Matters arising

Evidence from a statewide vaccination RCT shows the limits of nudges

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Nathaniel Rabb[1]✉, Megan Swindal[2], David Glick[1,3], Jake Bowers[1,4], Anna Tomasulo[2], Zayid Oyelami[5], Kevin H. Wilson[1] & David Yokum[1]

ARISING FROM H. Dai et al. *Nature* https://doi.org/10.1038/s41586-021-03843-2 (2021)

Simple messages derived from behavioural science have increased the uptake of the seasonal flu vaccine[1–5], and early studies from the coronavirus disease 2019 (COVID-19) vaccine rollout have found that this strategy works for recently eligible older adults[6] and healthcare workers[7]. However, it is unknown whether messaging on its own will encourage vaccination against COVID-19 among reluctant populations. In a randomized controlled trial (RCT) five to eight weeks after all adults in the study population (n = 142,428) were eligible for vaccination, we find that the best-performing nudge in previous studies[2,6] and seven additional messages—stressing vaccines' safety, efficacy, minimization of bad outcomes, accessibility (free, no identification required), protection of recipients' families or widespread adoption—had no detectable effect among people who had not been vaccinated according to state records. This suggests an important boundary condition for nudges that is consistent with a recent result from late in the flu season[8]. Public health authorities should consider simple messages to encourage vaccination at key inflection points (for example, rollout of paediatric COVID-19 vaccines and full Food and Drug Administration approval for adults), but may see diminishing returns if using them to encourage the more hesitant.

After a strong initial push, the rate of COVID-19 vaccinations declined in the USA. Efforts to encourage vaccination have run the gamut from free doughnuts and marijuana to million-dollar lotteries and rare experiences such as driving at a superspeedway. Recently, Dai et al.[6] reported promising results from an RCT evaluating another tactic—sending people short messages informed by behavioural science. The appeal of this approach is clear: it is cheap and minimally invasive. It is also well supported by convergent evidence: email messages increased COVID-19 vaccination appointment sign-ups among healthcare workers[7], and SMS[1–3], mail[4] and email[5] messages have increased seasonal flu vaccinations. Moreover, it has garnered considerable media attention[9], with pieces advocating it in *The Washington Post*, *Fortune*, *The Guardian*, *U.S. News & World Report* and this journal[10]. Policymakers also took note, as several states implemented SMS campaigns[9].

The Dai et al. study was conducted early in the COVID-19 vaccine rollout with recently eligible older adults. Although the results show the potential of nudges, it is unknown whether short messages can change motivations in the population that did not get vaccinated immediately. Indeed, Dai et. al. distinguish burden reduction (helping people to follow through on pre-existing intentions) from demand creation (changing intentions), and numerous reviews find limited and mixed evidence on what drives demand[11–14].

To test whether these findings generalize beyond the initial stages of COVID-19 vaccination, we evaluated the efficacy of text messages sent by the Rhode Island Department of Health (RIDOH) to increase uptake in May and June 2021. The messages included the best-performing 'ownership' language from Dai et al. and a related flu study[2]. This language was supplemented in most conditions with information about safety, efficacy or access, for example. This study offers a strong test of direct messaging because recipients were unvaccinated five to eight weeks after becoming eligible. It is also a realistic test of what a government can and, more importantly, cannot do (for example, craft messages containing false claims and send excessive communications).

RIDOH maintains separate databases of individuals who have been vaccinated and tested for COVID-19. Our study population is the difference of these lists (tested but not yet vaccinated) matched through a series of quasi-identifiers and excluding people under 18 when tested (final n = 142,428; see Extended Data Fig. 1 for randomization scheme). The primary outcome was vaccination by the end of the measurement period: 25 May 2021 to 21 June 2021 (one week after the last day of messaging). At time of launch, all Rhode Islanders over 16 had been eligible to get vaccinated since 19 April 2021, and free, walk-in availability was widespread. The study was deemed exempt by RIDOH's institutional review board. The sample size was dictated by policy goals, as all eligible individuals received messages. A previous study[2] with more conditions and a sample size similar to our first iteration detected meaningful effects.

We created eight messages (Extended Data Table 1, Supplementary Information section 1) on the basis of behavioural science research on COVID-19 health behaviours and other vaccination contexts. All included ownership language ('a vaccine is waiting for you')[2,6], a sentiment also appearing in a standalone condition. Other conditions further emphasized safety, access, minimal likelihood of bad outcomes, reduced risk to one's family, social norms or some combination. All included a link to a state-run page providing vaccination options.

Individuals were assigned to receive one of eight messages or no message (control group). We randomly divided the population into three consecutive iterations of 40,000, 39,709 or 78,394, and then into roughly equal groups per day within those weeks. Within these strata, individuals were assigned to receive one of eight messages or no message (control group).

To maximize overall vaccinations, in iterations 2 and 3 we used an adaptive design such that the likelihood of assignment to any given message was determined by message performance in the previous iteration, with an ε-bounded Thompson sampler adjusting the probability of assignment to condition over time (Supplementary Information section 2).

