

Algorithm-assisted personalized risk communication to encourage flu vaccination in the USA: three randomized field trials

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1 Inclusion and exclusion criteria

Inclusion and exclusion criteria for each study are listed below. Note that we operationally defined the general inclusion/exclusion criteria that were listed on ClinicalTrials.gov.

1.1 Study 1

Inclusion Criteria:

- Current Geisinger patient at the time of study, defined as follows:
 - Attended at least one primary care appointment at Geisinger between 10/1/2008 and June 2020
 - Were in the Electronic Health Record [EHR] since at least September 2019 and had at least one encounter between January 2018–2020
- Fell in the top 10% of risk for flu and complications (according to the flu-complication risk scores computed by Medial EarlySign's machine learning algorithm)
- Aged 17 or older

Exclusion Criteria:

- Had contraindications for flu vaccination
- Could not be contacted via any of the communication modalities (e.g., letter, patient portal, SMS) being used in the study, either due to insufficient/missing contact information in the EHR or because they opted out of all modalities

1.2 Study 2

Inclusion Criteria:

- Aged 18 or older
- Current Geisinger patient at the time of study, defined as follows:
 - Included on a list of active Geisinger patients who met the following criteria:
 - Attended at least one primary care appointment at Geisinger between 10/1/2008 and March 2021
 - Were in the EHR since at least September 2020 and had at least one encounter in 2019–2021
 - Had an encounter in the last 2 years as of August 2021
- Fell in the top 10% of risk for flu and complications

Exclusion Criteria:

- Had contraindications for flu vaccination
- Could not be contacted via any of the communication modalities being used in the study, either due to insufficient/missing contact information in the EHR or because they opted out of all modalities

1.3 Study 3

Inclusion Criteria:

- Included on a list of active Geisinger patients who met the following criteria:
 - Attended at least one primary care appointment at Geisinger between 10/1/2008 and 4/13/2022
 - Either of the following:
 - Had a Geisinger primary care provider assigned as of April 2022
 - Were in the EHR since at least September 2021 and had at least one encounter in 2020–2022
- Aged 18 or older
- Fell in the top 11–20% of risk for flu and flu complications
- Had a Geisinger PCP assigned as of August 2022
- Had an encounter in the last 2 years as of August 2022

Exclusion criteria:

- Could not be contacted via any of the communication modalities being used in the study, either due to insufficient/missing contact information in the EHR or because they opted out of all modalities

1.4 Study 4

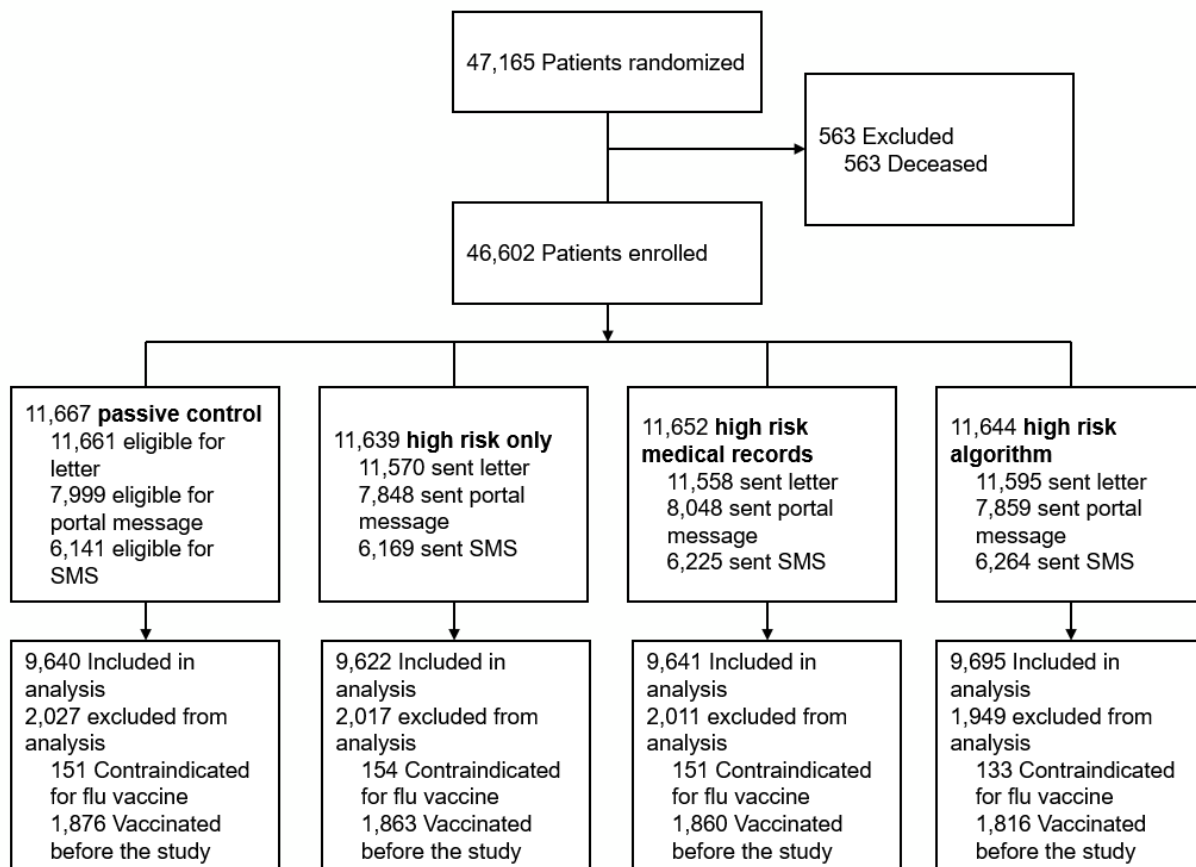
Inclusion Criteria:

- Included on a list of active Geisinger patients who met the following criteria:
 - Attended at least one primary care appointment at Geisinger between 10/1/2008 and 4/13/2022
 - Either of the following:
 - Had a Geisinger primary care provider assigned as of April 2022
 - Were in the EHR since at least September 2021 and had at least one encounter in 2020–2022
- Aged 18 or older
- Fell in the top 10% of risk for flu and flu complications
- Had a Geisinger PCP assigned as of August 2022
- Had an encounter in the last 2 years as of August 2022

Exclusion Criteria:

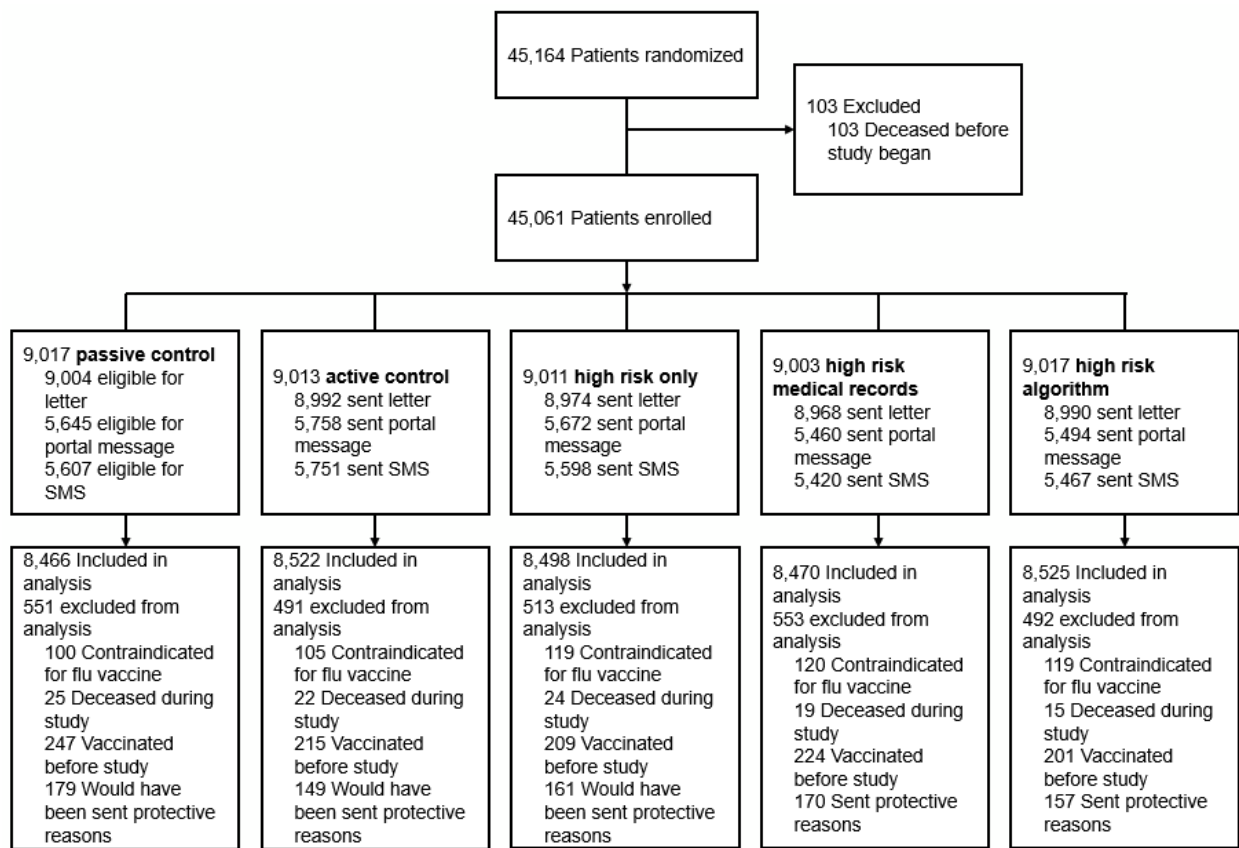
- Could not be contacted via any of the communication modalities being used in the study, either due to insufficient/missing contact information in the EHR or because they opted out of all modalities

2 CONSORT Diagrams



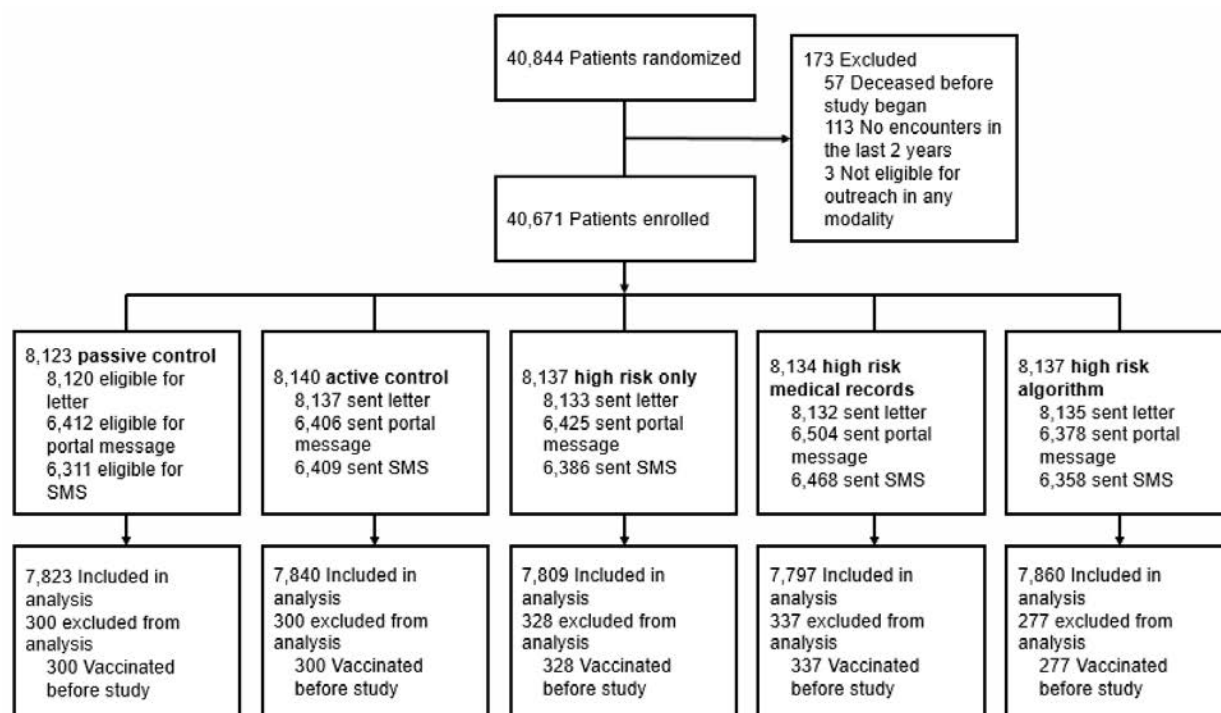
Supplementary Fig. 1. CONSORT diagram for Study 1.

Note: Patients in Study 1 were assessed for modality eligibility before randomization and excluded from the randomized dataset if they were not eligible for communication in any modalities at that time.



