marconi[5,6]

[1] Office of Evaluation Sciences, United States General Services Administration

[2] Center for Applied Behavioral Science, MDRC

[3] Dartmouth College

[4] London School of Economics and Political Science

[5] Atlanta VA Health Care System

[6] Emory University School of Medicine and Rollins School of Public Health

Author Note

Correspondence concerning this article should be addressed to Pompa Debroy, Office of

Evaluation Sciences, United States General Services Administration, 1800 F Street NW,

Washington DC. Email: pompa.debroy@gsa.gov.

Abstract

Objective: Adult vaccination rates in the United States fall short of national goals, and rates are particularly low for Black Americans. We tested a provider-focused vaccination uptake intervention: a modified electronic health record clinical reminder that bundled together three adult vaccination reminders, presented patient vaccination history, and included talking points for providers to address vaccine hesitancy. Method: Primary care teams at the Atlanta Veterans Affairs Medical Center, who saw 28,941 patients during this period, were randomly assigned to receive either the modified clinical reminder (N = 44 teams) or the status quo (N = 40 teams). Results: Uptake of influenza and other adult vaccinations was 1.6 percentage points higher in the intervention group, which was not statistically significant (CI =   [-1.3, 4.4], p = 0.28). The intervention had similar effects on Black and White patients and did not reduce the disparity in vaccination rates between these groups. Conclusion: Provider-focused interventions are a promising way to address vaccine hesitancy, but they may need to be more intensive than a modified clinical reminder to have appreciable effects on vaccination uptake.

A Cluster Randomized Controlled Trial of a Modified Vaccination Clinical Reminder for

Primary Care Providers

Adult vaccination rates fall substantially short of national goals (Tan, 2015). In the United States in 2017, only about 25% of adults aged 19 and over had received all of the recommended vaccines (Centers for Disease Control and Prevention, 2017). Low vaccination rates have health and economic consequences: vaccine-preventable diseases generated $26.5 billion in healthcare costs in 2013 (McLaughlin, 2013), and even before the COVID-19 pandemic, led to about 42,000 adult deaths annually in the United States (Office of Disease Prevention and Health Promotion, 2020).

Shortfalls in vaccination also reflect and contribute to health disparities across racial and ethnic groups. In the 2016 National Health Interview Survey, for instance, influenza vaccination coverage was 46% for non-Hispanic White adults, 33% for Hispanic adults, and 40% for non-Hispanic Black adults (Lu et al., 2019). One contributing factor may be provider fatigue. Fatigue, stress, and time pressure increase the influence of racial stereotypes (Burgess, 2010), which could lead some providers to make less compelling vaccination offers to Black and Hispanic patients whom they expect to decline vaccination anyway.

Most prior studies testing encouragements for vaccination used patient-focused interventions (Brewer, Chapman, et al., 2017; Thomas & Lorenzetti, 2018), rather than provider-focused interventions that could address provider fatigue. Provider-focused interventions need not replace patient-focused ones; they can be used in a complementary way to capitalize on the role of health care providers in creating easy vaccination opportunities and serving as critical messengers of the protective benefits of vaccines. Provider-focused interventions may create large returns on an intervention "investment," since each provider sees many patients and can provide multiple vaccinations during a single appointment in a way that is more difficult for a workplace vaccination drive or other non-clinical setting. Provider-focused interventions might

also help reduce racial disparities in vaccination by addressing the provider fatigue that could exacerbate stereotyping and reduce the quality of care given to Black and Hispanic patients.

The present study addressed these issues by developing and testing a multi-pronged provider-focused intervention. We first identified the mechanisms by which providers could address patient vaccine hesitancy (e.g., taking time, having accurate information, using persuasive language). We then considered the elements of an Electronic Health Records (EHR) system that should be in place to support those mechanisms (e.g., streamlined reminders, simple dashboard, language prompts), and redesigned an EHR clinical reminder to incorporate those elements. We evaluated the modified clinical reminder in a randomized controlled trial in a federal health care setting, a Veterans Administration Medical Center (VAMC).

Healthcare Providers and Vaccine Hesitancy

Practice and field guides from the Centers for Disease Control and from state and city departments of health have highlighted the role of providers in creating and expanding opportunities for vaccination. Providers who capitalize on patient contact at a regular clinic appointment or emergency room visit to offer vaccines can address patient uncertainty and overcome patient inertia related to making and attending appointments. Official guidance encourages clinical practice scheduling structures that standardize provider vaccination delivery (Advisory Committee on Immunization Practices, 2000).

In addition to creating opportunities for vaccination with scheduling structures, primary care providers also can use multiple behavioral and relational channels to address vaccination concerns. One of these channels is taking time to hear patient concerns, which can build empathy and mutual trust in a patient-focused clinic setting, increasing the likelihood that patients accept a vaccination recommendation. A second channel is discussing and distributing accurate information to address any questions and misconceptions. Providers can serve as trusted or credible messengers on topics where patients feel uncertain or confused. A third channel is using persuasive language to set social norms. Persuasive language can include

standardizing what doctors say about vaccination during appointments, specifically how they make vaccination recommendations and offers during a patient visit.

Vaccination recommendations and offers are, not surprisingly, associated with completed vaccinations. A survey study found that when patients reported that their provider recommended and offered the flu vaccine, they were 1.76 times more likely to be vaccinated (Benedict et al., 2017). Even those who reported a provider recommendation alone (no offer) were 1.72 times more likely to be vaccinated. A qualitative study showed that nearly all vaccinated respondents reported that their physicians recommended influenza vaccination, compared with 63% of unvaccinated respondents. The authors concluded "older patients need intentional messages from physicians that recommend vaccination" (Zimmerman et al., 2003). More recent research focuses on the framing of the provider-patient interaction, and indicates that vaccination uptake is higher when health care providers use "presumptive language" to tell patients that they are due for and will be receiving vaccines, rather than using participatory conversational language to ask patients if they would like to receive a vaccine (Jacobson et al., 2020). Both observational (Hofstetter et al., 2017; Opel et al., 2018) and intervention (Brewer, Hall, et al., 2017; Dempsey et al., 2018) studies of parents with children due to receive vaccines have shown that presumptive language increases vaccination uptake. When doctors are given talking points or a script, their use of presumptive language becomes more concrete and consistent.