This study is a block-randomized experiment. All analyses (preregistration: https://osf.io/pkhae) use either the Cochran–Mantel–

[1]The Policy Lab at Brown University, Providence, RI, USA. [2]Rhode Island Department of Health, Providence, RI, USA. [3]Department of Political Science, Boston University, Boston, MA, USA. [4]Department of Political Science, University of Illinois, Urbana-Champaign, IL, USA. [5]IBM, Armonk, NY, USA. ✉e-mail: nathaniel_rabb@brown.edu

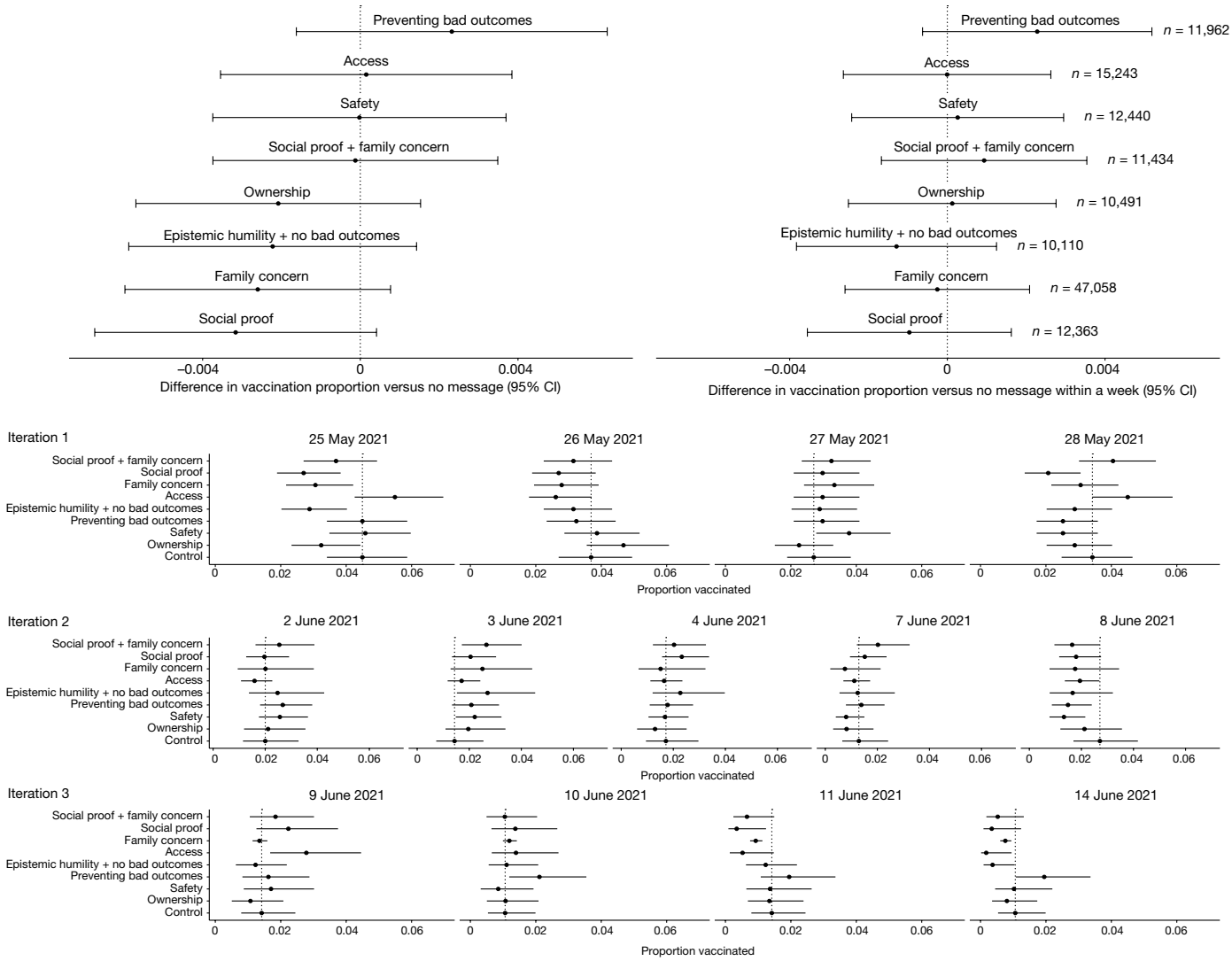

Fig. 1 | Average treatment effects for the eight experimental conditions overall and proportions vaccinated by day. Top left, the differences in the proportion vaccinated by the end of the study between each message condition and the control or 'no message' condition (2% of the control condition was vaccinated within the study period). Top right, the differences in the proportion vaccinated within a week of message sending (1% of the control condition was vaccinated within a week of message sending). The total control condition participation was 11,327. The total size of each arm is shown on the right. All point estimates with 95% confidence intervals (CIs). No adjustment was made for multiple testing as no test cast doubt on the null of no difference. Bottom, proportions vaccinated by 22 June 2021 in each message by the date messages were sent. The grey vertical line shows the proportion vaccinated in the control condition. The 95% confidence intervals for small proportions come from the binomial ensemble method of ref. [17].