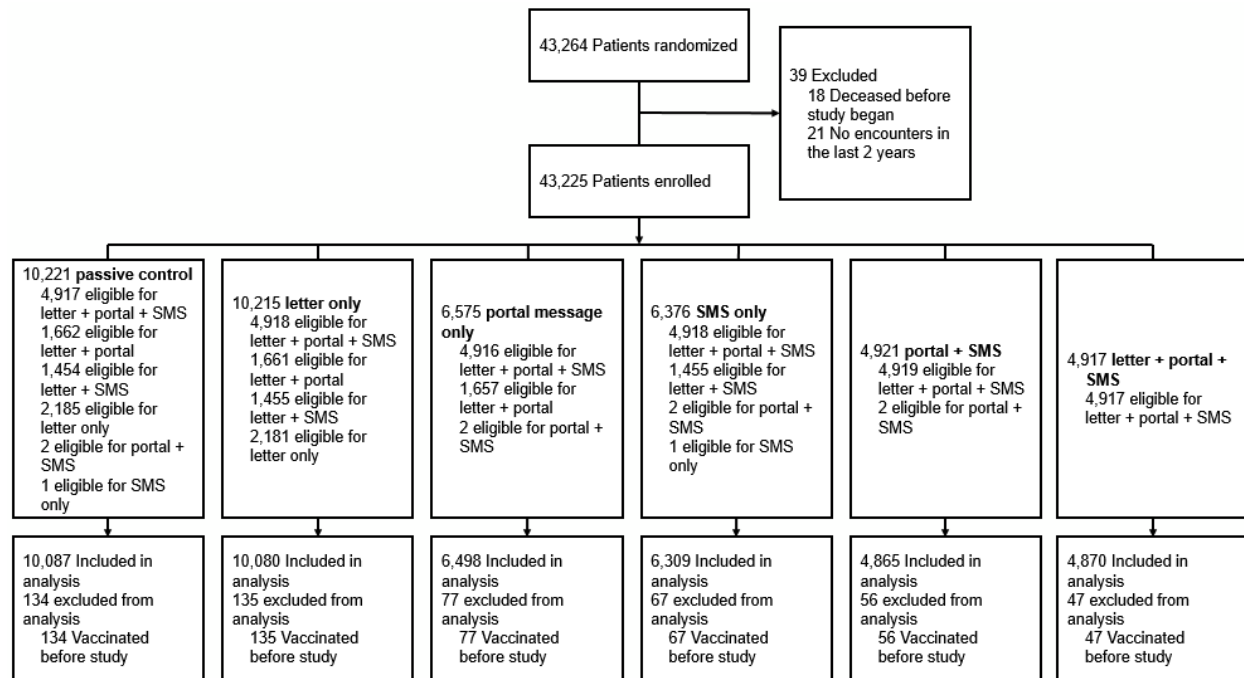
Supplementary Fig. 2. CONSORT diagram for Study 2.

Note: Patients in Study 2 were assessed for modality eligibility before randomization and excluded from the randomized dataset if they were not eligible for communication in any modalities at that time.



Supplementary Fig. 3. CONSORT diagram for Study 3.

Note: In Study 3, unlike Studies 1 and 2, patients were assessed for modality eligibility after, rather than before, randomization. This allowed for a more timely exclusion of patients who became ineligible throughout the study period.



Supplementary Fig. 4. CONSORT diagram for Study 4.

Note that the numbers in the figure include patients who were in any analysis and eligible for any combination of modalities. However, the primary analysis sample consists only of patients who were eligible for letter + portal + SMS.

3 Baseline data

Supplementary Tables 1–4 (SI section 3.1) show baseline data for all patients enrolled in Studies 1–4. Supplementary Tables 5–8 (SI section 3.2) show baseline data for all patients included in the preregistered analysis sample for each study.

3.1 Patients enrolled in each study

Supplementary Table 1. Baseline data for patients enrolled in Study 1.

	Passive control (n = 11667)	High risk only (n = 11639)	High risk medical records (n = 11652)	High risk algorithm (n = 11644)	Overall (n = 46602)
Age					
Mean (SD)	58.0 (19.3)	57.9 (19.3)	57.9 (19.2)	57.6 (19.4)	57.9 (19.3)
Median [Min, Max]	60.0 [17.0, 105]	60.0 [17.0, 107]	60.0 [17.0, 105]	60.0 [17.0, 103]	60.0 [17.0, 107]
Sex					
Female	7535 (64.6%)	7514 (64.6%)	7533 (64.6%)	7438 (63.9%)	30020 (64.4%)
Male	4132 (35.4%)	4125 (35.4%)	4119 (35.4%)	4206 (36.1%)	16582 (35.6%)
Race					
American Indian or Alaska Native	22 (0.2%)	21 (0.2%)	15 (0.1%)	22 (0.2%)	80 (0.2%)
Asian	32 (0.3%)	37 (0.3%)	28 (0.2%)	31 (0.3%)	128 (0.3%)
Black or African American	362 (3.1%)	382 (3.3%)	389 (3.3%)	416 (3.6%)	1549 (3.3%)
Native Hawaiian or Other Pacific Islander	18 (0.2%)	26 (0.2%)	20 (0.2%)	26 (0.2%)	90 (0.2%)
White	11223 (96.2%)	11159 (95.9%)	11194 (96.1%)	11136 (95.6%)	44712 (95.9%)
Unknown	10 (0.1%)	14 (0.1%)	6 (0.1%)	13 (0.1%)	43 (0.1%)
Ethnicity					
Hispanic or Latino	402 (3.4%)	457 (3.9%)	395 (3.4%)	413 (3.5%)	1667 (3.6%)
Not Hispanic or Latino	11253 (96.5%)	11159 (95.9%)	11240 (96.5%)	11207 (96.2%)	44859 (96.3%)
Unknown	12 (0.1%)	23 (0.2%)	17 (0.1%)	24 (0.2%)	76 (0.2%)

Note. Age refers to age at the time of enrollment. Demographic variables were obtained from the Geisinger electronic health record.

Supplementary Table 2. Baseline data for patients enrolled in Study 2.

	Passive control (n = 9017)	Active control (n = 9013)	High risk only (n = 9011)	High risk medical records (n = 9003)	High risk algorithm (n = 9017)	Overall (n = 45061)
Age						
Mean (SD)	54.1 (19.6)	54.0 (19.6)	53.9 (19.8)	54.1 (19.6)	54.1 (19.9)	54.0 (19.7)
Median [Min, Max]	55.0 [18.0, 104]	55.0 [18.0, 103]	55.0 [18.0, 102]	55.0 [18.0, 100]	55.0 [18.0, 109]	55.0 [18.0, 109]
Sex						
Female	6038 (67.0%)	6121 (67.9%)	6107 (67.8%)	6086 (67.6%)	6140 (68.1%)	30492 (67.7%)
Male	2979 (33.0%)	2892 (32.1%)	2904 (32.2%)	2917 (32.4%)	2877 (31.9%)	14569 (32.3%)
Race						
American Indian or Alaska Native	11 (0.1%)	19 (0.2%)	14 (0.2%)	16 (0.2%)	16 (0.2%)	76 (0.2%)
Asian	27 (0.3%)	21 (0.2%)	23 (0.3%)	26 (0.3%)	27 (0.3%)	124 (0.3%)
Native Hawaiian or Other Pacific Islander	15 (0.2%)	12 (0.1%)	12 (0.1%)	16 (0.2%)	20 (0.2%)	75 (0.2%)
Black or African American	348 (3.9%)	286 (3.2%)	300 (3.3%)	330 (3.7%)	300 (3.3%)	1564 (3.5%)
White	8596 (95.3%)	8660 (96.1%)	8648 (96.0%)	8602 (95.5%)	8636 (95.8%)	43142 (95.7%)
Unknown	20 (0.2%)	15 (0.2%)	14 (0.2%)	13 (0.1%)	18 (0.2%)	80 (0.2%)
Ethnicity						
Hispanic or Latino	381 (4.2%)	351 (3.9%)	374 (4.2%)	353 (3.9%)	365 (4.0%)	1824 (4.0%)
Not Hispanic or Latino	8608 (95.5%)	8635 (95.8%)	8607 (95.5%)	8627 (95.8%)	8630 (95.7%)	43107 (95.7%)
Unknown	28 (0.3%)	27 (0.3%)	30 (0.3%)	23 (0.3%)	22 (0.2%)	130 (0.3%)

Note. Age refers to age at the time of enrollment. Demographic variables were obtained from the Geisinger electronic health record.

Supplementary Table 3. Baseline data for patients enrolled in Study 3.

	Passive control (n = 8123)	Active control (n = 8140)	High risk only (n = 8137)	High risk medical records (n = 8134)	High risk algorithm (n = 8137)	Overall (n = 40671)
Age						
Mean (SD)	53.4 (19.7)	53.9 (19.7)	53.7 (19.8)	52.9 (19.7)	53.6 (19.7)	53.5 (19.7)
Median [Min, Max]	54.0 [18.0, 101]	55.0 [18.0, 103]	55.0 [18.0, 107]	54.0 [18.0, 100]	54.0 [18.0, 108]	55.0 [18.0, 108]
Sex						
Female	5121 (63.0%)	5009 (61.5%)	5116 (62.9%)	5116 (62.9%)	5055 (62.1%)	25417 (62.5%)
Male	3002 (37.0%)	3131 (38.5%)	3021 (37.1%)	3018 (37.1%)	3082 (37.9%)	15254 (37.5%)
Race						
American Indian or Alaska Native	17 (0.2%)	19 (0.2%)	24 (0.3%)	14 (0.2%)	17 (0.2%)	91 (0.2%)
Asian	36 (0.4%)	30 (0.4%)	37 (0.5%)	47 (0.6%)	45 (0.6%)	195 (0.5%)
Native Hawaiian or Other Pacific Islander	20 (0.2%)	31 (0.4%)	37 (0.5%)	26 (0.3%)	32 (0.4%)	146 (0.4%)
Black or African American	309 (3.8%)	329 (4.0%)	309 (3.8%)	298 (3.7%)	326 (4.0%)	1571 (3.9%)
White	7688 (94.6%)	7666 (94.2%)	7688 (94.5%)	7705 (94.7%)	7642 (93.9%)	38389 (94.4%)
More Than One Race	1 (0.0%)	2 (0.0%)	1 (0.0%)	0 (0%)	1 (0.0%)	5 (0.0%)
Unknown	52 (0.6%)	63 (0.8%)	41 (0.5%)	44 (0.5%)	74 (0.9%)	274 (0.7%)
Ethnicity						
Hispanic or Latino	411 (5.1%)	395 (4.9%)	415 (5.1%)	413 (5.1%)	422 (5.2%)	2056 (5.1%)
Not Hispanic or Latino	7670 (94.4%)	7691 (94.5%)	7675 (94.3%)	7680 (94.4%)	7673 (94.3%)	38389 (94.4%)
Unknown	42 (0.5%)	54 (0.7%)	47 (0.6%)	41 (0.5%)	42 (0.5%)	226 (0.6%)

Note. Age refers to age at time of enrollment. Demographic variables were obtained from the Geisinger electronic health record.

Supplementary Table 4. Baseline data for patients enrolled in Study 4.

	Passive control (n = 10221)	Letter (n = 10215)	Portal (n = 6575)	SMS (n = 6376)	Portal + SMS (n = 4921)	Letter + portal + SMS (n = 4917)	Overall (n = 43225)
Age							
Mean (SD)	59.2 (19.5)	58.9 (19.4)	55.0 (19.5)	52.8 (18.4)	51.6 (18.2)	52.2 (18.2)	55.9 (19.3)
Median [Min, Max]	62.0 [18.0, 104]	61.0 [18.0, 102]	56.0 [18.0, 101]	54.0 [18.0, 103]	52.0 [18.0, 100]	53.0 [18.0, 98.0]	58.0 [18.0, 104]
Sex							
Female	6581 (64.4%)	6609 (64.7%)	4526 (68.8%)	4290 (67.3%)	3482 (70.8%)	3428 (69.7%)	28916 (66.9%)
Male	3640 (35.6%)	3606 (35.3%)	2049 (31.2%)	2086 (32.7%)	1439 (29.2%)	1489 (30.3%)	14309 (33.1%)
Race							
American Indian or Alaska Native	20 (0.2%)	19 (0.2%)	20 (0.3%)	15 (0.2%)	14 (0.3%)	18 (0.4%)	106 (0.2%)
Asian	15 (0.1%)	21 (0.2%)	19 (0.3%)	26 (0.4%)	20 (0.4%)	12 (0.2%)	113 (0.3%)
Native Hawaiian or Other Pacific Islander	30 (0.3%)	29 (0.3%)	15 (0.2%)	20 (0.3%)	14 (0.3%)	12 (0.2%)	120 (0.3%)
Black or African American	351 (3.4%)	361 (3.5%)	189 (2.9%)	288 (4.5%)	177 (3.6%)	184 (3.7%)	1550 (3.6%)
White	9737 (95.3%)	9720 (95.2%)	6297 (95.8%)	5979 (93.8%)	4659 (94.7%)	4658 (94.7%)	41050 (95.0%)
More Than One Race	3 (0.0%)	0 (0%)	0 (0%)	2 (0.0%)	1 (0.0%)	0 (0%)	6 (0.0%)
Unknown	65 (0.6%)	65 (0.6%)	35 (0.5%)	46 (0.7%)	36 (0.7%)	33 (0.7%)	280 (0.6%)
Ethnicity							
Hispanic or Latino	430 (4.2%)	486 (4.8%)	278 (4.2%)	374 (5.9%)	228 (4.6%)	222 (4.5%)	2018 (4.7%)
Not Hispanic or Latino	9727 (95.2%)	9666 (94.6%)	6256 (95.1%)	5958 (93.4%)	4657 (94.6%)	4670 (95.0%)	40934 (94.7%)
Unknown	64 (0.6%)	63 (0.6%)	41 (0.6%)	44 (0.7%)	36 (0.7%)	25 (0.5%)	273 (0.6%)

Note. This table includes all patients enrolled in the study, regardless of which modalities for which they were eligible. However, the eligible modalities determined which arms to which they could be assigned (e.g., patients eligible for a letter but not a portal or SMS message could only be included in passive control or letter arms). Moreover, there were large differences in baseline variables as a function of modality eligibility. Therefore, the arms are unbalanced in this table. However, Supplementary Table 8 demonstrates that the primary analysis sample, which only included patients eligible for outreach in all modalities, was balanced across arms. Age refers to age at time of enrollment. Demographic variables were obtained from the Geisinger electronic health record.