However, there may be several barriers for providers to implement these strategies, even among those who want to. One barrier is provider caseload and associated fatigue. Having many appointments during a day can lead to fatigue; providing subsidized care to a vulnerable population is associated with provider fatigue and burnout (Friedberg et al., 2017). One prior study noted that although the Centers for Disease Control recommends that providers offer an influenza vaccine during clinic visits, as physicians become fatigued or fall behind schedule, they may—intentionally or unintentionally—make a less compelling offer, or no offer

at all. This hypothesis was supported by data showing that vaccination rates were significantly lower among patients seen later in the day than earlier in the day (Kim et al., 2018). A second barrier is the role of EHR systems, which can both increase and decrease burdens on providers. Although designed in part to support consistent practice via reminders and checklists, EHRs also can create information overload. Providers must navigate multiple dialog boxes and tabs or windows to record actions taken for their patients. Fielding multiple reminders from an EHR during a relatively short appointment may prompt providers to tune out reminders or stop short of delivering full information. Many providers find it challenging to manage a multitude of reminders from an EHR during an appointment (Phansalkar et al., 2013). These challenges were substantiated in the initial discovery work we conducted to inform the design of our intervention. VAMC providers we spoke with reported being tired of dealing with vaccination challenges and wishing for a structure to address their patients' multiple concerns.

A third barrier in a large hospital or clinic setting like a VAMC is differences in domain knowledge about vaccination. Many VAMCs have high turnover and staffing challenges (U.S. Government Accountability Office, 2017), which means that doctors and nurses are entering clinic settings with varying degrees of experience discussing vaccination with the VA patient population. Those with less experience might benefit more from changes that help them effectively and efficiently recommend vaccination (Mrkva et al., 2021).

An underlying contextual factor that moderates vaccination take-up is the persistence of racial disparities. These disparities show up even among patients with similar socioeconomic status who are treated at the same healthcare facilities. For example, after adjusting for a series of covariates, non-Hispanic Black Veterans at VA clinics were less likely to be vaccinated for influenza than non-Hispanic White Veterans at the same clinics (75% versus 81%) (Straits-Tröster et al., 2006). If some of the racial vaccination gap is due to differences in knowledge (e.g., about rates of side effects), then EHR changes that encourage providers to share information across all patients equally and to recommend vaccination might reduce the racial

disparity in vaccination rates. The racial vaccination gap may additionally or alternatively be due to lower trust between doctors and Black patients, given a history of unequal treatment and in some cases mistreatment by the medical establishment. Building trust may require closer attention from a provider (to hear patients' valid concerns), or more tailored use of persuasive language that discusses benefits more than social norms. EHR changes that create time for closer attention and that prompt the use of persuasive language may also help reduce the racial disparity in vaccination rates.

The Present Research

Following the reasoning outlined above, we created an intervention with three key elements (Figure 1). First, to address provider time constraints and overload in fielding multiple clinical reminders, we modified the clinical reminder so that it bundled together the clinical reminders for three adult vaccines—Influenza, Pneumococcal, and Tdap (Tetanus, Diphtheria, Pertussis)—thereby decreasing the overall number of reminders displayed. In the status quo condition, these reminders were presented separately, the default setup in the EHR system. Bundling the reminders was expected to free up providers' time and attention as compared to the status quo. Second, we addressed an informational and procedural barrier identified in our initial discovery work. That work demonstrated that a patient's full vaccination history was not easily visible on the primary dashboard, and some providers resorted to time-consuming workarounds to understand and communicate vaccination history to other providers. We modified the EHR to present a dashboard relaying patient vaccination history and status. This change was expected to prevent providers from needing to compile fragmented information about vaccines from the patient's records   , further freeing up time and attention, as well as highlighting the need for vaccinations at the current appointment.

The third and final element of the intervention was designed to address patient uncertainty related to vaccination by providing structured scripts for the use of presumptive language. Presumptive communications present vaccination as the default behavior, leveraging

the strong effects of defaults on decisions (Jachimowicz et al., 2019) while preserving patients'

freedom to decline. The bulk of research on this language, outlined above, pertains to parents

deciding about their children's vaccinations. There is less evidence to date that presumptive

language has the same effect on adults deciding about their own vaccinations. However, given

the public health campaigns present at a VA facility for vaccination, cancer screening, and other

preventive health measures, we speculated that the veteran population might be accustomed

and responsive to presumptive communication. In light of this context and considering the

promising results with childhood vaccination, we incorporated a prompt to use presumptive

language into the provider-intervention. We also included structured talking points providers

could use to address specific forms of patient uncertainty or refusal. This content made it easy

for providers to give   personalized responses, which are typically more effective than generic

ones (Teeny et al., 2021) to patients with different forms of vaccine hesitancy. With these

combined elements, our EHR modification went beyond the simple EHR vaccination reminders

that increased influenza vaccination rates for children in winter by about five percentage points

(Stockwell et al., 2015). Our intervention also addressed recent suggestions to ensure that

provider nudges go beyond mere reminders and were embedded in existing workflows to

become part of standard practice (Patel et al., 2017).

----------Insert Figure 1 here----------

We embedded our intervention in an EHR, the computerized patient record system, that

facilitates care coordination at the VAMC by providing centralized access to patient information

and reminders about appropriate services, while tracking billable services delivered during a

patient appointment (O'malley et al., 2010). The VA health care system is a uniquely valuable

setting to study vaccination uptake interventions and particularly to ask whether those

interventions could reduce racial disparities in vaccination rates. About 42% of Veterans in the

US (8.4 million individuals) are enrolled in VA healthcare (U. S. Veterans Health Administration,

2020); they have lower incomes (Dursa et al., 2016) and are older on average than the general

population, leaving them at higher risk of complications and death from influenza (Young-Xu et al., 2017). After the implementation of quality-improvement measures in the mid-1990s, patients at VA clinics were more likely to have received influenza and pneumococcal vaccinations than comparable community-dwelling adults (Jha et al., 2007). However, vaccination rates for Veterans are still typically below national goals (Boersma et al., 2022), making this group an appropriate target for intervention. Moreover, the VAMC in the present research has   a patient base which is over 50% Black. This racial distribution contrasts with other large-sample tests of vaccination "nudges" where the majority of participants are White (Milkman et al., 2021).