Haenszel (CMH) test for 9 (condition) × 2 (outcome) × 13 (day) strata tables or a block-specific weighting, which provides unbiased estimates of intent-to-treat effects and randomization-justified variance calculations.

No SMS message did substantially better or worse than the control whether vaccination rates were measured one week after the messages were sent or at the end of the study period. Figure 1 illustrates the small size of these differences: the largest positive difference was 0.002 for the 'preventing bad outcomes' condition (that is, 2% of control and 2.2% of 'preventing bad outcomes' were vaccinated). Furthermore, we see no evidence of differences in vaccination rates (however measured) between the control and an aggregated 'any message' condition (estimated difference in proportions vaccinated −0.001, 95% confidence interval (CI) −0.004 to 0.001, CMH test, $P = 0.27$), nor between the arms taken all together (CMH test for 9 × 2 × 13 table, $P = 0.12$). For demographics, see Extended Data Table 2; for additional analyses see Supplementary Information sections 3–6.

We find no evidence that a strategy found effective early in the vaccine rollout[6,7] increased COVID-19 vaccination among people who remained unvaccinated five or more weeks after becoming eligible. Public health officials—especially those avoiding or legally barred from mandates—may turn to this strategy to increase vaccination rates among the less enthusiastic but will probably see minimal impact. Dai et al. highlighted a promising, valuable and low-cost tool that can help to increase vaccinations; although our result does not contradict theirs, it does bound the reach of such approaches, a possibility one of their co-authors contemplated elsewhere[10].

One limitation of our study is that the initial recipient list may contain some vaccinated people. Rhode Island residents could get tested at home but vaccinated out of state, and certain sites (for example, Veterans Affairs hospitals) do not need to report individual-level records to the state. Base rates may be inaccurate because of this and other sources of noise (Supplementary Information section 6), although this would not mask treatment effects, as message assignment was

random. Another limitation is that race and ethnicity information is incomplete (Extended Data Table 2).

The study by Dai et al. differed from ours in several ways, including population age (mean age 70 versus 39), message source (recipients' health network versus a state agency), sign-up ease (recipients being directed to a sign-up system versus a page providing vaccination options) and vaccination context (appointments were scarce in February 2021 but abundant by May 2021). Although these factors could account for the different outcomes, flu vaccine findings suggest otherwise: similar interventions have shown success among younger populations[1], when issued by the state[15], and using inconvenient media (mailed letters[4]), and flu vaccines are comparatively easy to procure. One feature that Dai et al. and many flu vaccine studies do share is that they were conducted early in their respective campaigns, whereas ours was not. Notably, a study of older adults found increased uptake of flu vaccines due to postcard messages in October but not November, December or January[8]. Taken together, this suggests that nudges help early in vaccination campaigns, but the efficacy decays. Another COVID-19 study recently made public provides further support[16].

Although we cannot identify the mechanism(s) responsible for decaying efficacy of nudges, the possibilities include novelty effects early on, oversaturation effects later on, different types of hesitancy (logistical barriers versus objections to vaccines), and, especially for COVID-19, increasingly polarized discourse, divergent social norms and differential vaccine knowledge. Future work in public health communication should distinguish these mechanisms to better implement message campaigns. It may also be that short messages effectively encourage those somewhat inclined to vaccinate but cannot move those less inclined, regardless of timing, and with time, the former group shrinks. Despite our null result, nudges may serve foreseeable public health needs (for example, vaccinating children under 5 or promoting boosters) if timed correctly. Indeed, we know of no studies showing reduced vaccinations owing to message campaigns, so they carry little potential harm. However, their ability to move the more reluctant may be limited.

Reporting summary

Further information on experimental design is available in the Nature Research Reporting Summary linked to this paper.

Data availability

The data analysed in this paper were provided by the Rhode Island Department of Health and contains protected health information. To protect privacy, we cannot publicly post individual-level data. Qualified researchers with a valuable research question and relevant approvals including ethical approval can request access to the de-identified data about this trial from the corresponding author. A formal contract will be signed and an independent data protection agency should oversee the sharing process to ensure the safety of the data. Lightly aggregated data that support most of the analyses in this paper can be found at https://github.com/thepolicylab/COVID-SMSExperiment. Some demographic analyses rely on publicly available data from the United States Census Bureau, the United States Department of Housing and Urban Development, the Rhode Island Geographical Information System and the Rhode Island Board of Elections. Copies of these data and, where appropriate, the code that gathered the data are available at https://github.com/thepolicylab/COVID-SMSExperiment.

Code availability

The code to replicate the analyses and figures in the paper and the Extended Data is available at https://github.com/thepolicylab/COVID-SMSExperiment.