3.2 Patients included in analysis

Supplementary Table 5. Baseline data for patients included in Study 1 analysis.

	Passive control (n = 9640)	High risk only (n = 9622)	High risk medical records (n = 9641)	High risk algorithm (n = 9695)	Overall (n = 38598)
Age					
Mean (SD)	56.4 (19.5)	56.3 (19.5)	56.4 (19.4)	56.1 (19.6)	56.3 (19.5)
Median [Min, Max]	58.0 [17.0, 105]	58.0 [17.0, 107]	58.0 [17.0, 105]	58.0 [17.0, 103]	58.0 [17.0, 107]
Sex					
Female	6278 (65.1%)	6285 (65.3%)	6312 (65.5%)	6266 (64.6%)	25141 (65.1%)
Male	3362 (34.9%)	3337 (34.7%)	3329 (34.5%)	3429 (35.4%)	13457 (34.9%)
Race					
American Indian or Alaska Native	20 (0.2%)	20 (0.2%)	12 (0.1%)	18 (0.2%)	70 (0.2%)
Asian	27 (0.3%)	28 (0.3%)	23 (0.2%)	22 (0.2%)	100 (0.3%)
Black or African American	336 (3.5%)	347 (3.6%)	355 (3.7%)	372 (3.8%)	1410 (3.7%)
Native Hawaiian or Other Pacific Islander	16 (0.2%)	23 (0.2%)	16 (0.2%)	23 (0.2%)	78 (0.2%)
Unknown	8 (0.1%)	12 (0.1%)	6 (0.1%)	11 (0.1%)	37 (0.1%)
White	9233 (95.8%)	9192 (95.5%)	9229 (95.7%)	9249 (95.4%)	36903 (95.6%)
Ethnicity					
Hispanic or Latino	339 (3.5%)	406 (4.2%)	354 (3.7%)	362 (3.7%)	1461 (3.8%)
Not Hispanic or Latino	9289 (96.4%)	9196 (95.6%)	9272 (96.2%)	9314 (96.1%)	37071 (96.0%)
Unknown	12 (0.1%)	20 (0.2%)	15 (0.2%)	19 (0.2%)	66 (0.2%)

Note. Age refers to the age at time of enrollment. Demographic variables were obtained from the Geisinger electronic health record.

Supplementary Table 6. Baseline data for patients included in Study 2 analysis.

	Passive control (n = 8466)	Active control (n = 8522)	High risk only (n = 8498)	High risk medical records (n = 8470)	High risk algorithm (n = 8525)	Overall (n = 42481)
Age						
Mean (SD)	53.6 (19.6)	53.6 (19.7)	53.5 (19.8)	53.6 (19.6)	53.7 (19.9)	53.6 (19.7)
Median [Min, Max]	54.0 [18.0, 104]	55.0 [18.0, 103]	54.0 [18.0, 102]	55.0 [18.0, 100]	55.0 [18.0, 109]	54.0 [18.0, 109]
Sex						
Female	5670 (67.0%)	5794 (68.0%)	5746 (67.6%)	5740 (67.8%)	5816 (68.2%)	28766 (67.7%)
Male	2796 (33.0%)	2728 (32.0%)	2752 (32.4%)	2730 (32.2%)	2709 (31.8%)	13715 (32.3%)
Race						
American Indian or Alaska Native	11 (0.1%)	16 (0.2%)	10 (0.1%)	16 (0.2%)	15 (0.2%)	68 (0.2%)
Asian	26 (0.3%)	18 (0.2%)	22 (0.3%)	24 (0.3%)	26 (0.3%)	116 (0.3%)
Native Hawaiian or Other Pacific Islander	14 (0.2%)	12 (0.1%)	10 (0.1%)	15 (0.2%)	17 (0.2%)	68 (0.2%)
Black or African American	337 (4.0%)	277 (3.3%)	284 (3.3%)	316 (3.7%)	290 (3.4%)	1504 (3.5%)
White	8058 (95.2%)	8185 (96.0%)	8158 (96.0%)	8086 (95.5%)	8163 (95.8%)	40650 (95.7%)
Unknown	20 (0.2%)	14 (0.2%)	14 (0.2%)	13 (0.2%)	14 (0.2%)	75 (0.2%)
Ethnicity						
Hispanic or Latino	362 (4.3%)	335 (3.9%)	355 (4.2%)	336 (4.0%)	347 (4.1%)	1735 (4.1%)
Not Hispanic or Latino	8076 (95.4%)	8160 (95.8%)	8116 (95.5%)	8113 (95.8%)	8156 (95.7%)	40621 (95.6%)
Unknown	28 (0.3%)	27 (0.3%)	27 (0.3%)	21 (0.2%)	22 (0.3%)	125 (0.3%)

Note. Age refers to the age at time of enrollment. Demographic variables were obtained from the Geisinger electronic health record.

Supplementary Table 7. Baseline data for patients included in Study 3 analysis.

	Passive control (n = 7823)	Active control (n = 7840)	High risk only (n = 7809)	High risk medical records (n = 7797)	High risk algorithm (n = 7860)	Overall (n = 39129)
Age						
Mean (SD)	52.9 (19.6)	53.5 (19.7)	53.2 (19.7)	52.3 (19.6)	53.2 (19.6)	53.0 (19.7)
Median [Min, Max]	54.0 [18.0, 101]	55.0 [18.0, 103]	54.0 [18.0, 107]	53.0 [18.0, 100]	54.0 [18.0, 108]	54.0 [18.0, 108]
Sex						
Female	4936 (63.1%)	4828 (61.6%)	4921 (63.0%)	4906 (62.9%)	4886 (62.2%)	24477 (62.6%)
Male	2887 (36.9%)	3012 (38.4%)	2888 (37.0%)	2891 (37.1%)	2974 (37.8%)	14652 (37.4%)
Race						
American Indian or Alaska Native	16 (0.2%)	17 (0.2%)	22 (0.3%)	13 (0.2%)	17 (0.2%)	85 (0.2%)
Asian	34 (0.4%)	29 (0.4%)	35 (0.4%)	46 (0.6%)	42 (0.5%)	186 (0.5%)
Native Hawaiian or Other Pacific Islander	20 (0.3%)	31 (0.4%)	37 (0.5%)	25 (0.3%)	32 (0.4%)	145 (0.4%)
Black or African American	304 (3.9%)	320 (4.1%)	302 (3.9%)	296 (3.8%)	322 (4.1%)	1544 (3.9%)
White	7397 (94.6%)	7379 (94.1%)	7374 (94.4%)	7376 (94.6%)	7373 (93.8%)	36899 (94.3%)
More Than One Race	1 (0.0%)	2 (0.0%)	1 (0.0%)	0 (0%)	1 (0.0%)	5 (0.0%)
Unknown	51 (0.7%)	62 (0.8%)	38 (0.5%)	41 (0.5%)	73 (0.9%)	265 (0.7%)
Ethnicity						
Hispanic or Latino	399 (5.1%)	391 (5.0%)	411 (5.3%)	400 (5.1%)	415 (5.3%)	2016 (5.2%)
Not Hispanic or Latino	7382 (94.4%)	7397 (94.3%)	7354 (94.2%)	7360 (94.4%)	7403 (94.2%)	36896 (94.3%)
Unknown	42 (0.5%)	52 (0.7%)	44 (0.6%)	37 (0.5%)	42 (0.5%)	217 (0.6%)

Note. Age refers to the age at time of enrollment. Demographic variables were obtained from the Geisinger electronic health record.

Supplementary Table 8. Baseline data for patients included in Study 4 analysis.

	Passive control (n = 4855)	Letter (n = 4873)	Portal (n = 4860)	SMS (n = 4865)	Portal + SMS (n = 4863)	Letter + portal + SMS (n = 4870)	Overall (n = 29186)
Age							
Mean (SD)	52.1 (18.2)	52.0 (18.0)	51.4 (18.4)	51.8 (18.4)	51.5 (18.2)	52.1 (18.1)	51.8 (18.2)
Median [Min, Max]	52.0 [18.0, 101]	53.0 [18.0, 101]	51.0 [18.0, 101]	52.0 [18.0, 103]	51.0 [18.0, 100]	52.5 [18.0, 98.0]	52.0 [18.0, 103]
Sex							
Female	3482 (71.7%)	3434 (70.5%)	3421 (70.4%)	3436 (70.6%)	3446 (70.9%)	3397 (69.8%)	20616 (70.6%)
Male	1373 (28.3%)	1439 (29.5%)	1439 (29.6%)	1429 (29.4%)	1417 (29.1%)	1473 (30.2%)	8570 (29.4%)
Race							
American Indian or Alaska Native	12 (0.2%)	8 (0.2%)	18 (0.4%)	10 (0.2%)	14 (0.3%)	18 (0.4%)	80 (0.3%)
Asian	10 (0.2%)	10 (0.2%)	17 (0.3%)	24 (0.5%)	19 (0.4%)	12 (0.2%)	92 (0.3%)
Native Hawaiian or Other Pacific Islander	16 (0.3%)	20 (0.4%)	14 (0.3%)	9 (0.2%)	14 (0.3%)	12 (0.2%)	85 (0.3%)
Black or African American	169 (3.5%)	176 (3.6%)	165 (3.4%)	188 (3.9%)	176 (3.6%)	184 (3.8%)	1058 (3.6%)
White	4607 (94.9%)	4624 (94.9%)	4620 (95.1%)	4601 (94.6%)	4603 (94.7%)	4611 (94.7%)	27666 (94.8%)
More Than One Race	2 (0.0%)	0 (0%)	0 (0%)	0 (0%)	1 (0.0%)	0 (0%)	3 (0.0%)
Unknown	39 (0.8%)	35 (0.7%)	26 (0.5%)	33 (0.7%)	36 (0.7%)	33 (0.7%)	202 (0.7%)
Ethnicity							
Hispanic or Latino	226 (4.7%)	248 (5.1%)	247 (5.1%)	234 (4.8%)	228 (4.7%)	222 (4.6%)	1405 (4.8%)
Not Hispanic or Latino	4595 (94.6%)	4592 (94.2%)	4585 (94.3%)	4597 (94.5%)	4599 (94.6%)	4623 (94.9%)	27591 (94.5%)
Unknown	34 (0.7%)	33 (0.7%)	28 (0.6%)	34 (0.7%)	36 (0.7%)	25 (0.5%)	190 (0.7%)

Note. This table only includes patients analyzed in the primary analysis sample, which included patients who were eligible for letters, portal messages, and SMS messages. Age refers to the age at time of enrollment. Demographic variables were obtained from the Geisinger electronic health record.

4 Additional patients enrolled in Study 1

Household members of patients in the top 10% of risk were considered enrolled in Study 1 to test for possible spillover effects of our intervention. The primary outcome for these patients is reported on ClinicalTrials.gov. There were no statistically significant spillover effects.

Additionally, patients in the top 11–20% of risk were enrolled to assess baseline flu vaccination rates in patients just below the risk threshold used for the intervention. The flu vaccination rate for this group during the primary outcome time frame was 45.64%.

5 Enrollment across studies

Supplementary Table 9. The proportion of overlap among enrolled patients in Studies 1–4.