Methods

Intervention

The intervention introduced a modification to the current version of the EHR interface with three elements. First, the clinical reminders for three adult vaccinations (Influenza, Pneumococcal, and Tdap) were bundled into one clinical reminder. Second, the bundled reminder included a dashboard providing an overview of patient vaccination history and those vaccines due for each patient. And third, it presented talking points providers could use to address patient uncertainty or refusal of the vaccine(s), prompting presumptive language (Jacobson et al., 2020) with the instructions: "Use language that assumes the patient will get vaccinated - 'It is time for your X shot(s) today'." (See Figure 1.) Vaccination-related activities were in one place in the EHR, but providers still had to click to additional dialog boxes to open patient-specific information, as in the status quo.

Participants and Design

Patients who receive primary care at the Atlanta VAMC are assigned to teams of providers known as patient-aligned care teams (PACTs), and a typical appointment includes interaction with both an intake nurse and a provider from a single PACT, both of whom interact with EHR clinical reminders and potentially communicate with patients about vaccinations. To minimize treatment spillover both across and within appointments, we randomized PACTs as

clusters to receive either the intervention or the status quo EHR reminders. A small number of PACTs shared doctors or nurses, and these were combined into single clusters for randomization to prevent treatment spillover. In all, 96 provider clusters were assigned to the intervention and control conditions by simple randomization   , and 84 of these went on to treat patients who were due for at least one vaccine during the trial period, with the remaining 12 either being absorbed into other PACTs or dissolved before they treated patients in the study window. Of the 84 clusters, 44 were assigned to the intervention and 40 to the control condition. Figure 2 shows a CONSORT diagram outlining this process (see also Supplementary Materials Section 1). The control condition involved the status quo standard unbundled clinical reminders for the Influenza, Pneumococcal, and Tdap vaccines, presented without the vaccination history dashboard or talking points.

----------Insert Figure 2 here----------

The relevant Institutional Review Board determined that this study   was   a Quality Improvement project and exempt from review. Given the nature of the project, providers were not asked to consent, but they were notified that they would be participating in an EHR change while some of their colleagues would not be included, and were provided a primer on the changes and instructions on how to use the modified clinical reminder. The Atlanta VAMC implemented the intervention to the selected PACTs between October 2018 and April 2019, and these teams saw 28,941 unique patients during this period. Basic patient demographics by condition are in Table 1.

----------Insert Table 1 here----------

The project was initially designed to detect a difference of 5.5 percentage points in vaccination rates between the intervention and control conditions, but, due to more within-cluster correlation in vaccination rates than expected, the de facto power was lower than the initial assumptions (Supplementary Materials Section 3).

Data

EHR data were used and included whether a patient received each of the three vaccines (Influenza, Pneumococcal, or Tdap) at each primary care visit during the trial period, the date received, and the associated PACT. The data also contained information that enabled inferences about whether the patient was due for each vaccine at a visit (specifically, the most recent date the patient received each vaccine prior to the visit, which could be combined with age and other information to infer whether the patient was due). The data also included individual patient characteristics, such as age, gender, race, and rurality. There was no information about provider age, gender, or race.

Statistical Analysis

Outcomes included patient receipt of influenza vaccination and patient receipt of any one of the three vaccinations (Influenza, Pneumococcal, Tdap). We separately analyzed the first appointment for each patient when a vaccine was due (first appointment per patient during the trial period) and then combined across all the appointments where the vaccine was due (all appointments per patient). A time-stamped analysis plan created prior to receipt of the data is located at [link removed for blind review]. The Supplementary Materials have more details on the statistical methods, which include clustering of standard errors at the unit of randomization (a PACT cluster) to adjust inference for within-team correlations in patient outcomes.

<div align="center">

Results

</div>

Main effect of intervention

First, we examined whether the EHR modification increased influenza vaccinations. For the analysis of the first appointment, the raw proportion of vaccination was directionally higher among patients who saw primary care teams in the intervention group than patients who saw teams in the control group (22.3% versus 20.8%), although not statistically significant. When accounting for demographic characteristics and the clustering of patients within respective care teams, we observed a statistically insignificant difference of 1.6 percentage points (pp) between the treatment and control groups on first appointment influenza vaccination rates (the 95% CI on

this regression coefficient ranged from -1.3 pp to 4.5 pp, *p* = 0.28   ). For the analysis of all

appointments, we also saw a statistically insignificant difference in influenza vaccination rates

with a 95% confidence interval of -1.3 pp to 4.5 pp around the regression coefficient,   *p* =

0.29   .

Second, we examined whether the EHR modification increased vaccinations for any of

the three target vaccines (Influenza, Pneumococcal, or Tdap). We defined this outcome as

having received any of the three vaccines, among patients who were due for that vaccine. Like

for influenza alone, unadjusted vaccination rates for any of the three vaccines were higher

among patients who saw primary care teams in the intervention group than in the control group

(20.5% compared to 19.0%). However, as with influenza alone, these differences were not

statistically significant after adjusting for demographic characteristics and patient clustering

within care teams, or when we analyzed outcomes for either the first appointment when a

patient was due (estimated effect = 1.5 percentage points, 95% CI = [–1.0 pp, 4.0 pp], *p* = 0.29,

) or all appointments when they were due (estimated effect = 1.6 percentage points, 95% CI = [-

1.2 pp, 4.4 pp], *p* = 0.26,   ). Results for the first appointment are presented in Table 2 and

visualized in Figure 3.