1. Lee, W.-N. et al. Large-scale influenza vaccination promotion on a mobile app platform: a randomized controlled trial. *Vaccine* **38**, 3508–3514 (2020).
2. Milkman, K. L. et al. A megastudy of text-based nudges encouraging patients to get vaccinated at an upcoming doctor's appointment. *Proc. Natl Acad. Sci. USA* **118**, e2101165118 (2021).
3. Regan, A. K., Bloomfield, L., Peters, I. & Effler, P. V. Randomized controlled trial of text message reminders for increasing influenza vaccination. *Ann. Fam. Med.* **15**, 507–514 (2017).
4. Yokum, D., Lauffenburger, J. C., Ghazinouri, R. & Choudhry, N. K. Letters designed with behavioural science increase influenza vaccination in Medicare beneficiaries. *Nat. Hum. Behav.* **2**, 743–749 (2018).
5. Baskin, E. Increasing influenza vaccination rates via low cost messaging interventions. *PLoS ONE* **13**, e0192594 (2018).
6. Dai, H. et al. Behavioral nudges increase COVID-19 vaccinations. *Nature* **597**, 404–409 (2021).
7. Santos, H. C., Goren, A., Chabris, C. F. & Meyer, M. N. Effect of targeted behavioral science messages on COVID-19 vaccination registration among employees of a large health system: a randomized trial. *JAMA Netw. Open* **4**, e2118702 (2021).
8. Chen, N., Trump, K.-S., Hall S. & Le Q. The effect of postcard reminders on vaccinations among the elderly: a block-randomized experiment. *Behav. Public Policy* https://doi.org/10.1017/bpp.2020.34 (2020).
9. Mascarenhas, L. This simple text message can encourage people to get vaccinated, researchers say. *CNN* https://www.cnn.com/2021/06/29/health/text-messages-vaccination-wellness/index.html (2021).
10. Kozlov, M. A simple text has the power to increase COVID vaccinations. *Nature* https://doi.org/10.1038/d41586-021-02108-2 (2021).
11. Brewer, N. T., Chapman, G. B., Rothman, A. J., Leask, J. & Kempe, A. Increasing vaccination: putting psychological science into action. *Psychol. Sci. Public Interest* **18**, 149–207 (2017).
12. Dubé, E., Gagnon, D. & MacDonald, N. E. Strategies intended to address vaccine hesitancy: review of published reviews. *Vaccine* **33**, 4191–4203 (2015).
13. Jarrett, C., Wilson, R., O'Leary, M., Eckersberger, E. & Larson, H. J. Strategies for addressing vaccine hesitancy: a systematic review. *Vaccine* **33**, 4180–4190 (2015).
14. Lawes-Wickwar, S. et al. A rapid systematic review of public responses to health messages encouraging vaccination against infectious diseases in a pandemic or epidemic. *Vaccines* **9**, 72 (2021).
15. Esteban-Vasallo, M. et al. Effect of mobile phone text messaging for improving the uptake of influenza vaccination in patients with rare diseases. *Vaccine* **37**, 5257–5264 (2019).
16. Chang, T. et al. Financial incentives and other nudges do not increase COVID-19 vaccinations among the vaccine hesitant. *NBER* https://doi.org/10.3386/w29403 (2021).
17. Park, H. & Leemis, L. M. Ensemble confidence intervals for binomial proportions. *Stat. Med.* **38**, 3460–3475 (2019).
18. Milkman, K. L. et al. A mega-study of text-message nudges encouraging patients to get vaccinated at their pharmacy. *SSRN* https://doi.org/10.2139/ssrn.3780356 (2021).
19. Hamel, L. et al. KFF COVID-19 vaccine monitor: April 2021. *KFF* http://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-april-2021 (2021).
20. Callaghan, T. et al. Correlates and disparities of COVID-19 vaccine hesitancy. *SSRN* https://doi.org/10.2139/ssrn.3667971 (2020).
21. Gibson, D. et al. COVID-19 vaccine acceptability and inequity in the United States: results from a nationally representative survey. Preprint at *MedRxiv* https://doi.org/10.1101/2021.01.29.21250784 (2021).
22. Huynh, H. Most (but not all) anti-vaccination attitudes increased alongside the occurrence and persistence of COVID-19: a snapshot of the trends in the U.S. Preprint at *PsyArXiv* https://doi.org/10.31234/osf.io/yzu9r (2020).
23. Kaplan, R. M. & Milstein, A. Influence of a COVID-19 vaccine's effectiveness and safety profile on vaccination acceptance. *Proc. Natl Acad. Sci. USA* **118**, e2021726118 (2021).
24. Reiter, P. L., Pennell, M. L. & Katz, M. L. Acceptability of a COVID-19 vaccine among adults in the United States: how many people would get vaccinated? *Vaccine* **38**, 6500–6507 (2020).
25. Taylor, S. et al. A proactive approach for managing COVID-19: the importance of understanding the motivational roots of vaccination hesitancy for SARS-CoV2. *Front. Psychol.* **11**, 575950 (2020).
26. Karafillakis, E. & Larson, H. J. The benefit of the doubt or doubts over benefits? A systematic literature review of perceived risks of vaccines in European populations. *Vaccine* **35**, 4840–4850 (2017).
27. Yaqub, O. et al. Attitudes to vaccination: a critical review. *Soc. Sci. Med.* **112**, 1–11 (2014).
28. Hallsworth, M., Mirpuri, S. & Toth, C. Four messages that can increase uptake of the COVID-19 vaccines. *Behavioural Insights Team* https://www.bi.team/blogs/four-messages-that-can-increase-uptake-of-the-covid-19-vaccines/ (2021).
29. Hamel, L. et al. KFF COVID-19 vaccine monitor: March 2021. *KFF* https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-march-2021/ (2021).
30. Prochaska, J. O. & Velicer, W. F. The transtheoretical model of health behavior change. *Am. J. Health Promot.* **12**, 38–48 (1997).
31. Amin, A. B. et al. Association of moral values with vaccine hesitancy. *Nat. Hum. Behav* **1**, 873–880 (2017).
32. de Figueiredo, A. et al. Mapping global trends in vaccine confidence and investigating barriers to vaccine uptake: a large-scale retrospective temporal modelling study. *Lancet* **396**, 898–908 (2020).
33. Kerr, J. R. et al. Correlates of intended COVID-19 vaccine acceptance across time and countries: results from a series of cross-sectional surveys. *BMJ Open* **11**, e048025 (2021).
34. Larson, H. J. et al. Measuring trust in vaccination: a systematic review. *Hum. Vac. Immunother.* **14**, 1599–1609 (2017).
35. Linholdt, M. F. et al. Public acceptance of COVID-19 vaccines: cross-national evidence on levels and individual-level predictors using observational data. *BMJ Open* **11**, e048172 (2021).
36. Mesch, G. S. & Schwirian, K. P. Social and political determinants of vaccine hesitancy: lessons learned from the H1N1 pandemic of 2009–2010. *Am. J. Infect. Control* **43**, 1161–1165 (2015).