		Proportion of patients enrolled in...			
		Study 1 (2020–2021)	Study 2 (2021–2022)	Study 3 (2022–2023)	Study 4 (2022–2023)
Who were also enrolled in...	Study 1 (2020–2021)	-	0.56	0.20	0.50
	Study 2 (2021–2022)	0.54	-	0.22	0.51
	Study 3 (2022–2023)	0.18	0.19	-	0
	Study 4 (2022–2023)	0.46	0.49	0	-

Note. Study 4 (reported in SI section 7) and Study 3 were conducted in the same flu season on patients in separate risk strata. Therefore, there was no overlap in enrollment across these samples

6 Adverse events

6.1 Contraindications

In Studies 1 and 2, our exclusion criteria listed “Has contraindications for flu vaccination.” In both studies, we unintentionally failed to remove a small number of patients contraindicated for flu vaccines from the sample before the outreach. The error was discovered after letters were sent in Study 2. After the error was discovered (after letters were sent, but before the patient portal or SMS messages outreach), we removed the patients (n = 563) completely from the study, including from all analyses. We later learned the error had occurred in Study 1 as well, after the original data set had been analyzed. We excluded these patients from analysis in the present manuscript (n = 589). Before beginning Studies 3 and 4, we consulted with infectious disease leadership, who felt there were almost no true contraindications to the current vaccines, and clinical staff could be trusted to do the necessary flagging of patients at the time of vaccination. We decided not to exclude patients with contraindications in these two studies,

but messages included a disclaimer recommending patients talk to their provider if they did not think they should get a flu shot.

6.2 Protective risk reasons

In Study 2, subject characteristics that were protective against high risk outcomes were unintentionally included in messages for 327 patients, but almost all of the reasons communicated were appropriate contributors to high risk. That is, one or two of the reasons listed for these patients' high-risk determination were protective against flu, despite patients' overall high-risk designation by the model. The error was discovered prior to sending portal messages and SMS messages. Because the initial messages may have been confusing and were not the precise messages originally intended, the patients were removed from the study and from the primary analysis sample, but we report preregistered robustness checks including these patients as follows. For consistency across groups, for study conditions where patients did not receive risk reasons, we determined which patients would have been excluded from the study had they been assigned to a condition with reasons and removed those patients ($n = 489$) from analysis.

6.3 Letter signatures

In Study 2, letters were signed by the patient's PCP or by a Geisinger clinical leader for patients who did not have a PCP assigned. Due to a coding error, 4,099 patients' letters were signed by PCPs who do not work at Geisinger. These patients were not sent portal or SMS messages, but they were included in all analyses.

7 Study 4: Risk Messaging Modalities RCT

Study 4, like Study 3, was conducted in the 2022–23 flu season. As in Studies 1 and 2, we sent messages to patients in the top 10% of risk. However, instead of varying the message content, we varied and tested the relative effectiveness of message *modalities* (letter, patient portal message, SMS text message). In Studies 1–3, all patients received high-risk messages in all modalities for which they were eligible, so it was unclear whether all modalities were similarly or cumulatively effective, or whether some were unnecessary or less effective.

7.1 Methods

Study 4 was determined by the Geisinger IRB to be a health care operations project that did not constitute human subjects research (IRB submission 2022-0373). It was originally preregistered on ClinicalTrials.gov (<https://clinicaltrials.gov/study/NCT05509270>) on August 19, 2022.

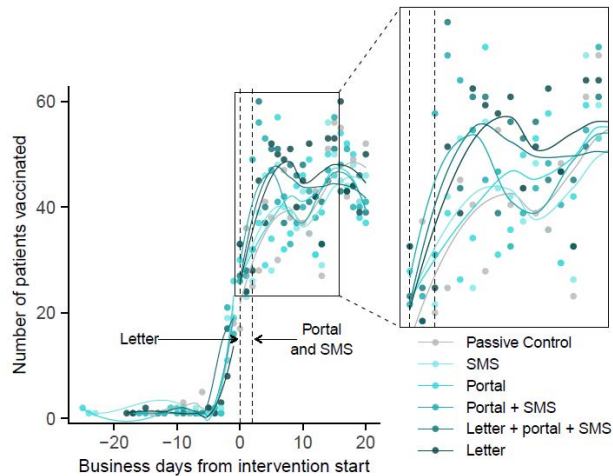
7.1.1 Materials and Procedure

Patients were first divided into the following groups according to the modalities for which they were eligible: letter + portal + SMS (29,505 patients), letter + portal (4,980 patients), letter only (4,366 patients), letter + SMS (4,364 patients), portal + SMS (8 patients), or SMS only (2 patients). No eligible patients had only patient portal access.

Then, each modality group was randomized evenly, using parallel random assignment (using the *complete_ra* function in the R *randomizr*¹ package) across study conditions for which the patients were eligible: (1) passive control, (2) letter only, (3) patient portal only, (4) SMS only, (5) patient portal + SMS, and/or (6) letter + patient portal + SMS. For example, patients eligible to receive a letter and an SMS were randomized to passive control, letter only, or SMS only. Due to power limitations, we did not test all possible combinations of modalities (e.g., we did not include a letter + SMS study condition).

Messages were the same as in the Study 3, high risk medical records condition, but patients were told they were in the “top 3% of risk” or the “top 10% of risk” (for those in the top 4–10%) based on their risk level. See SI section 11 for full study materials.

In order to compare the modalities as closely as possible, we timed message sends in hopes of them arriving on the same day. Therefore, modalities were sent at a condensed time scale relative to Studies 1–3. Print letters were sent on 9/6/2023, followed two days later by patient portal messages and SMS messages on 9/8/2023 (Supplementary Fig. 5), based on advice from Geisinger’s mail room that letters typically take about two days to arrive in the Geisinger service area.



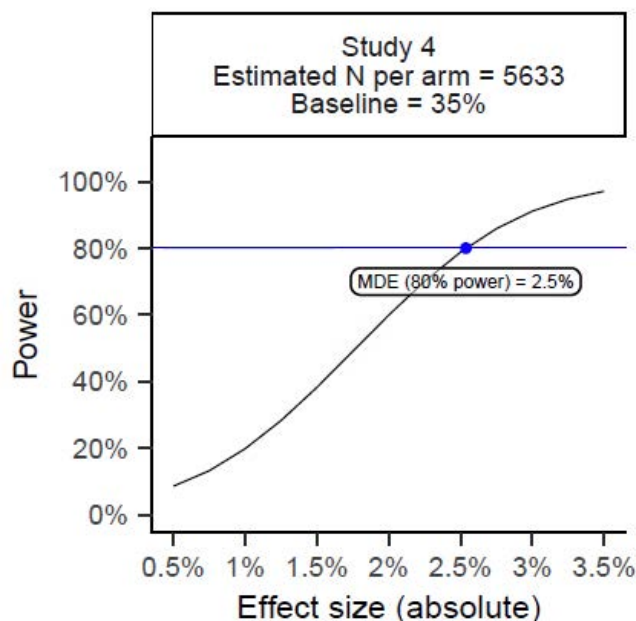
Supplementary Fig. 5. Study 4 vaccination timing.

The number of patients vaccinated by study arm for each day relative to the intervention start date overlaid with local-linear regression lines estimated separately before (8/1/2022–9/5/2022) and after (9/6/2022–10/4/2022) the intervention start date. Send dates for each modality are indicated by the vertical, dotted lines. Sample sizes for the arms are as follows: passive control $n = 4,855$, SMS $n = 4,865$, portal $n = 4,860$, portal + SMS $n = 4,863$, letter + portal + SMS $n = 4,870$, letter $n = 4,873$.

7.1.2 Statistical Power

We expected to enroll about 33,800 patients who were eligible for the primary analysis sample (i.e., those eligible for outreach via all three modalities—letter, patient portal, and SMS). Study 4 had a relatively lower expected sample size for this primary analysis and required more arms to test questions of interest. Having observed a 2.6 percentage-point effect in Study 2 comparing high-risk messages with passive control, we felt comfortable powering for a 2.5 percentage-point effect in Study 4, where all messages informed patients they were at high risk. We therefore planned a study with 6 arms and about 5,633 patients per arm. This sample size would have provided 80% power to detect a 2.5 percentage-point difference in vaccination between any 2 arms, assuming a baseline vaccination rate of 35%, with two-tailed $p < .05$ (Supplementary Fig. 6).

There were 29,505 patients enrolled who were eligible for all three modalities. The primary analysis sample ultimately included 29,186 patients, with a minimum of 4,855 patients per arm. The baseline vaccination rate was 18.1%. The analysis sample allowed at least 80% power to detect a 2.7 percentage-point increase in vaccination with two-tailed $p < .05$.



Supplementary Fig. 6. Study 4 power sensitivity analysis.

This study was powered to detect MDEs at or above 2.5 percentage points, consistent with previous nudge literature.

7.1.3 Analysis

The preregistered primary outcome time frame was 29 days, from September 6, 2022 through October 4, 2022. This timeframe was shorter than Studies 1–3 because all messages were sent within two days, whereas the outreach was more protracted in the other studies.

As with Studies 2–3, we preregistered and reported Ordinary Least Squares (OLS) regressions for Study 4.

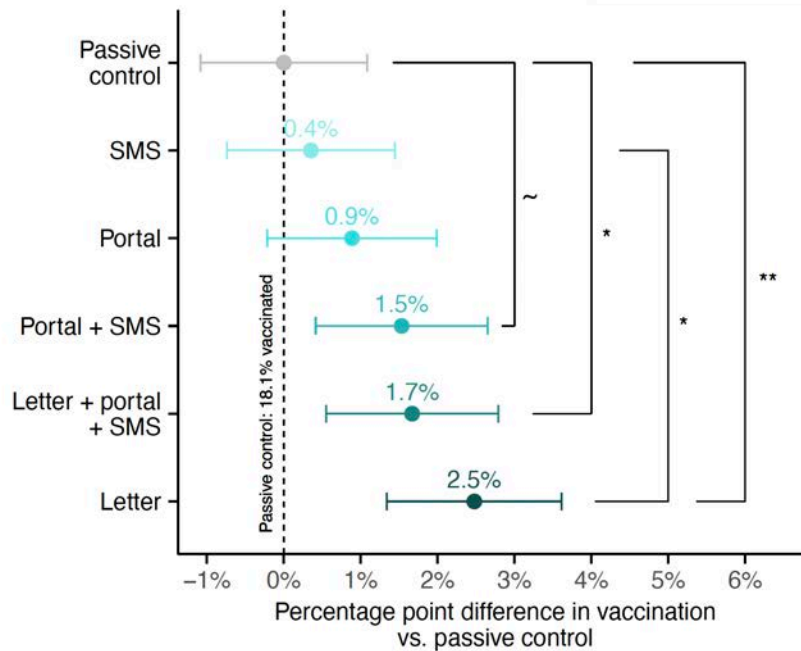
The primary analysis sample ($n = 29,186$) included only patients who were eligible for all three modalities. Analyses of other modality groups can be found in the Web Appendix Section 5.5.

Analysis exclusion criteria

There were 516 patients who were vaccinated prior to the study starting. These patients were excluded from analysis, per our Statistical Analysis Plan.

7.2 Results

Results for the primary outcome are shown in Supplementary Fig. 7. Compared with the passive control group (vaccination rate = 18.1%), patients sent only a letter were 2.5 percentage points more likely to be vaccinated within four weeks of the first messages being sent ($b = 0.025$ [95% CI: 0.009, 0.040], $t(29180) = 3.096$, $p = .002$). Those sent a letter, portal message, and SMS were 1.7 percentage points more likely to be vaccinated than passive control ($b = 0.017$ [95% CI: 0.001, 0.032], $t(29180) = 2.085$, $p = .037$).



Supplementary Fig. 7. Study 4 difference in vaccination from passive control.

Vaccination rates during the primary outcome time frame, from 9/6/2022 through 10/4/2022 (29 days, inclusive) for each arm. Arms are ordered by intervention effectiveness. Sample sizes for the arms are as follows: passive control $n = 4,855$, SMS $n = 4,865$, portal $n = 4,860$, portal + SMS $n = 4,863$, letter + portal + SMS $n = 4,870$, letter $n = 4,873$. Note: ~ $p < .1$, * $p < .05$, ** $p < .01$; Letter vs Passive control: OLS regression, $b = 0.025$ [95% CI: 0.009, 0.040], $t(29180) = 3.096$, uncorrected, two-tailed $p = .002$; Letter + Portal + SMS vs. Passive control: OLS regression, $b = 0.017$ [95% CI: 0.001, 0.032], $t(29180) = 2.085$, uncorrected two-tailed $p = .037$; Portal + SMS vs. Passive control: OLS regression, $b = 0.015$ [95% CI: -0.000, 0.031], $t(29180) = 1.915$, uncorrected two-tailed $p = .056$; Letter vs. SMS: OLS regression $b = 0.021$, [95% CI: 0.002, 0.040], $t(14595) = 2.652$, two-tailed $p = .022$, Tukey-corrected for multiple pairwise comparisons between individual modality arms (SMS, Portal, Letter). Error bars indicate 95% confidence intervals. Note: percentages are rounded.