-----------Insert Table 2 here----------

----------Insert Figure 3 here----------

Focusing on influenza vaccination, in Supplementary Materials Section 4.3, we examine

the significance of the differences if we: (1) do not adjust for either demographic covariates or

clustering of patients within teams, or (2) adjust for clustering of patients within teams but do not

adjust for demographic covariates. When we   adjust for neither the clustering of patients

within teams nor patient-level demographics, the same point estimate is highly statistically

significant (Table 6, *p* < 0.01). When we adjust for the clustering of patients within teams but do

not adjust for patient-level demographics, we find substantively similar results of 1.5-1.6

percentage point changes that are not statistically significant (Supplementary Materials Tables

2, 4, 7, and 9). However, the clustering approach was pre-registered and accounts for important within-team correlation in patient outcomes.

Heterogeneous effects of intervention

Finally, we looked at whether the EHR modification reduced the gap in vaccination rates between White and Black patients. However, as seen in Figure 4, there were persistently low vaccination rates among Black patients, regardless of their provider's assignment to the treatment, with an 18% vaccination rate in control group Black patients compared to a 24% rate among white patients, and a 20% vaccination rate among intervention group Black patients compared to a 26% rate among White patients. As the persistent six percentage point gap in each group shows, the interaction effect of condition by race was neither directionally nor statistically significant (b = -0.01, 95% CI = [-0.05, 0.02], p = 0.55   ).

----------Insert Figure 4 here----------

Supplementary Materials Section 6 explores heterogeneous effects by gender (null) and rurality (borderline significant, possibly reflecting the importance of appointments for far-traveling rural patients).

In an exploratory analysis, we also built upon past research showing that provider fatigue meant that vaccination rates were significantly lower among patients seen later in the day than earlier in the day (Kim et al., 2018). We found similar main effects, with patients seen later in the day for their focal appointment significantly less likely to receive an influenza vaccination (b = -0.008, 95% CI = [-0.01, -0.005], p < 0.001   ). The intervention made some difference in closing these time-of-day differences, but the differences were too small in magnitude to be statistically significant (b = 0.003, 95% CI = [-0.001, 0.007], p = 0.13   ).

While these analyses focus on heterogeneous treatment effects by two individual-level characteristics (patient demographics and appointment time), we also descriptively explore whether certain treatment teams had especially high vaccination rates following the intervention. Supplementary Materials Section 7.2 (Table 14; Figure 9) explores characteristics of high-

vaccination treatment teams; we see that, unsurprisingly, treatment teams with higher

concentrations of male, older, and rural patients have higher vaccination rates, while teams with

higher concentrations of Black patients have lower vaccination rates (Spearman rho correlation

coefficients in Supplementary Materials Table 14). As we note in the limitation section, we

lacked data on team characteristics beyond the characteristics of the patients they treated.

Provider perceptions of the intervention

We spoke with five nurses and one physician following the rollout of the intervention to

understand provider perceptions and reactions to the EHR modification. In most cases, the

participants had forgotten which elements had changed between the versions, indicating that

the modification was normalized and well-accepted. They noted that the altered reminder was

intuitive and easy to use, and one nurse referred to the reminder as a "one-stop shop" for

vaccinations, asking for additional vaccines to be included in the reminder. Given the number of

reminders the providers are used to fielding, it was clear that future reminders should be even

easier to navigate and possibly simpler, to account for the fields the providers regularly used.

The change was mostly recalled as a bundled vaccination reminder, and discussions indicated

the providers did not make use of some of the other features, including the talking points.

Discussion

This study was focused on   promoting and easing vaccine delivery by modifying the

EHR system to streamline providers'   use of clinical reminders and promote effective

communication with patients.   Uptake of influenza and other adult vaccinations was slightly

higher among patients whose providers received the intervention, but the differences   were

not statistically significant. Our data showed both influenza and overall vaccination rates at

VAMC appointments during the study period of only around 20%. This is lower than the

influenza vaccination coverage rate for adults in the United States, which is typically above 40%

(United States Centers for Disease Control, 2020). The low rate we observed may be due in

part to data limitations, discussed in more detail below, and may also point to larger systemic challenges for vaccinating this population.

Black patients had persistently low vaccination rates, and the EHR modification did not reduce the gap for these patients compared to White patients. The fact that there was a racial disparity in vaccination, even within this regional VAMC, replicates previous work (Straits-Tröster et al., 2006). This persistent gap speaks against one potential explanation for the null result. One might argue that racial disparities in vaccination are due solely to differences in education and income, and that the VA population which is more homogenous would not show these disparities. Given that there were racial disparities in both treatment and control groups, that explanation is unlikely.

From our conversations with providers, it appeared that the reminders were accepted, and in some cases mistaken for the status quo. Our few conversations with nurses indicated acceptance of bundling as a tool for fielding multiple related clinical reminders. However, more work needs to be done to assess the effect of these interventions on provider fatigue. The EHR modification was designed to make it easier for providers, assuming they shared this desire, to vaccinate patients. Indeed, the larger effect of the intervention for rural patients (described in Supplementary Materials Section 6), who may typically have lower vaccination rates at VA appointments if they visit the VA less frequently and therefore have more to cover during an appointment, is consistent with this mechanism. Recent research on COVID-19 vaccination found that longer travel distance to a vaccine site predicted less likelihood of vaccination (Mazar et al., 2022), highlighting the role of convenience for vaccination. However, if providers in the present study did not actually have the goal of vaccinating most patients, a different intervention aimed at setting this goal could be more effective.

Our study is not alone in finding that it can be difficult to shift vaccination behavior. The COVID-19 vaccination drive has drawn attention to vaccine hesitancy and to historically rooted racial differences in trust of medical providers. Even effective interventions aimed at patients

have achieved increases in vaccination uptake in the neighborhood of one to four percentage points (Milkman et al., 2011; Yokum et al., 2018). Our effect size estimate, while not statistically significant, falls in the same range. One implication is that provider-focused interventions do not necessarily achieve larger effects on vaccination rates, although a previous EHR basic reminder did increase influenza vaccination rates for children in winter by about five percentage points. However, given the difficulty of increasing vaccination uptake and the importance of doing so, even small changes like the one we observed may be a meaningful foundation for future interventions, especially if combined with patient-directed interventions.