37. Banker, S. & Park, J. Evaluating prosocial COVID-19 messaging frames: evidence from a field study on Facebook. *Judgm. Decis. Mak.* **15**, 1037–1043 (2020).
38. Rabb, N. et al. No evidence that collective-good appeals best promote COVID-related health behaviors. *Proc. Natl Acad. Sci. USA* **118**, e2100662118 (2021).
39. Falco, P. & Zaccagni, S. Promoting social distancing in a pandemic: beyond good intentions. *PLoS ONE* **16**, e0260457 (2021).
40. Bicchieri, C. et al. In science we (should) trust: expectations and compliance across nine countries during the COVID-19 pandemic. *PLoS ONE* **16**, e0252892 (2021).
41. Goldberg, M. H. et al. Social norms motivate COVID-19 preventive behaviors. Preprint at *PsyArXiv* https://doi.org/10.31234/osf.io/9whp4 (2020).
42. Lees, J. et al. Intentions to comply with COVID-19 preventive behaviors are associated with personal beliefs, independent of perceived social norms. Preprint at *PsyArXiv* https://doi.org/10.31234/osf.io/97jry (2020).
43. Bruine de Bruin, W. et al. Reports of social circles' and own vaccination behavior: a national longitudinal survey. *Health Psychol.* **38**, 975–983 (2019).
44. Kumar, S. et al. The social ecological model as a framework for determinants of 2009 H1N1 influenza vaccine uptake in the United States. *Health Educ. Behav.* **39**, 229–243 (2012).
45. Sheeran, P. et al. The impact of changing attitudes, norms, and self-efficacy on health-related intentions and behavior: a meta-analysis. *Health Psychol.* **35**, 1178–1188 (2016).
46. Sinclair, S. & Agerström, J. Do social norms influence young people's willingness to take the COVID-19 vaccine? *Health Commun*. https://doi.org/10.1080/10410236.2021.1937832 (2021).
47. Moehring, A. et al. Surfacing norms to increase vaccine acceptance. Preprint at *PsyArXiv* https://doi.org/10.31234/osf.io/srv6t (2021).
48. Schmidtke, K. A. et al. Randomised controlled trial of a theory-based intervention to prompt front-line staff to take up the seasonal influenza vaccine. *BMJ Qual. Saf.* **29**, 189–197 (2020).

Author contributions N.R., M.S., D.G., J.B., A.T., K.H.W. and D.Y. conceived of and designed the study. Z.O. and K.H.W. oversaw data collection. J.B., K.H.W., D.G. and N.R. conducted the analysis. J.B., K.H.W., D.G., N.R. and M.S. interpreted the data. All authors contributed to the manuscript.

Competing interests The authors declare no competing interests.