Patients sent a portal message and SMS were not more likely to get vaccinated than passive control (1.5 percentage-point increase; $b = 0.015$ [95% CI: -0.000, 0.031], $t(29180) = 1.915$, $p = .056$). Neither SMS nor portal messages alone yielded significant increases in vaccination relative to passive control (SMS: $b = 0.004$ [95% CI: -0.012, 0.019], $t(29180) = 0.441$, $p = .659$; Portal: $b = 0.009$ [95% CI: -0.007, 0.025], $t(29180) = 1.107$, $p = .268$).

Next, we tested whether vaccination rates significantly differed among any of the individual communication modality groups (letter, portal, SMS). An OLS regression revealed that letters were significantly more effective than SMS after applying Tukey's HSD test for multiple comparisons ($b = 0.021$, [95% CI: 0.002, 0.040], $t(14595) = 2.652$, $p = .022$). There was not a significant difference in vaccination rates between letters and portal messages ($b = 0.016$, [95% CI: -0.003, 0.035], $t(14595) = 1.985$, $p = .116$) or between portal messages and SMS ($b = .005$, [95% CI: -0.013, 0.024], $t(14595) = 0.665$, $p = .784$).

In a separate OLS regression, we found that an SMS and a portal message combined were not significantly more effective than sending a message via either modality alone (portal vs. portal + SMS: $b = 0.006$, [95% CI: -0.009, 0.022], $t(14595) = 0.811$, $p = .417$; SMS vs. portal

+ SMS: $b = 0.012$, [95% CI: -0.004, 0.027], $t(14595) = 1.481$, $p = .139$). Finally, yet another regression suggested that there is not added utility to sending a letter in addition to portal + SMS messages (OLS regression comparing portal + SMS and letter + portal + SMS groups: $b = 0.001$, [95% CI: -0.014, 0.017], $t(9731) = 0.168$, $p = .866$).

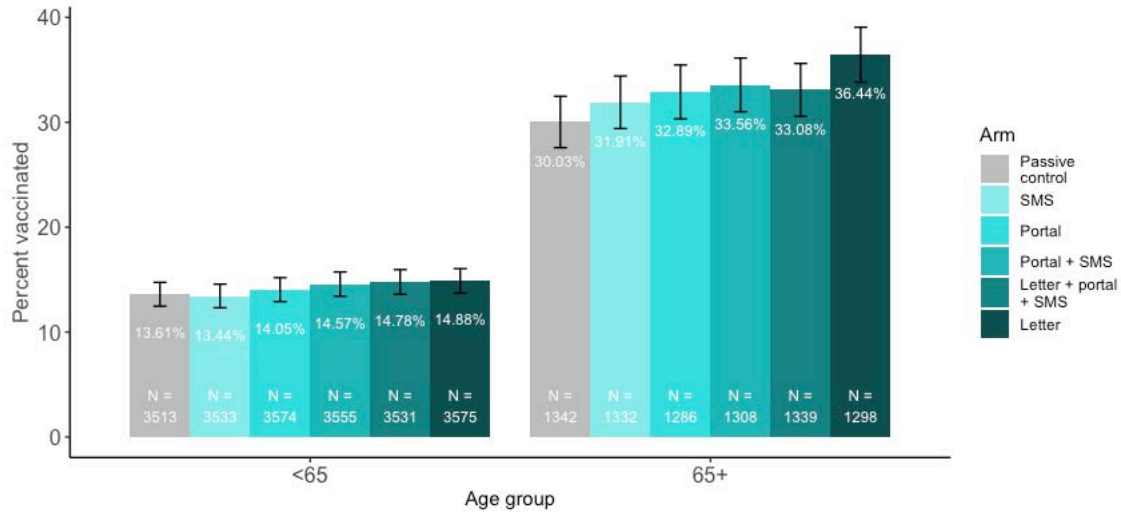
Within the primary analysis sample, we tested whether patients ages 65+ reacted differently to study arms compared with patients under age 65. We tested for an interaction between study arm and age group (65+ vs. under 65).

Regression results are shown in Supplementary Table 10. Patients ages 65+ ($n = 7,905$) were 16.4 percentage points more likely to get vaccinated than patients under age 65 ($n = 21,281$) in the passive control arm (Supplementary Fig. 8). Additionally, there was a significant interaction effect such that letters (compared with passive control) boosted vaccination an additional 5.1 percentage points in patients over age 65 compared with younger patients.

Supplementary Table 10. Study 4 OLS regression results for vaccination by age group (65+ vs. under 65) in the primary analysis sample.

Predictors	Estimates	95% CI	<i>t</i>	<i>df</i>	<i>p</i>
(Intercept)	0.136	0.123 – 0.149	20.910	29174	<0.001
Study arm: SMS	-0.002	-0.020 – 0.016	-0.176	29174	0.860
Study arm: Portal	0.004	-0.014 – 0.022	0.479	29174	0.632
Study arm: Portal + SMS	0.010	-0.008 – 0.028	1.051	29174	0.293
Study arm: Letter + portal + SMS	0.012	-0.006 – 0.030	1.280	29174	0.200
Study arm: Letter	0.013	-0.005 – 0.031	1.391	29174	0.164
Age 65+	0.164	0.140 – 0.188	13.269	29174	<0.001
Study arm: SMS * Age 65+	0.020	-0.014 – 0.055	1.164	29174	0.245
Study arm: Portal * Age 65+	0.024	-0.010 – 0.059	1.375	29174	0.169
Study arm: Portal + SMS * Age 65+	0.026	-0.009 – 0.060	1.462	29174	0.144
Study arm: Letter + portal + SMS * Age 65+	0.019	-0.016 – 0.053	1.073	29174	0.283
Study arm: Letter * Age 65+	0.051	0.017 – 0.086	2.920	29174	0.004

Note. The reference group for the study arm variable is passive control. Age is a binary variable coded as 1 for patients ages 65+ and 0 for patients under age 65.



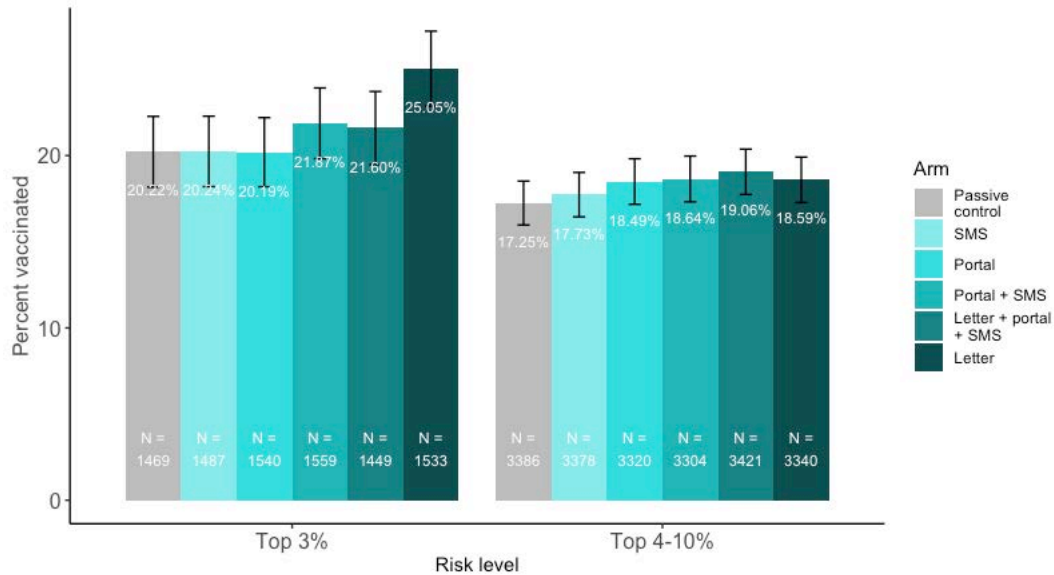
Supplementary Fig. 8. Vaccination rate as a function of age group and message arm in Study 4. Percentage of patients who were vaccinated in the primary outcome time frame by age group and arm in the primary analysis sample. Error bars represent 95% confidence intervals.

We ran a preregistered OLS regression to test whether the most effective modality or modalities varied by risk level (top 3% or top 4–10%). We found a significant interaction between study arm and risk level, such that letters were more effective for those in the top 3% compared with those in the top 4–10% (Supplementary Table 11 and Supplementary Fig. 9).

Supplementary Table 11. Study 5 OLS regression results for vaccination by study arm and risk level.

Predictors	Estimates	95% CI	<i>t</i>	<i>df</i>	<i>p</i>
(Intercept)	0.202	0.182 – 0.222	19.653	29174	<0.001
Study arm: SMS	0.000	-0.028 – 0.029	0.017	29174	0.987
Study arm: Portal	-0.000	-0.028 – 0.028	-0.016	29174	0.987
Study arm: Portal + SMS	0.017	-0.012 – 0.045	1.154	29174	0.248
Study arm: Letter + portal + SMS	0.014	-0.015 – 0.042	0.948	29174	0.343
Study arm: Letter	0.048	0.020 – 0.077	3.356	29174	0.001
Risk Level	-0.030	-0.054 – -0.006	-2.411	29174	0.016
Study arm: SMS * Risk Level	0.005	-0.029 – 0.039	0.265	29174	0.791
Study arm: Portal * Risk Level	0.013	-0.021 – 0.047	0.734	29174	0.463
Study arm: Portal + SMS * Risk Level	-0.003	-0.036 – 0.031	-0.150	29174	0.881
Letter + portal + SMS * Risk Level	0.004	-0.030 – 0.038	0.245	29174	0.806
Study arm: Letter * Risk Level	-0.035	-0.069 – -0.001	-2.013	29174	0.044

Note. The reference group for study arm is passive control. Risk level is a binary variable coded as 0 for top 3% and 1 for top 4-10%.



Supplementary Fig. 9. Vaccination rate as a function of risk level and study arm in Study 4.

The percent of patients in each risk level and study arm who were vaccinated during the primary outcome time frame. Error bars represent 95% confidence intervals.

7.3 Discussion

Among patients with access to all modalities, formal messages sent via letters appeared to be the most effective, generally outperforming the digital modalities (patient portal and SMS messages) in increasing vaccination. Although text messages can often be salient as they interrupt attention on mobile devices, perhaps the formality of the communication in the letters—familiar to patients accustomed to receiving other important healthcare communications via this modality—was particularly effective.² Additionally, our results are aligned with prior work suggesting paper letters are more effective nudges than electronic communications, especially for older adult populations.³ Therefore, despite the added costs of printing and mailing, it may not be advisable to send risk communications only via SMS or patient portal messages. Unexpectedly, letters were more effective than the combination of letters, portal messages, and SMS messages in Study 4. An important caveat is that the combinations of modalities were executed nearly simultaneously in Study 4, to facilitate a fair comparison across the three modalities. In contrast, the messages and modalities in Studies 1–3 were spaced out over several weeks so as not to inundate recipients all at once. Therefore, it remains an open question whether a letter alone is as or more effective than sending messages in different modalities across a protracted timeline.

8 Additional analyses

This section includes additional analyses of the primary vaccination outcome for each study that *were referenced* in the main text. For additional analyses that were not referenced in the main text, see the OSF Web Appendix (available at <https://osf.io/mqbux/>).

All preregistered analyses of the primary outcome are included here or in the Web Appendix. Note that preregistered analyses differed across studies.

8.1 Study 1

8.1.1 Logistic regression analyses

Our preregistration for Study 1 stated that we would run logistic regressions. However, OLS regressions are preferable to logistic regressions with dichotomous predictor variables because coefficients directly reflect the average treatment effects in terms of probability changes, whereas in logistic regressions they do not.⁴ Moreover, average treatment effects and *p*-values from OLS and logistic regressions are nearly identical in situations with categorical predictor variables and large samples, such as our studies.^{4,5} For these reasons, preregistered analyses for Studies 2–4 were OLS regressions. To keep analysis methods consistent within the main text, we report OLS regressions for all four studies.

Supplementary Tables 12–14 report the preregistered logistic regression analyses for Study 1. As expected, *p*-values were identical between OLS and logistic regressions to 3 decimal places. Note that our preregistration stated that we would use the Holm procedure to adjust *p*-values for multiple comparisons. Uncorrected *p*-values are reported below. None of the comparisons were significant uncorrected or according to the Holm method. The main text reports Tukey HSD-corrected *p*-values for this analysis. The uncorrected *p*-values from the OLS regressions are the same as the uncorrected *p*-values listed in Supplementary Table 13.

Supplementary Table 12. Study 1 logistic regression results for vaccination by study arm.

Predictors	Odds Ratio	95% CI	<i>p</i>
(Intercept)	1.034	0.994 – 1.650	.099
High risk messages	1.071	1.023 – 1.122	.004

Note. High risk messages is a binary variable coded as 1 for patients in any high-risk arm (high risk only, high risk medical records, high risk algorithm) and 0 for patients in the passive control arm.

Supplementary Table 13. Study 1 logistic regression results for vaccination by high risk study arm – pairwise comparisons.