The EHR modification intervention included a prompt to use presumptive language. Several studies have shown this language, when directed at parents, to be an effective way of increasing vaccination uptake for children. The null results of our provider intervention might relate to variation in the provider population, with more experienced providers using their own scripts and ideas (our sample size and limited data on providers did not permit investigation of provider tenure as a moderating factor). Our conversations with providers in the intervention group suggested that many did not actually make use of the talking points or presumptive language. Future research could explore ways to make these prompts more salient, or perhaps to explicitly train providers in the delivery of this messaging, as has been done for childhood vaccinations (Brewer, Hall, et al., 2017; Dempsey et al., 2018). This topic is worth further exploration given that presumptive language is a strategy suggested for COVID vaccination uptake (Centers for Disease Control and Prevention, 2021).

Implications

The intervention fielded in this study incorporates many recommendations and standard practices that health departments are currently proposing to boost COVID-19 vaccination rates. Despite the null results, this study is a useful complement to health systems' use of behavioral science to improve provider or patient experience. The intervention was designed to present information during an appointment, address patient concerns, and help providers deliver better

care. The modified clinical reminder also was designed to reduce the burden providers face in identifying patient vaccination needs and delivering vaccination recommendations. Providers in this intervention could help people set vaccination intentions and follow through on them during one visit; consider multiple vaccinations, when relevant, during a single visit; and consider vaccination as part of an existing clinical appointment rather than a separate visit. It could be that these features did improve the provider experience and reduce provider burden, but that it was not sufficient to boost vaccination rates in this sample. It also could be that asking providers to click through to additional windows or dialog boxes to see patient vaccination information or due dates felt too time-consuming during the appointment. These ideas are relevant for clinics in other VA health centers, other federal health facilities (such as Federally Qualified Health Centers) or other public hospitals that may be serving a designated population.

　　　　Our findings also contribute to research on racial disparities in vaccination, suggesting that interventions meant to improve *overall* vaccination rates do not necessarily reduce these disparities. Providers or health institutions may need to do additional outreach to patients whose vaccination histories and current rates are lower than average. Facilities could use data on which patients declined vaccination in the past to identify those who may need additional outreach and discussion time. A different plan may be needed for those patients, specifically to offer to answer questions or concerns related to vaccination, or perhaps more slowly introduce information before an appointment and build to a vaccination decision with scripts that providers can use during an appointment. Most existing research on presumptive communication was done in younger populations; for older adults like this Veteran population, more work may be needed to refine specific communication messages and overcome vaccine hesitance. Research on the efficacy of motivational interviewing, currently part of CDC guidance, suggests this approach of acknowledging concerns and building solutions together can be helpful. Ideally, this approach can be integrated into existing administrative outreach so that it does not exacerbate provider burden.

Finally, providers and health facilities may want to consider how to reach and target clients differently, using data-driven strategies. Data management systems may need to record more appointment interaction features: experience (patient understanding and reaction), decisions (vaccination or not), and then the reasons for acceptance or refusal decisions (trust in provider, trust in vaccines, not enough time to make a decision, more pressing concern, etc.). Currently EHRs do have discrete fields to record this information, but it is often in open-text fields or with too many categories that end up resulting in inconsistent or missing data across providers. Capturing more nuanced data, but in a standard way that does not increase burden, could allow for more personalization of patient outreach and conversation strategies. It also may be helpful to view the full universe of potential patients and see to what extent patients who show up for appointments are systematically different than those who do not. Additional strategies to boost vaccination rates could include contacting those who do not show up for any appointment, contacting those who have refused in the past, and scheduling longer appointments or other conversation occasions for people who express concerns.

Limitations

We were not able to access EHR data to directly assess whether and how providers interacted with the reminders (click-   through rates), the ease of use (time required to navigate the dashboard), or if providers overall spent more or less time viewing and fielding reminders. We do not have information about the race and ethnicity of providers, so we cannot attempt to replicate findings about racial matching of providers and patients, specifically that providers of a particular race/ethnicity could increase uptake of preventive health services for patients of that same race/ethnicity (Alsan et al., 2019). Indeed, our exploratory analysis of clustering effects suggests that the intervention had more impact on some teams, but we were only able to measure demographics of the patients in the care of those teams and not provider or team-level characteristics. With more data about providers or teams (e.g., team tenure), future research could identify these teams and look to spread their effective practices (Ruggeri & Folke, 2020).

A further limitation of these data is that they do not reliably include   vaccinations that happen

outside the VA (e.g., at pharmacies).. It is possible that the EHR modification—and the provider-

patient interactions it sparked—may have led some patients, after further reflection, to get

vaccinated elsewhere. If vaccinations outside the VA are more common in the intervention

group, then our treatment effect was underestimated.

The intervention was implemented, and vaccinations recorded, from October to April.

Some in the patient pool may have been vaccinated in August or September when influenza

vaccines were initially available. These individuals are probably not the patients most in need of

provider support and encouragement, so we do not see the study timing as a key limitation for

our question of interest.

Conclusion

Encouraging vaccination by focusing on health care providers rather than directly on

patients is a potentially promising way to address low adult vaccination rates and racial

disparities in those rates. Despite this promise, our provider intervention led to a two

percentage-point increase in the uptake of influenza and other adult vaccinations, which was not

statistically significant, and which did not reduce the gap in vaccination rates between Black and

White VA patients. Further work is needed to find effective ways to help providers to vaccinate

more patients.

References

Advisory Committee on Immunization Practices. (2000). *Use of Standing Orders Programs to*

Increase Adult Vaccination Rates.

https://www.cdc.gov/mmwr/preview/mmwrhtml/rr4901a2.htm

Benedict, K. M., Santibanez, T. A., Black, C. L., Ding, H., Graitcer, S. B., Bridges, C. B., &

Kennedy, E. D. (2017). Recommendations and offers for adult influenza vaccination,

2011–2012 season, United States. *Vaccine*, *35*(9), 1353–1361.

Boersma, P., Cohen, R. A., Zelaya, C. E., & Moy, E. (2022). Influenza and Pneumococcal

Vaccination Among Male Veterans and Nonveterans, 2016-2018. *Public Health Reports*,

00333549221081119.