Additional information
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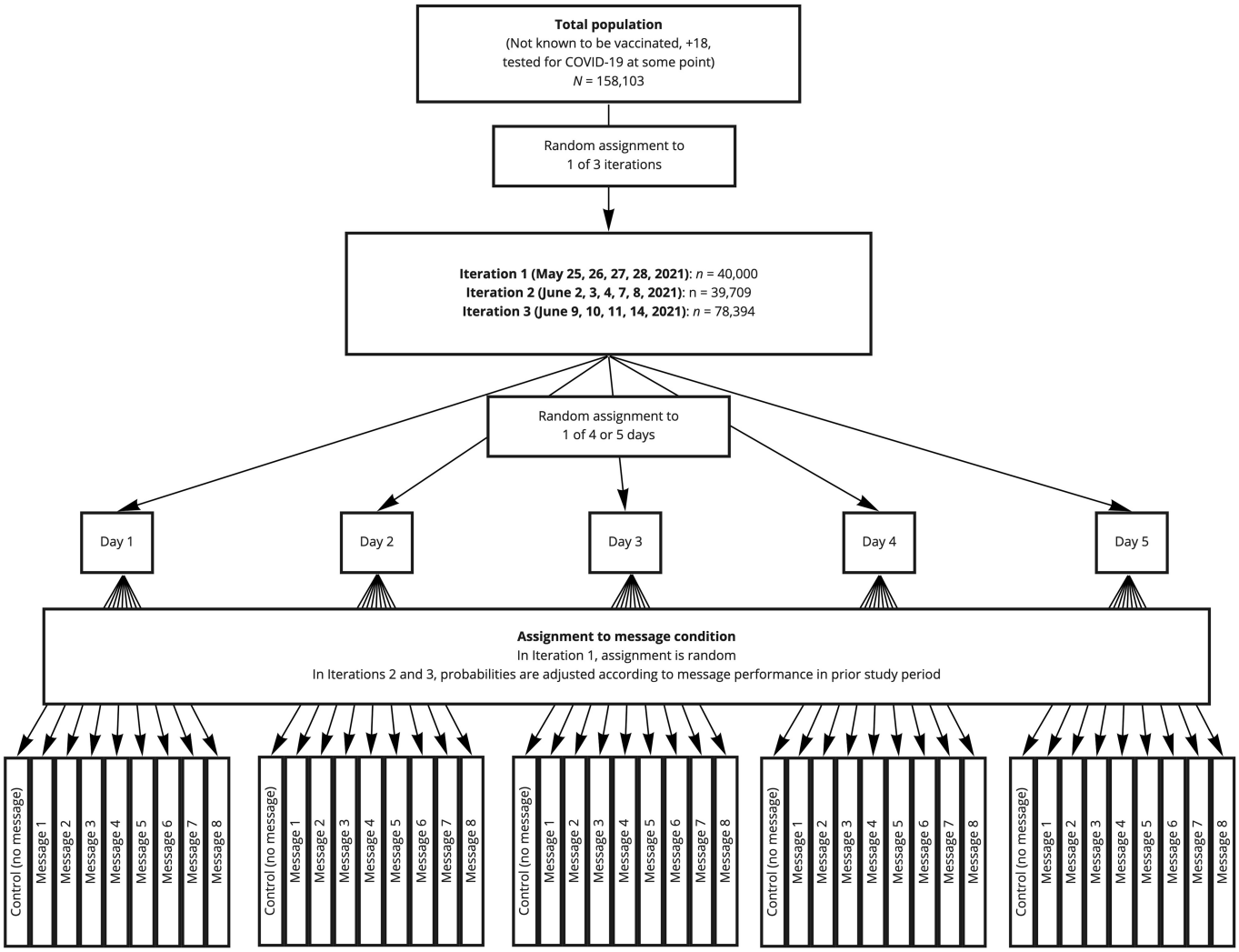

Extended Data Fig. 1 | Randomization scheme and sample. RIDOH maintains separate databases of (a) individuals who have been vaccinated and (b) individuals who have been tested for COVID-19. Vaccination data comes from medical providers and pharmacies receiving vaccines supplied by the State of Rhode Island, who are required to participate in the Rhode Island Child and Adult Immunization Registry (RICAIR) through electronic data reporting. Immunization records can be accessed by an individual's medical provider or by authorized RIDOH users conducting public health surveillance activities including linking vaccination records with the state's COVID-19 testing or case databases to verify information collected during case investigation. COVID-19 testing data (b) is reported to the state through the National Electronic Disease Surveillance System (NEDSS). Our study population is the difference of lists (a) and (b); the resulting database contained 162,504 unique entries. The study ended one day early after RIDOH received complaints about excessive communication. It is unclear how many complaints were received and how many were specifically about this study; other concurrent outreach efforts included SMS messages about COVID-19 testing and phone calls to older adults encouraging vaccination. Nevertheless, leadership halted all such communications out of concern that people would block crucial emergency messages. The final N for the study is 142,428. A small subset of the initial population ($N \approx 800$) had chosen Spanish as their preferred language on testing sign-up forms. While we had initially planned to send this group messages translated into Spanish, an unresolved encoding problem prevented Spanish characters from displaying properly on some cell phones. The project team decided to reintroduce these individuals into the general study population for Iteration 3.