Predictors	Odds Ratio	95% CI	Uncorrected <i>p</i>
Study arm: High risk medical records vs. high risk algorithm	1.101	1.058 – 1.146	.714
Study arm: High risk medical records vs passive control	1.015	0.959 – 1.074	.613
Study arm: Passive control vs. high risk algorithm	1.004	0.949 – 1.062	.889

Supplementary Table 14. Study 1 logistic regression results for vaccination by communicated risk levels.

Predictors	Odds Ratio	95% CI	<i>p</i>
(Intercept)	1.112	1.070 – 1.157	< .001
Risk condition: top 3% vs. top 10%	1.031	0.973 – 1.092	.301
Risk condition: high risk vs. top 10%	0.963	0.912 – 1.018	.181

Note. This regression includes only patients who were sent risk communications. Risk condition is a categorical variable with 3 levels: top 3% for patients in the top 3% of risk, and top 10% or high risk for patients in the top 10% of risk.

8.1.2 Vaccination timing

We compared the average time to get vaccinated between vaccinated patients who were sent any message and those in the passive control arm in an OLS regression, with time specified as the number of days since the beginning of the intervention. Among vaccinated patients in Study 1, those informed of their risk status ($n = 15,129$) were vaccinated a mean of 2.71 days sooner than those not informed ($n = 4,901$; OLS regression including patients who were vaccinated: $b = 2.713$ [95% CI: 1.607, 3.820], $t(20118) = 4.805$, $p < .001$; Fig. 1A in the main text).

We additionally explored whether timing differed across intervention arms in an OLS regression including only vaccinated patients who also received messages ($n = 15,219$). Patients in the high risk medical records arm were vaccinated 1.67 days earlier than patients in the high risk only condition (corrected using Tukey's HSD: $b = 1.665$ [95% CI: 0.091, 3.240], $t(15216) = 2.479$, $p = .035$). Neither of the other pairwise comparisons among arms reached significance after Tukey's HSD correction (high risk algorithm vs. high risk only: $b = 1.33$ [95% CI: -0.242, 2.910], $t(15216) = 1.984$, $p = .116$; high risk algorithm vs. high risk medical records: $b = 0.333$ [95% CI: -1.240, 1.904], $t(15216) = 0.496$, $p = .873$).

8.1.3 Risk level

We performed additional preregistered analyses to assess whether risk message effectiveness varied as a function of risk level. First, we evaluated whether risk messages overall were differently effective for patients in the top 3% of risk compared with those in the top 4–10% of risk. An OLS regression indicated that there was not a significant interaction between risk level and whether patients were sent risk messages ($b = 0.009$, 95% CI [-0.017, 0.034], $t(38594) = 0.666$, $p = .505$).

Second, we tested whether the way in which risk information was communicated in messages (i.e., whether patients were told they were in the top 3% of risk, top 10% of risk, or high risk) moderated the effectiveness of the individual message types (high risk only, high risk medical records, high risk algorithm) among patients who were sent messages. An OLS regression that included the interaction term did not explain significantly more variance than an OLS regression that included main effects of risk communication and individual message types (ANOVA comparing the regression without and with the interaction term: $F(4,28949) = 0.860$, $p = .484$).

8.1.4 Intent-to-treat robustness check

In an exploratory robustness check, we reran regressions testing the effectiveness of risk messages including patients who were already vaccinated prior to the study ($n = 7,415$). Results did not change meaningfully from those reported in the main manuscript. The primary outcome in the passive control group was 42.6%. Patients sent high-risk messages were 1.6 percentage points more likely to get a flu vaccine compared with those in passive control (OLS regression: $b = .016$, [95% CI: 0.005, 0.026], $t(46011) = 2.920$, $p = .004$). None of the high-risk arms significantly differed from one another (OLS regression with Tukey HSD correction: High risk only vs. high risk medical records: $b = 0.003$, [95% CI: -0.012, 0.019], $t(34494) = 0.504$, $p = .869$; high risk only vs. high risk algorithm: $b = 0.003$, [95% CI: -0.012, 0.019], $t(34494) = 0.485$, $p = .878$; high risk medical records vs. high risk algorithm: $b = 0.000$, [95% CI: -0.015, 0.015], $t(34494) = 0.019$, $p = .999$).

8.1.5 29-day vaccination

The preregistered primary outcome time frame varied across studies. The Study 1 time frame was 253 days. As a robustness check, we reran the key analyses with the Study 4 (SI section 7) time frame of 29 days. These results must be interpreted with caution as this was not the preregistered time frame. However, all interventions were administered by day 18 of the study, so 29 days is sufficient to capture at least some effect of all intervention messages.

At 29 days post-study start, the vaccination rate in the passive control arm was 28.6%. There was a significant difference between passive control and high-risk arms combined ($b = 0.027$, [95% CI: 0.016, 0.039], $t(38596) = 4.989$, $p < .001$). There was no difference among high-risk arms (high risk only vs. high risk medical records: $b = .009$, [95% CI: -0.007, 0.024], $t(28955) = 1.321$, $p = .383$; high risk only vs. high risk algorithm: $b = 0.006$, [95% CI: -0.010, 0.022], $t(28955) = 0.919$, $p = .628$; high risk medical records vs. high risk algorithm: $b = 0.003$, [95% CI: -0.013, 0.018], $t(28955) = 0.404$, $p = .914$).

8.1.6 Modality eligibility by arm

Supplementary Table 15. Study 1 modalities and modality combinations at enrollment for enrolled sample.

	Passive control	High risk only	High risk medical records	High risk algorithm	Uncorrected <i>p</i> -value for chi-square
Letter Only	19.7% (2301)	20.3% (2361)	19.6% (2280)	19.9% (2319)	.551
Letter+Portal	27.8% (3240)	27.0% (3143)	27.2% (3175)	26.5% (3089)	.193
Letter+SMS	12.0% (1402)	12.3% (1429)	11.7% (1360)	12.7% (1475)	.123
Letter+Portal+SMS	40.4% (4718)	40.4% (4697)	41.4% (4829)	40.8% (4756)	.311
Portal Only	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	
SMS Only	0.0% (2)	0.0% (3)	0.0% (1)	0.0% (1)	
Portal+SMS	0.0% (4)	0.1% (6)	0.1% (7)	0.0% (4)	
Total N	11667	11639	11652	11644	

Note. This table shows modality eligibility at randomization. Patients were excluded at this stage if they could not be contacted via any modality, so all patients were eligible for at least one modality. We did not run chi-square tests on the modality categories with few or no patients.

Supplementary Table 16. Study 1 actual study modalities for analysis sample.

	Passive control	High risk only	High risk medical records	High risk algorithm	Uncorrected <i>p</i> -value for chi-square
Letter Only	19.1% (1843)	20.0% (1927)	18.7% (1805)	19.4% (1882)	.133
Letter+Portal	26.7% (2576)	25.5% (2458)	26.2% (2523)	25.4% (2461)	.129
Letter+SMS	12.3% (1186)	12.4% (1189)	12.0% (1154)	12.9% (1254)	.232
Letter+Portal+SMS	41.8% (4029)	41.4% (3985)	42.2% (4072)	41.8% (4057)	.720
Portal Only	0.0% (0)	0.0% (16)	0.0% (21)	0.0% (6)	
SMS Only	0.0% (2)	0.0% (11)	0.0% (19)	0.0% (6)	
Portal+SMS	0.0% (4)	0.3% (29)	0.3% (27)	0.2% (19)	
No modalities	0.0% (0)	0.1% (7)	0.2% (20)	0.1% (10)	
Total N	9640	9622	9641	9695	

Note. Modalities in this table were assessed immediately prior to deployment of each modality. We did not run chi-square tests on the modality categories with few or no patients.

8.1.7 Vaccine data source by arm

Supplementary Table 17. Study 1 vaccine data source by arm.

	Passive control	High risk only	High risk medical records	High risk algorithm
Vaccinated: EHR data	4708 (96.1% of vaccinated pts.)	4852 (96.2% of vaccinated pts.)	4930 (96.9% of vaccinated pts.)	4912 (96.5% of vaccinated pts.)
Vaccinated: Non-EHR data	193 (3.9% of vaccinated pts.)	190 (3.8% of vaccinated pts.)	157 (3.1% of vaccinated pts.)	178 (3.5% of vaccinated pts.)
Not vaccinated	4739	4580	4554	4605
Total N	9640	9622	9641	9695

Note. There was no difference in data source across arms, $\chi^2(3) = 6.04$, $p = .110$; EHR = Electronic Health Record.

8.2 Study 2

8.2.1 Vaccination timing

We compared the average time to get vaccinated between vaccinated patients who were sent any message and those in the passive control arm with time specified as the number of days since the beginning of the intervention. Among vaccinated patients, those who were sent messages ($n = 11,495$) were vaccinated a mean of 1.63 days earlier than those who were not sent messages ($n = 2,668$; OLS regression including patients who were vaccinated, $b = 1.630$ [95% CI: 0.982, 2.278], $t(14161) = 4.929$, $p < .001$; Extended Data Fig. 2).

8.2.2 Intent-to-treat robustness check

As a preregistered robustness check, we reran regressions testing the effectiveness of risk messages with several groups that were excluded from our primary analyses: patients who were vaccinated before the study ($n = 1,096$), those sent protective risk reasons or who would have been sent protective risk reasons if they had been assigned to an arm with reasons in the message ($n = 816$), and those who died during the study ($n = 105$). Results did not meaningfully change. The primary outcome vaccination rate was 30.7% in the passive control group and 32.0% in the active control group. Patients sent high-risk messages were more likely to get vaccinated than patients sent active control messages (OLS regression: $b = .012$, [95% CI: 0.001, 0.023], $t(35579) = 2.114$, $p = .035$) and 2.5 percentage points more likely to get vaccinated than those in the passive control group (OLS regression: $b = .025$, [95% CI: 0.014, 0.037], $t(35588) = 4.427$, $p < .001$). There were again no differences among high-risk arms (OLS regression with Tukey HSD correction: High risk only vs. high risk medical records: $b = 0.006$, [95% CI: -0.011, 0.022], $t(26670) = 0.812$, $p = 0.696$; high risk only vs. high risk algorithm: $b = 0.009$, [95% CI: -0.007, 0.026], $t(26670) = 1.289$, $p = 0.401$; high risk medical records vs. high risk algorithm: $b = 0.003$, [95% CI: -0.013, 0.02], $t(26670) = 0.477$, $p = 0.882$).

8.2.3 Shared household member robustness check

Some patients in the study shared an address with at least one other patient in the study ($n = 7,480$), but we decided to randomize patients independently, without accounting for whether a household member was also in the study. Therefore, some patients may have been assigned to different groups from their household members. To ensure that the effect of experimental arms were not diluted by the inclusion of patients from different arms at the same address we ran a preregistered sensitivity analysis removing all patients who share an address with another patient in the study.

Results did not substantively change when these patients were excluded: patients sent high-risk messages were 1.5 percentage points more likely to get vaccinated than patients sent active control messages (OLS regression: $b = .015$, [95% CI: 0.002, 0.028], $t(28018) = 2.313$, $p = .021$). Those sent high-risk messages were 2.8 percentage points more likely to be vaccinated than those in the passive control group (OLS regression: $b = .028$, [95% CI: 0.015, 0.041], $t(27957) = 4.260$, $p < .001$).

8.2.4 Geisinger PCP covariate robustness check

We tested whether patients with a Geisinger PCP had different outcomes relative to those without a Geisinger PCP, as flu shot data in the Geisinger EHR may be less reliable from those with an external PCP.

Indeed, patients with a Geisinger PCP had significantly higher vaccination rates relative to those without a Geisinger PCP. In the regression testing for a difference between active control and high-risk messages, patients with a Geisinger PCP were 25.2 percentage points more likely to get vaccinated (OLS regression: $b = .252$, [95% CI: 0.239, 0.265], $t(34012) = 37.03$, $p < .001$). When including the Geisinger PCP covariate, the effect of sending risk messages is 0.3 percentage points higher compared with the regression in the main text without the covariate (1.4% vs. 1.1%; OLS regression: $b = .014$, [95% CI: 0.003, 0.025], $t(34012) = 2.418$, $p = .016$).

Similarly, in the regression comparing vaccination in passive control patients versus those sent high-risk messages, vaccination was 25.3 percentage points higher in those with a Geisinger PCP than those without one (OLS regression: $b = .253$, [95% CI: 0.240, 0.267], $t(33956) = 37.455$, $p < .001$). The effect of sending a risk message was 0.1 percentage points larger in the regression with the Geisinger PCP covariate (OLS regression: $b = .027$, [95% CI: 0.015, 0.026], $t(33956) = 4.62$, $p < .001$).

8.2.5 29-day vaccination

The preregistered primary outcome time frame varied across studies. The Study 2 time frame was 58 days. As a robustness check, we reran the key analyses with the Study 4 (SI section 7) time frame of 29 days. These results must be interpreted with caution as messages for Study 2 were sent as many as 43 days after the study began, so 29 days is not enough time to capture effects of the full intervention.