Brewer, N. T., Chapman, G. B., Rothman, A. J., Leask, J., & Kempe, A. (2017). Increasing

vaccination: Putting psychological science into action. *Psychological Science in the*

Public Interest, *18*(3), 149–207.

Brewer, N. T., Hall, M. E., Malo, T. L., Gilkey, M. B., Quinn, B., & Lathren, C. (2017).

Announcements versus conversations to improve HPV vaccination coverage: A

randomized trial. *Pediatrics*, *139*(1).

Burgess, D. J. (2010). Are providers more likely to contribute to healthcare disparities under

high levels of cognitive load? How features of the healthcare setting may lead to biases

in medical decision making. *Medical Decision Making*, *30*(2), 246–257.

Centers for Disease Control and Prevention. (2017). *Vaccination Coverage Among US Adults,*

NHIS. www.cdc.gov/vaccines/imz-managers/coverage/adultvaxview/pubs-

resources/NHIS-2017.html

Centers for Disease Control and Prevention. (2021). *COVID-19 Vaccination Field Guide: 12*

Strategies for Your Community (p. 48). https://www.cdc.gov/vaccines/covid-

19/downloads/covid19-vax-field-guide-12-strategies.pdf

Dempsey, A. F., Pyrznawoski, J., Lockhart, S., Barnard, J., Campagna, E. J., Garrett, K., Fisher, A., Dickinson, L. M., & O'Leary, S. T. (2018). Effect of a health care professional communication training intervention on adolescent human papillomavirus vaccination: A cluster randomized clinical trial. *JAMA Pediatrics*, *172*(5), e180016–e180016.

Dursa, E. K., Barth, S. K., Bossarte, R. M., & Schneiderman, A. I. (2016). Demographic, military, and health characteristics of VA health care users and nonusers who served in or during Operation Enduring Freedom or Operation Iraqi Freedom, 2009-2011. *Public Health Reports*, *131*(6), 839–843.

Friedberg, M. W., Reid, R. O., Timbie, J. W., Setodji, C., Kofner, A., Weidmer, B., & Kahn, K. (2017). Federally qualified health center clinicians and staff increasingly dissatisfied with workplace conditions. *Health Affairs*, *36*(8), 1469–1475.

Hofstetter, A. M., Robinson, J. D., Lepere, K., Cunningham, M., Etsekson, N., & Opel, D. J. (2017). Clinician-parent discussions about influenza vaccination of children and their association with vaccine acceptance. *Vaccine*, *35*(20), 2709–2715.

Jachimowicz, J. M., Duncan, S., Weber, E. U., & Johnson, E. J. (2019). When and why defaults influence decisions: A meta-analysis of default effects. *Behavioural Public Policy*, *3*(2), 159–186.

Jacobson, R. M., St. Sauver, J. L., Griffin, J. M., MacLaughlin, K. L., & Finney Rutten, L. J. (2020). How health care providers should address vaccine hesitancy in the clinical setting: Evidence for presumptive language in making a strong recommendation. *Human Vaccines & Immunotherapeutics*, 1–5.

Jha, A. K., Wright, S. M., & Perlin, J. B. (2007). Performance measures, vaccinations, and pneumonia rates among high-risk patients in Veterans Administration health care. *American Journal of Public Health*, *97*(12), 2167–2172.

Kim, R. H., Day, S. C., Small, D. S., Snider, C. K., Rareshide, C. A., & Patel, M. S. (2018). Variations in influenza vaccination by clinic appointment time and an active choice

intervention in the electronic health record to increase influenza vaccination. *JAMA*

Network Open, *1*(5), e181770–e181770.

Lu, P., Hung, M.-C., O'Halloran, A. C., Ding, H., Srivastav, A., Williams, W. W., & Singleton, J.

A. (2019). Seasonal influenza vaccination coverage trends among adult populations, US,

2010–2016. *American Journal of Preventive Medicine*, *57*(4), 458–469.

Mazar, A., Tomaino, G., Carmon, Z., & Wood, W. (2022). *Distance to Vaccine Sites is

Associated with Lower COVID-19 Vaccine Uptake*.

McLaughlin, J. M. (2013). Estimated Human And Economic Burden Of Four Major Adult

Vaccine-Preventable Diseases In The United States, 2010. *Value in Health*, *16*(3), A86.

Milkman, K. L., Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2011). Using

implementation intentions prompts to enhance influenza vaccination rates. *Proceedings

of the National Academy of Sciences*, *108*(26), 10415–10420.

http://www.pnas.org/content/108/26/10415.short

Milkman, K. L., Patel, M. S., Gandhi, L., Graci, H. N., Gromet, D. M., Ho, H., Kay, J. S., Lee, T.

W., Akinola, M., & Beshears, J. (2021). A megastudy of text-based nudges encouraging

patients to get vaccinated at an upcoming doctor's appointment. *Proceedings of the

National Academy of Sciences*, *118*(20).

Mrkva, K., Posner, N. A., Reeck, C., & Johnson, E. J. (2021). Do nudges reduce disparities?

Choice architecture compensates for low consumer knowledge. *Journal of Marketing*,

0022242921993186.

Office of Disease Prevention and Health Promotion. (2020). *Immunization and Infectious

Diseases*. www.healthypeople.gov/2020/topics-objectives/topic/immunization-and-

infectious-diseases

O'malley, A. S., Grossman, J. M., Cohen, G. R., Kemper, N. M., & Pham, H. H. (2010). Are

electronic medical records helpful for care coordination? Experiences of physician

practices. *Journal of General Internal Medicine*, *25*(3), 177–185.

Opel, D. J., Zhou, C., Robinson, J. D., Henrikson, N., Lepere, K., Mangione-Smith, R., & Taylor, J. A. (2018). Impact of childhood vaccine discussion format over time on immunization status. *Academic Pediatrics*, *18*(4), 430–436.

Patel, M. S., Volpp, K. G., Small, D. S., Wynne, C., Zhu, J., Yang, L., Honeywell, S., & Day, S. C. (2017). Using active choice within the electronic health record to increase influenza vaccination rates. *Journal of General Internal Medicine*, *32*(7), 790–795.