Extended Data Table 1 | Messages used in the RCT and rationales

Condition	Text	FK	Rationale
1. Ownership (baseline prompt)	A COVID-19 vaccine is available for you.	3	At the time of the study, only one messaging RCT that measured vaccination against COVID-19 had been publicly reported.[6] The most effective message in this large trial was conceptually similar to the best performers in two large RCTs measuring vaccination against seasonal flu.[2,18] The core idea is to confer a sense of ownership by informing recipients that vaccines have become available *for them* and may now be claimed. Given the unusually strong evidence for this strategy and the need for a concluding prompt in each message, we used ownership language in all treatment conditions. A baseline condition included only this message. We note as well that survey data indicated that Black and Latinx people were less likely to know that vaccination was free.[19] We therefore emphasized that vaccines are free in all conditions.
2. Safety	More than 150 million people across the nation from diverse backgrounds got the COVID-19 vaccines. They are very safe. A vaccine is available for you.	3.5	Vaccine safety is a perennial concern among those reluctant to vaccinate against COVID-19[20-25] and other diseases.[26,27] Although the long-term effects of COVID-19 vaccines were unknown, the sheer volume of participants in the clinical trials casted doubt on the likelihood of hidden dangers. This kind of information had been shown to be effective in a COVID-related survey experiment[28] and a public opinion poll.[29]
3. Pros of vaccination (implicit choice): preventing bad outcomes	Vaccines are extremely effective at preventing bad COVID-19 outcomes. A vaccine is available for you.	5.4	On one theory of health behavior, people unvaccinated against COVID-19 but considering it weigh the pros and cons of the decision.[30] While an extensive list of advantages and disadvantages was impossible in a short SMS message, one pro was conspicuous: vaccines demonstrably reduce severe disease and hospitalization to near zero. A message emphasizing this was effective in a public opinion poll that did not randomize message assignment.[29] Given that some groups may be reluctant to get vaccinated because they feel their freedom is threatened,[31] a potentially helpful feature of highlighting pros of COVID-19 vaccines is the (true) implication that the message recipient is making a choice.
4. Epistemic humility + pros of vaccination (implicit choice): preventing bad outcomes	We don't fully understand why some people with no medical conditions have bad COVID-19 outcomes. But we do know that vaccines mostly prevent these outcomes. A vaccine is available for you.	5.3	Choosing to get vaccinated requires trust in a community of scientific experts.[32-36] But science is not infallible, and scientists can be wrong. We extended the pros condition to include an acknowledgment of the uncertainty inherent in science. Groups concerned about safety and liberty may be more convinced by claims that COVID-19 vaccines minimize hospitalization when they are coupled with an acknowledgment that other aspects of the disease are not well understood.
5. Access	A free COVID-19 vaccine is available for you at CVS, Walgreens, or Stop & Shop and sites across the state. You don't need an appointment, insurance or other documents.	5.6	Some groups may not get vaccinated because of logistical or structural barriers rather than reluctance. Some of these barriers had been reduced by recent developments, such as the eligibility of all adults and the availability of no-appointment vaccines at CVS or other pharmacies. But people (especially Black and Latinx individuals) may not have realized that they were eligible to be vaccinated or that vaccination is free.[19] In a related finding, an RCT showed increased vaccine uptake due to logistical facilitation (messages that included a map indicating the location of vaccination centers).[5]
6. Family concern	Keep your family safe. A COVID-19 vaccine is available for you.	2.8	Some studies had suggested that appeals to the wellbeing of people's families are superior to appeals to the wellbeing of their communities[37,38] or to no message at all[28,39] when encouraging COVID-related health behaviors including vaccine information search. This framing had also been a conspicuous element in Rhode Island's emergency communications during the pandemic, so we tested its utility in promoting vaccine uptake.
7. Social proof	Over 600,000 Rhode Islanders have already been vaccinated against COVID-19. A vaccine is available for you.	5.7	Our own survey work in Rhode Island and numerous studies nationally[40-42] showed a strong relationship between beliefs about others' COVID-related health behaviors and reports of one's own. This relationship extends to vaccination and is seen in many other health behaviors.[43-45] Some studies had found effects of messages emphasizing the behaviors of others,[46,47] while others had not.[48] We tested the effectiveness of such messages by reporting the (true) number of Rhode Islanders that had been vaccinated to date.
8. Social proof + family concern	Keep your family safe and join the 600,000 Rhode Islanders who have already been vaccinated against COVID-19. A vaccine is available for you.	5.8	One concern with the above strategy is that it could impart a *lack* of necessity to getting vaccinated for recipients unworried about the risks of COVID-19. We therefore coupled the latter message with the emphasis on the wellbeing of people's families.

All messages were preceded by "A message from the Rhode Island Department of Health:" and concluded with "Click here for all the ways to claim your free dose: health.ri.gov/[address unique to the message condition]." Rationales are based on refs. [2,5,6,18–48]. FK, Flesch–Kincaid readability score.

Extended Data Table 2 | Demographics for study population

Age	
Mean	SD
39.14	16.94

	Gender		
	Female	Male	Unknown
count	65310	62446	14700
%	45.85%	43.84%	10.32%

	Race/ethnicity					
	Unknown	White	Hispanic	Black	Other	Declined
count	63810	50286	12157	5659	4867	5677
%	44.79%	35.30%	8.53%	3.97%	3.42%	3.99%

Demographic information was entered by individuals or medical technicians at the time of COVID-19 testing and was voluntary. Thus, this information is incomplete, with missing race and ethnicity values for 45% of individuals and missing gender for 10%. We report the demographics that are known as a partial look at the characteristics of the group.