With this modified 29-day time frame, the vaccination rate was 17.0% in the passive control group. There were significant differences in vaccination between passive control and active control ($b = 0.028$ [95% CI: 0.016, 0.040], $t(16986) = 4.726$, $p < .001$) and between passive control and high-risk arms ($b = 0.030$, [95% CI: 0.020, 0.040], $t(42478) = 6.068$, $p < .001$). However, there was not a significant difference between active control and high-risk arms ($b = -0.002$, [95% CI: -0.012, 0., 0.008], $t(42478) = -0.400$, $p = .689$) or among high-risk arms (High risk only vs. high risk medical records: $b = 0.011$, [95% CI: -0.003, 0.025], $t(25490) = 1.752$, $p = .186$; high risk only vs. high risk algorithm: $b = 0.010$, [95% CI: -0.005, 0.024], $t(25490) = 1.579$, $p = .255$; high risk medical records vs. high risk algorithm: $b = 0.001$, [95% CI: -0.013, 0.015], $t(25490) = -.176$, $p = .983$).

8.2.6 Modality eligibility by arm

Supplementary Table 18. Study 2 modality eligibility at enrollment for enrolled sample.

	Passive control	Active control	High risk only	High risk medical records + reasons	High risk algorithm + reasons	Uncorrected <i>p</i> -value for chi-square
Letter Only	16.3% (1472)	15.9% (1436)	16.3% (1466)	17.0% (1529)	16.6% (1498)	.393
Letter+Portal	29.1% (2628)	29.7% (2680)	29.9% (2692)	29.1% (2623)	29.0% (2617)	.616
Letter+SMS	9.8% (883)	9.5% (856)	9.6% (863)	9.5% (856)	9.3% (841)	.881
Letter+Portal+SMS	44.6% (4021)	44.8% (4038)	44.2% (3982)	44.3% (3984)	44.9% (4049)	.828
Portal Only	0.0% (6)	0.0% (1)	0.0% (3)	0.0% (2)	0.0% (0)	
SMS Only	0.0% (1)	0.0% (1)	0.0% (3)	0.0% (2)	0.0% (5)	
Portal+SMS	0.1% (6)	0.0% (1)	0.0% (2)	0.1% (7)	0.1% (7)	
Total N	9017	9013	9011	9003	9017	

Note. This table shows modality eligibility at randomization. Patients were excluded at this stage if they could not be contacted via any modality, so all patients were eligible for at least one modality. We did not run chi-square tests on the modality categories with few or no patients.

Supplementary Table 19. Study 2 actual study modalities for analysis sample.

	Passive control	Active control	High risk only	High risk medical records + reasons	High risk algorithm + reasons	Uncorrected <i>p</i> -value for chi-square
Letter Only	26.8% (2267)	25.3% (2153)	26.3% (2239)	27.1% (2295)	27.2% (2318)	.030
Letter+Portal	10.2% (861)	9.8% (833)	10.2% (865)	10.3% (869)	9.9% (840)	.776
Letter+SMS	10.1% (854)	9.9% (846)	9.3% (793)	10.0% (844)	9.6% (822)	.470
Letter+Portal+SMS	52.8% (4472)	54.8% (4671)	53.7% (4565)	52.3% (4428)	53.0% (4518)	.011
Portal Only	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (2)	
SMS Only	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	
Portal+SMS	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	
No modalities	0.1% (12)	0.2% (19)	0.4% (36)	0.4% (34)	0.3% (25)	
Total N	8466	8522	8498	8470	8525	

Note. Due to logistical challenges, portal messages were modified such that they mentioned the letters, so we decided to only send portal messages to those who were sent a letter and for whom it was not returned at that point. We also decided to send SMS to those who were sent a letter. Two patients were sent a letter and subsequently a portal message, but the letter was returned after the portal message was already sent. We did not send these patients an SMS, so there were two Portal-only patients. There was a total of 126 patients who did not end up getting messages in any modalities. A robustness check without these patients (Web Appendix section 3.5.1) showed that the results did not differ when these patients were removed from analysis. We did not run chi-square tests on the modality categories with few or no patients.

The distribution of eligibility for Letter only and Letter + portal + SMS was significantly different across arms (though when corrected for multiple comparisons across the 4 tests run, only Letter + portal + SMS was significant at $p = .044$). To follow up on this, we ran a regression to test whether the key effects were significant controlling for modality group (excluding the handful of patients who were eligible for Portal only or no modalities). High risk messages (coded as baseline here) were significantly more effective than active or passive control (Supplementary Table 20).

Supplementary Table 20. Study 2 modality robustness check.

Predictors	Estimates	95% CI	<i>t</i>	<i>df</i>	<i>p</i>
(Intercept)	0.251	0.242 – 0.260	52.728	42347	<0.001
Modalities: Letter + portal vs. Letter only	0.210	0.194 – 0.227	25.044	42347	<0.001
Modalities: Letter + SMS vs. Letter only	0.038	0.021 – 0.054	4.433	42347	<0.001
Modalities: Letter + portal + SMS vs. Letter only	0.124	0.114 – 0.135	23.054	42347	<0.001
Study arm: Passive control vs. high-risk messages	-0.026	-0.038 – -0.015	-4.449	42347	<0.001
Study arm: Active control vs. high-risk messages	-0.013	-0.025 – -0.002	-2.257	42347	0.024

Note. Study arm is coded as 0 for patients in any high-risk arm (high risk only, high risk medical records, high risk algorithm) 1 for patients in the passive control arm, and 2 for patients in the active control arm. Modalities is a categorical variable, and Letter only is coded as baseline.

8.2.7 Vaccine data source by arm

Supplementary Table 21. Study 2 vaccine data source by arm.

	Passive control	Active control	High risk only	High risk medical records	High risk algorithm
Vaccinated: EHR data	2656 (99.6% of vaccinated pts.)	2795 (99.6% of vaccinated pts.)	2929 (99.7% of vaccinated pts.)	2875 (99.6% of vaccinated pts.)	2855 (99.7% of vaccinated pts.)
Vaccinated: Non-EHR data	12 (0.4% of vaccinated pts.)	12 (0.4% of vaccinated pts.)	9 (0.3% of vaccinated pts.)	12 (0.4% of vaccinated pts.)	8 (0.3% of vaccinated pts.)
Not vaccinated	5798	5715	5560	5583	5662
Total N	8466	8522	8498	8470	8525

Note. There was no difference in data source across arms, $X^2(4) = 1.81$, $p = .771$; EHR = Electronic Health Record.

8.3 Study 3

8.3.1 Vaccination timing

We compared the average time to get vaccinated between vaccinated patients who were sent any message and those in the passive control arm, with time specified as the number of days since the beginning of the intervention. Timing was relatively unaffected by the interventions. Among patients who were vaccinated, those who were contacted ($n = 8,433$) were vaccinated a mean of 0.99 days earlier than those in the passive control arm ($n = 1,858$; OLS regression including patients who were vaccinated, $b = 0.986$ [95% CI: 0.385, 1.587], $t(10289) = 3.217$, $p = .001$; Extended Data Fig. 4).

8.3.2 Intent-to-treat robustness check

In an exploratory robustness check, we reran regressions testing the effectiveness of risk messages with patients who were vaccinated prior to the study ($n = 1,542$). Results were similar to those reported in the main text with the preregistered sample. The primary outcome vaccination rate was 22.9% for those in the passive control arm and 24.9% for those in the active control arm. There was a 3.4 percentage-point increase in vaccination for those who received high-risk messages vs. those in passive control (OLS regression: $b = 0.034$, [95% CI: 0.023, 0.045], $t(32529) = 6.029$, $p < .001$). There was a 1.3 percentage-point increase in vaccination for those in high-risk arms vs. those in active control (OLS regression: $b = .013$, [95% CI: 0.002, 0.024], $t(32546) = 2.309$, $p = .021$). Again, there were no differences among high-risk arms (OLS regression with Tukey HSD correction: High risk only vs. high risk medical records: $b = 0.007$, [95% CI: -0.009, 0.023], $t(24405) = 0.984$, $p = 0.587$; high risk only vs. high risk algorithm: $b = 0.013$, [95% CI: -0.003, 0.029], $t(24405) = 1.871$, $p = 0.147$; high risk medical records vs. high risk algorithm: $b = 0.006$, [95% CI: -0.01, 0.022], $t(24405) = 0.887$, $p = 0.648$).

8.3.3 29-day vaccination

The preregistered primary outcome time frame varied across studies. The Study 3 time frame was 43 days. As a robustness check, we reran the key analyses with the Study 4 (SI section 7) time frame of 29 days. These results must be interpreted with caution as messages for Study 3 were sent as many as 30 days after the study began, so 29 days is not enough time to capture effects of the full intervention.

In Study 3, the results were not meaningfully different using the modified time frame compared with using the preregistered timeframe. The passive control vaccination rate was 17.0%. Vaccination was significantly higher in active control vs. passive control ($b = 0.016$, [95% CI: 0.004, 0.028], $t(15661) = 2.442$, $p = .011$), high-risk arms vs. passive control ($b = 0.035$, [95% CI: 0.025, 0.045], $t(39126) = 6.894$, $p < .001$), and high-risk arms vs. active control ($b = 0.020$, [95% CI: 0.010, 0.030], $t(39126) = 3.828$, $p < .001$). There were again no significant differences among high-risk arms (high risk only vs. high risk medical records: $b = 0.002$, [95% CI: -0.013, 0.017], $t(23463) = 0.307$, $p = .949$; high risk only vs. high risk algorithm: $b = 0.011$, [95% CI: -0.005, 0.026], $t(23463) = 1.631$, $p = .233$; high risk medical records vs. high risk algorithm: $b = 0.009$, [95% CI: -0.007, 0.024], $t(23463) = 1.322$, $p = .383$).

8.3.4 Modality eligibility by study arm

Supplementary Table 22. Study 3 modalities at enrollment for enrolled sample.

	Passive control	Active control	High risk only	High risk medical records	High risk algorithm	Uncorrected <i>p</i> -value for chi-square
Letter Only	10.9% (883)	10.2% (832)	10.4% (843)	9.3% (760)	10.3% (840)	.029
Letter+Portal	11.4% (927)	11.0% (897)	11.2% (908)	11.1% (905)	11.5% (939)	.823
Letter+SMS	10.2% (827)	11.1% (902)	10.7% (867)	10.7% (870)	11.3% (919)	.183
Letter+Portal+SMS	67.5% (5483)	67.6% (5506)	67.8% (5515)	68.8% (5597)	66.8% (5437)	.105
Portal Only	0.0% (2)	0.0% (2)	0.0% (0)	0.0% (1)	0.0% (0)	
SMS Only	0.0% (1)	0.0% (0)	0.0% (2)	0.0% (0)	0.0% (0)	
Portal+SMS	0.0% (0)	0.0% (1)	0.0% (2)	0.0% (1)	0.0% (2)	
Total N	8123	8140	8137	8134	8137	

Note. Eligibility for each modality in Study 3 was only assessed once, immediately prior to each individual modality deployment. Patients were *not* considered to be enrolled if, after the trial was completed, they were never eligible for any modalities. In contrast, for Studies 1 and 2, modalities were assessed first at the beginning of the trial (at which point patients were excluded for not having any modality eligibility) and again before each modality.

Supplementary Table 23. Study 3 actual study modalities for analysis sample.

	Passive control	Active control	High risk only	High risk medical records	High risk algorithm	Uncorrected <i>p</i> -value for chi-square
Letter Only	10.7% (834)	10.1% (795)	10.2% (798)	9.0% (705)	10.3% (807)	.013
Letter+Portal	11.1% (868)	10.8% (846)	11.0% (858)	10.9% (848)	11.4% (897)	.761
Letter+SMS	10.3% (806)	11.2% (880)	10.8% (847)	10.7% (835)	11.5% (901)	.159
Letter+Portal+SMS	67.9% (5312)	67.8% (5316)	67.9% (5302)	69.3% (5407)	66.8% (5253)	.021
Portal Only	0.0% (2)	0.0% (2)	0.0% (0)	0.0% (1)	0.0% (0)	
SMS Only	0.0% (1)	0.0% (0)	0.0% (2)	0.0% (0)	0.0% (0)	
Portal+SMS	0.0% (0)	0.0% (1)	0.0% (2)	0.0% (1)	0.0% (2)	
Total N	7823	7840	7809	7797	7860	

The distribution of eligibility for Letter only and Letter + portal + SMS was significantly different across arms, though when corrected for multiple comparisons across the 4 tests run, none were significant at $p < .05$. Even so, we ran a robustness check regression to test whether the key effects were significant controlling for modality group (excluding the handful of patients who were eligible for SMS only, Portal only or Portal + SMS). High risk messages (coded as baseline here) were significantly more effective than active or passive control (Supplementary Table 24).

Supplementary Table 24. Study 3 modality robustness check.