Phansalkar, S., Van der Sijs, H., Tucker, A. D., Desai, A. A., Bell, D. S., Teich, J. M., Middleton, B., & Bates, D. W. (2013). Drug—Drug interactions that should be non-interruptive in order to reduce alert fatigue in electronic health records. *Journal of the American Medical Informatics Association*, *20*(3), 489–493.

Ruggeri, K., & Folke, T. (2020). Unstandard deviation: The untapped value of positive deviance for reducing inequalities. *Perspectives on Psychological Science*, 17456916211017864.

Straits-Tröster, K. A., Kahwati, L. C., Kinsinger, L. S., Orelien, J., Burdick, M. B., & Yevich, S. J. (2006). Racial/ethnic differences in influenza vaccination in the Veterans Affairs Healthcare System. *American Journal of Preventive Medicine*, *31*(5), 375–382.

Tan, L. (2015). Adult vaccination: Now is the time to realize an unfulfilled potential. *Human Vaccines & Immunotherapeutics*, *11*(9), 2158–2166.

Teeny, J. D., Siev, J. J., Briñol, P., & Petty, R. E. (2021). A review and conceptual framework for understanding personalized matching effects in persuasion. *Journal of Consumer Psychology*, *31*(2), 382–414.

Thomas, R. E., & Lorenzetti, D. L. (2018). Interventions to increase influenza vaccination rates of those 60 years and older in the community. *Cochrane Database of Systematic Reviews*, *5*.

U. S. Veterans Health Administration. (2020). *Health Centers Serving Veterans: A Toolkit for the Veteran Community Care Program (VCCP) Administered by the U.S. Veterans Health Administration*.

https://cdn1.digitellinc.com/uploads/nachc/articles/58fe9dfc94d9a4409bdb89dcc4793b3f.

pdf

United States Centers for Disease Control. (2020). *Flu Vaccination Coverage, United States,*

2019-20 Influenza Season. https://www.cdc.gov/flu/fluvaxview/coverage-

1920estimates.htm

U.S. Government Accountability Office. (2017). *Veterans Health Administration: Better Data and*

Evaluation Could Help Improve Physician Staffing, Recruitment, and Retention

Strategies. https://www.gao.gov/products/gao-18-124

Yokum, D., Lauffenburger, J. C., Ghazinouri, R., & Choudhry, N. K. (2018). Letters designed

with behavioural science increase influenza vaccination in Medicare beneficiaries.

Nature Human Behaviour, *2*(10), 743–749.

Young-Xu, Y., van Aalst, R., Russo, E., Lee, J. K., & Chit, A. (2017). The annual burden of

seasonal influenza in the US veterans affairs population. *PLoS One*, *12*(1), e0169344.

Zimmerman, R. K., Santibanez, T. A., Janosky, J. E., Fine, M. J., Raymund, M., Wilson, S. A.,

Bardella, I. J., Medsger, A. R., & Nowalk, M. P. (2003). What affects influenza

vaccination rates among older patients? An analysis from inner-city, suburban, rural, and

Veterans Affairs practices. *The American Journal of Medicine*, *114*(1), 31–38.

Table 1. Respondent demographics

Characteristic	Focal: influenza vaccination		Focal: any vaccination	
	Treatment group	Control group	Treatment group	Control group
% Black	57.81%	55.15%	56.34%	53.31%
% White	37.55%	40.25%	39.03%	42.11%
% Rural	16.47%	15.86%	16.82%	16.11%
% Male	87.99%	85.39%	88.46%	85.91%
Median age	59	59	60	61
N patients	12,433	13,317	13,934	15,007
N clusters	44	40	44	40

NOTES: Data extracted from the Veterans Health Information Systems & Technology Architecture (VISTA) covering the 2018-2019 flu season (09.01.2018 - 04.30.2019). Demographics correspond to the filtered analytic sample. Patients with multiple appointments were coded to demographics at first observed appointment. The treatment sample had a slightly higher percentage Black, rural, and male population, leading our primary specification to be one that controls for these pre-treatment attributes.

Table 2. Regression results for vaccinations

Term	Influenza vaccination				Any vaccination			
	Beta	SE	Beta	SE	Beta	SE	Beta	SE
Intercept	0.208	0.010	0.052	0.016	0.190	0.009	0.075	0.016
Treatment PACT	0.015	0.016	0.016	0.015	0.016	0.014	0.016	0.014
Age			0.003	0.000			0.002	0.000
Male (1 = yes)			0.032	0.008			0.035	0.007
Black (1 = yes)			-0.042	0.008			-0.031	0.007
Rural (1 = yes)			0.013	0.011			0.014	0.010
Controls	No		Yes		No		Yes	
Adjusted R^2	0.0002929		0.0164		0.0003512		0.009583	

NOTES: Author's analysis of data extract from VISTA covering the 2018-2019 flu season (09.01.2018 - 04.30.2019). Analytic sample is comprised of patients who (1) are age eligible for the relevant vaccination, (2) had an appointment with a provider in the analytic sample, (3) did not have contraindications for vaccination in question, and (4) were due for a vaccination at that appointment (e.g., hadn't received one earlier in the season). These proportions are of patients vaccinated at the focal appointment. Standard errors are clustered by randomization cluster.