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Corresponding author(s): Nathaniel Rabb

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☐	☒ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒ For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐ Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	The database of not-yet-vaccinated Rhode Islanders who had previously taken a COVID test was provided to The Policy Lab by the Rhode Island Department of Health (RIDOH) based on its administrative data systems. The outcomes, vaccinations, were also provided by RIDOH using its own administrative systems. The randomization was conducted using python. Code available in https://github.com/thepolicylab/COVID-SMSExperiment. Each day of the study the randomized id numbers were provided to RIDOH who used the Code Red SMS messaging system to send the text messages. Some descriptive analyses rely on publicly available data from the US Census Bureau and Department of Housing and Urban Development, Rhode Island GIS. Some data from the Board of Elections of Rhode Island required scraping from their website. The code to pull and aggregate this data is also available at https://github.com/thepolicylab/COVID-SMSExperiment.
Data analysis	Code for data analysis is available in the public github repository: https://github.com/thepolicylab/COVID-SMSExperiment

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

The aggregated datasets generated during and/or analysed for the main findings of the current study are available at https://github.com/thepolicylab/COVID-SMSExperiment. Some of the exploratory analyses used ZIP code level data. To protect privacy, we cannot publicly post individual-level data or ZIP code level data. Qualified researchers with a valuable research question and relevant approvals including ethical approval can request access to the de-identified data about this trial from the corresponding author. A formal contract will be signed and an independent data protection agency should oversee the sharing process to ensure the safety of the data.

Demographic data for some of our exploratory analyses came from the US Census Bureau, the US Department of Housing and Urban Development, the Rhode Island Geographical Information System, and the Rhode Island Board of Elections. Copies of this data, and where necessary the code that retrieved the data, are available at https://github.com/thepolicylab/COVID-SMSExperiment.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☒ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	This is a quantitative randomized control trial.
Research sample	The Rhode Island Department of Health (RIDOH) maintains separate databases of individuals who have been vaccinated and tested for COVID-19. Our study population is the difference of these lists (tested but not yet vaccinated) matched through a series of quasi-identifiers and excluding people under 18 when tested (final N = 142,428).
Sampling strategy	We used this entire database. We did not sample.
Data collection	Data were collected by RIDOH using their administrative data systems: vaccinations (the outcome of the analysis) are reported to RIDOH from almost all providers in the state (some providers, such as Veterans Affairs hospitals, are not required to provide data). Exploratory supplementary analyses using ZIP code level census data used publicly available data on those geographic units merged onto the main database.
Timing	May 25, 2021 through June 21, 2021
Data exclusions	No data were excluded from the analysis. Note that the process of merging outcomes ("vaccinated or not") onto the main dataset involved some matching (using three letters of first names, last names, and phone numbers where available). So, some duplicated observations were excluded en route to a clean set of data with one row per participant.
Non-participation	If anyone declined SMS messages from the Rhode Island Department of Health, it occurred before the start of this study. The vaccination outcome information was also collected by RIDOH as a part of its legal obligations to the state.
Randomization	The Policy Lab randomly assigned 8 active messages and 1 control message to subjects with probabilities that varied by iteration (roughly, week of the study), and also by day within iteration (with the same probabilities). Goal of the study was both to 1) learn which messages were more effective so that RIDOH might use them to help overcome vaccine hesitancy at a low cost and 2) increase overall vaccination. Thus we combined a fixed probability randomization within block (day of the study) with an partially adaptive randomization (for weeks 2 and 3). Randomization occurred using python and the adaptive algorithm withheld a proportion ε of the pool for each week for fixed, equal probability randomization and (1 - ε) for adaptive randomization using the Thompson sampling approach. In weeks 1 and 2, ε = 0.25. For week 3, ε = 0.33. See https://github.com/thepolicylab/COVID-SMSExperiment for the code used for randomization, data cleaning and merging, and analysis.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☐	☒ Human research participants
☐	☒ Clinical data
☒	☐ Dual use research of concern

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Human research participants

Policy information about studies involving human research participants

Population characteristics	The Rhode Island Department of Health (RIDOH) maintains separate databases of individuals who have been vaccinated and tested for COVID-19. Our study population is the difference of these lists (tested but not yet vaccinated) matched through a series of quasi-identifiers and excluding people under 18 when tested (final N = 142,428).
Recruitment	RIDOH maintains this database as a part of its COVID surveillance duties.
Ethics oversight	The study was deemed exempt by RIDOH's IRB.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Clinical data

Policy information about clinical studies

All manuscripts should comply with the ICMJE guidelines for publication of clinical research and a completed CONSORT checklist must be included with all submissions.

Clinical trial registration	https://osf.io/pkhae/
Study protocol	https://osf.io/pkhae/
Data collection	The setting is Rhode Island, USA. Time period is May 25, 2021 through June 21, 2021.
Outcomes	The outcomes were vaccination by end of the study period OR vaccination within a week of being assigned an SMS message.