**Figure 1.** Electronic Health Records (EHR) modified clinical reminder intervention

```
VACCINATION DOCUMENTATION

☐ Your patient is DUE for the following vaccines: Click box to review the clinical reminder
   findings.
☐ Click here to view IMMUNIZATION HISTORY
☐ Click here to review a summary of VHA guidance for these vaccines.

                        ***INSTRUCTIONS***
Use language that assumes the patient will get vaccinated - "It is time for your X shot today"
```
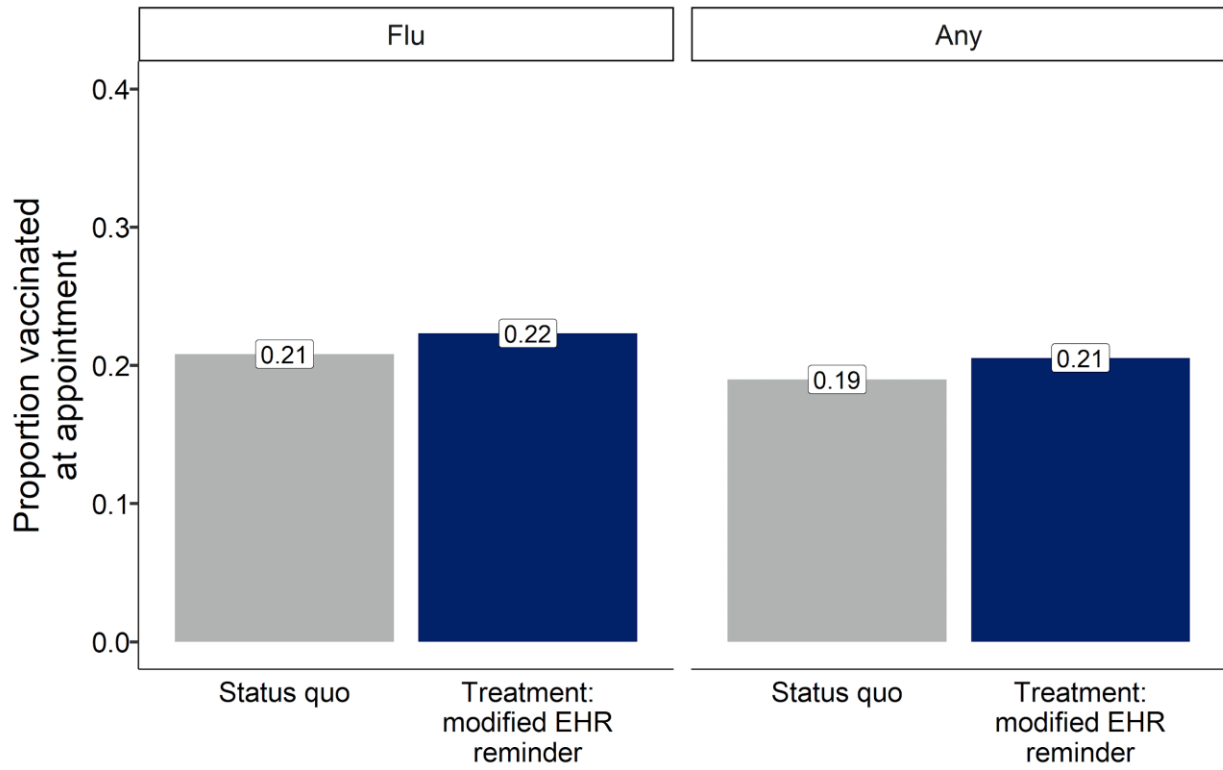
Figure 2. CONSORT Diagram
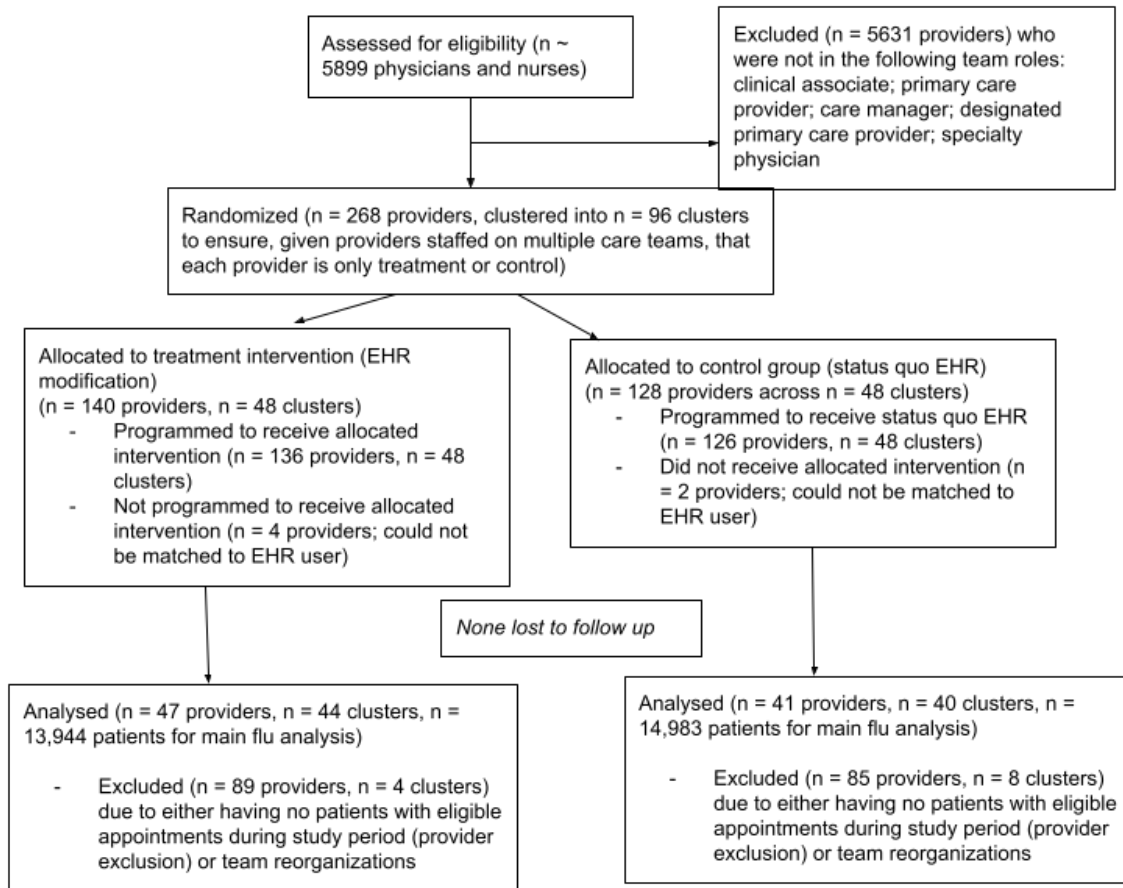
Figure 3. Raw vaccination rates at appointments where due

NOTES: These proportions are of patients vaccinated for influenza (left side) and any vaccination (right side) at the focal appointment.

Figure 4. The intervention did not close racial disparities in vaccination rate