Predictors	Estimates	CI	<i>t</i>	<i>df</i>	<i>p</i>
(Intercept)	0.312	0.298 – 0.326	43.158	39109	<0.001
Modalities: Letter + portal vs. Letter only	0.018	-0.001 – 0.037	1.894	39109	0.058
Modalities: Letter + SMS vs. Letter only	-0.137	-0.156 – -0.118	-14.169	39109	<0.001
Modalities: Letter + portal + SMS vs. Letter only	-0.038	-0.053 – -0.024	-5.109	39109	<0.001
Study arm: Passive control vs. high-risk messages	-0.036	-0.048 – -0.025	-6.354	39109	<0.001
Study arm: Active control vs. high-risk messages	-0.014	-0.025 – -0.002	-2.388	39109	0.017

Note. Study arm is coded as 0 for patients in any high-risk arm (high risk only, high risk medical records, high risk algorithm) 1 for patients in the passive control arm, and 2 for patients in the active control arm. Modalities is a categorical variable, and Letter only is coded as baseline.

8.3.5 Vaccine data source by arm

Supplementary Table 25. Study 3 vaccine data source by arm.

	Passive control	Active control	High risk only	High risk medical records	High risk algorithm
Vaccinated: EHR data	1719 (92.5% of vaccinated pts.)	1892 (93.2% of vaccinated pts.)	2028 (92.7% of vaccinated pts.)	1997 (93.7% of vaccinated pts.)	1921 (92.2% of vaccinated pts.)
Vaccinated: Non-EHR data	139 (7.5% of vaccinated pts.)	138 (6.8% of vaccinated pts.)	160 (7.3% of vaccinated pts.)	135 (6.3% of vaccinated pts.)	162 (7.8% of vaccinated pts.)
Not vaccinated	5965	5810	5621	5665	5777
Total N	7823	7840	7809	7797	7860

Note. There was no difference in data source across arms, $X^2(4) = 4.16$, $p = .385$; EHR = Electronic Health Record.

8.4 Study 4

8.4.1 Vaccination timing

We assessed whether shot time varied between those sent a message and those in the passive control arm among patients eligible for outreach via all modalities (i.e. our primary analysis sample). Among patients who were vaccinated, those who were contacted ($n = 4,752$) were vaccinated 0.85 days earlier than those in the passive control group ($n = 881$; OLS regression: $b = 0.852$ [95% CI: 0.269, 1.435], $t(5631) = 2.866$, $p = .004$; Supplementary Fig. 5).

8.4.2 Intent-to-treat robustness check

In an exploratory robustness check, we reran our analyses of the primary analysis sample (those eligible for all three modalities) including 319 patients who were vaccinated before the study began. The passive control vaccination rate was 17.9%. Patients who were sent a letter were 2.5 percentage points more likely to get vaccinated compared with passive control group ($b = 0.025$ [95% CI: 0.010, 0.041], $t(29499) = 3.177$, $p = .001$). Those who were

sent a letter, portal message and SMS were 1.7 percentage points more likely to get vaccinated than passive control ($b = 0.017$ [95% CI: 0.002, 0.033], $t(29499) = 2.156$, $p = .031$). The 1.5 percentage-point increase in vaccination for those sent both Portal messages and SMS vs. passive control was similar in size to the effect reported in the main analysis control ($b = 0.015$ [95% CI: -0.000, 0.031], $t(29499) = 1.940$, $p = .052$). In this robustness check, the Tukey HSD-corrected difference in vaccination between SMS and letters was no longer significant ($b = 0.008$ [95% CI: -0.013, 0.031], $t(14749) = 0.896$, $p = .643$). None of the other tests reached statistical significance either in the main analysis nor in the present robustness check.

8.4.3 Vaccine data source by arm

Supplementary Table 26. Study 4 vaccine data source by arm.

	Passive control	Letter	Portal	SMS	Portal + SMS	Letter + portal + SMS
Vaccinated: EHR data	1927 (94.4% of vaccinated pts.)	2121 (93.3% of vaccinated pts.)	1257 (94.7% of vaccinated pts.)	1062 (94.6% of vaccinated pts.)	909 (95.0% of vaccinated pts.)	910 (94.3% of vaccinated pts.)
Vaccinated: Non-EHR data	115 (5.6% of vaccinated pts.)	152 (6.7% of vaccinated pts.)	71 (5.3% of vaccinated pts.)	61 (5.4% of vaccinated pts.)	48 (5.0% of vaccinated pts.)	55 (5.7% of vaccinated pts.)
Not vaccinated	8045	7807	5170	5186	3908	3905
Total N	10087	10080	6498	6309	4865	4870

Note. There was no difference in data source across arms, $X^2(5) = 5.27$, $p = .384$; EHR = Electronic Health Record.

9 Pre-tests

9.1 Pre-test 1: Baseline characteristics

Before beginning Study 1, we ran two pre-tests on Amazon Mechanical Turk (MTurk) to inform nudge message wording.

Baseline demographics and responses to questions about flu shots for both pre-test studies are listed in Supplementary Tables 27–29.

Supplementary Table 27. Baseline characteristics for Study 1 pre-tests: Age, sex, and race/ethnicity.

	Algorithm study (n = 614)	Risk study (n = 2170)
Age		
Mean (SD)	58.7 (7.48)	37.3 (11.7)
Median [Min, Max]	58.0 [28.0, 89.0]	35.0 [18.0, 88.0]
Missing	12 (2.0%)	70 (3.2%)
Sex		
Female	358 (58.3%)	1040 (47.9%)
Male	246 (40.1%)	1055 (48.6%)
Other	0 (0%)	10 (0.5%)
No response	10 (1.6%)	65 (3.0%)
Race/Ethnicity		
Asian	16 (2.6%)	259 (11.9%)
Black/African American	42 (6.8%)	184 (8.5%)
Hispanic or Latino	14 (2.3%)	89 (4.1%)
White	518 (84.4%)	1467 (67.6%)
Other	4 (0.7%)	22 (1.0%)
More than one race	9 (1.5%)	82 (3.8%)
No response	11 (1.8%)	67 (3.1%)

Supplementary Table 28. Baseline characteristics for Study 1 pre-tests: Education, income, political ideology, and religion.

	Algorithm study (N = 614)	Risk study (N = 2170)
Highest level of education		
Less than High School	1 (0.2%)	14 (0.6%)
High School Degree	58 (9.4%)	177 (8.2%)
Some College	190 (30.9%)	576 (26.5%)
Four-Year College Degree	196 (31.9%)	857 (39.5%)
Some Graduate School	29 (4.7%)	73 (3.4%)
Graduate Degree	129 (21.0%)	408 (18.8%)
No response	11 (1.8%)	65 (3.0%)
Annual household income		
Less than \$20,000	68 (11.1%)	192 (8.8%)
Between \$20,000 and \$40,000	143 (23.3%)	427 (19.7%)
Between \$40,000 and \$60,000	117 (19.1%)	448 (20.6%)
Between \$60,000 and \$80,000	86 (14.0%)	382 (17.6%)
Between \$80,000 and \$100,000	58 (9.4%)	239 (11.0%)
More than \$100,000	126 (20.5%)	400 (18.4%)
No response	16 (2.6%)	82 (3.8%)
Political ideology		
Very Conservative	71 (11.6%)	150 (6.9%)
Conservative	160 (26.1%)	391 (18.0%)
Moderate	137 (22.3%)	563 (25.9%)
Liberal	174 (28.3%)	719 (33.1%)
Very Liberal	55 (9.0%)	273 (12.6%)
No response	17 (2.8%)	74 (3.4%)
Religion		
Buddhist	6 (1.0%)	43 (2.0%)
Christian - Catholic	108 (17.6%)	366 (16.9%)
Christian - Protestant	199 (32.4%)	453 (20.9%)
Christian - Other	73 (11.9%)	198 (9.1%)
Hindu	2 (0.3%)	28 (1.3%)
Jewish	8 (1.3%)	35 (1.6%)
Muslim	2 (0.3%)	25 (1.2%)
Non-religious	174 (28.3%)	871 (40.1%)
Other	30 (4.9%)	71 (3.3%)
No response	12 (2.0%)	80 (3.7%)

Supplementary Table 29. Baseline characteristics for Study 1 pre-tests: Questions about comorbidities and flu vaccination.

	Algorithm study (N = 614)	Risk study (N = 2170)
Number of medical conditions*		
0	383 (62.4%)	1671 (77.0%)
1	151 (24.6%)	303 (14.0%)
2	41 (6.7%)	74 (3.4%)
More than 2	28 (4.6%)	33 (1.5%)
No response	11 (1.8%)	90 (4.1%)
How frequently do they get the flu shot		
Never	181 (29.5%)	671 (30.9%)
Some years	97 (15.8%)	515 (23.7%)
Almost every year	82 (13.4%)	379 (17.5%)
Every year	244 (39.7%)	546 (25.2%)
No response	10 (1.6%)	59 (2.7%)
Do they plan to get a flu shot this year		
Not at all likely	131 (21.3%)	496 (22.9%)
Somewhat likely	61 (9.9%)	270 (12.4%)
Moderately likely	60 (9.8%)	317 (14.6%)
Very likely	47 (7.7%)	256 (11.8%)
Extremely likely	305 (49.7%)	772 (35.6%)
No response	10 (1.6%)	59 (2.7%)
Perceived risk of flu complications in real life		
Very low risk	105 (17.1%)	534 (24.6%)
Somewhat low risk	178 (29.0%)	730 (33.6%)
Medium risk	167 (27.2%)	552 (25.4%)
Somewhat high risk	109 (17.8%)	222 (10.2%)
Very high risk	45 (7.3%)	73 (3.4%)
No response	10 (1.6%)	59 (2.7%)

Note. The "number of medical conditions" item indicates participant responses to the following question: "How many of the following medical conditions are you currently diagnosed with? Conditions: asthma, cancer, chronic respiratory disease, chronic kidney disease, chronic liver disease, chronic heart disease, diabetes, any form of immunosuppressive illness."

9.2 Pre-test 1a: Algorithm framing

There were 614 participants in this pre-test. This study targeted participants ages 50 or older, aiming to test algorithm message framing in an age group similar to that anticipated for our patient population. Despite the 50+ age constraint, 53 participants reported being under age 50.

After removing 5 participants for failing an attention check, 4 who finished the survey in under 2 minutes, and 3 who did not complete the survey, 602 remained eligible for analysis.

Participants were shown the following prompt:

Imagine that you are a patient with “Omega Health,” a network of hospitals and health clinics, and have agreed to receive text messages from them. You receive the following text message this September, at the beginning of flu season. Please read the text carefully and answer the questions that follow.

Omega: Our [ALGORITHM TEXT] indicates that you are at HIGH RISK of experiencing health complications if you get the flu. Help prevent this with a flu shot. To schedule your FREE flu shot, call 800-555-5555 or visit myOmega.org

Supplementary Table 30. Algorithm text conditions and sample sizes included in the final analysis.

Condition name	Algorithm text	N
Artificial Intelligence	artificial-intelligence-based analysis of your medical records	147
Computer Algorithm	computer algorithm-based analysis of your medical records	151
Machine Learning	machine-learning-based analysis of your medical records	151
All Three	machine-learning artificial intelligence-based computer algorithm	153

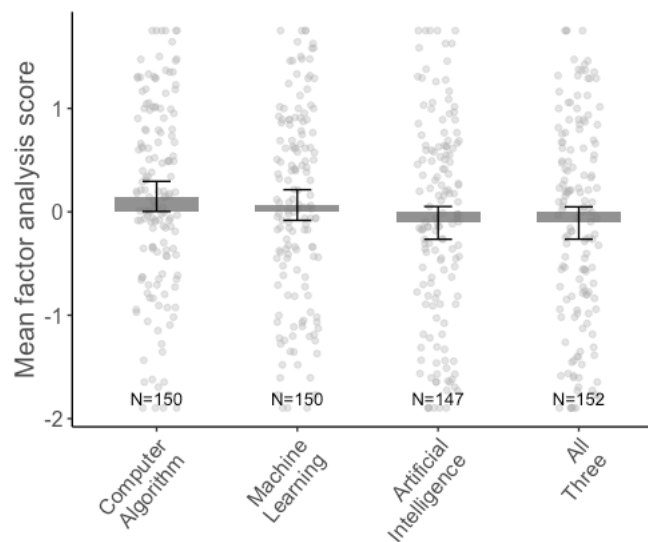
Participants were randomized to an algorithm text condition. The ALGORITHM TEXT field above was populated with one of the versions listed in Supplementary Table 30. After reading the prompt, participants responded to the first six questions listed in Supplementary Table 31. Participants responded to all questions on a scale from 1, indicating not at all (e.g., “not at all likely” to get a flu shot), to 5 indicating extremely (e.g., “extremely likely” to get a flu shot).

Cronbach’s alpha was .899 for responses to the 6 questions for the Algorithm study shown in Supplementary Table 31. Responses were submitted to a factor analysis. The Kaiser rule (computed using the nScree function from the nFactors R package) suggested that a 1-factor solution was most appropriate for the data. A factor analysis (using the factanal function) showed that the 1-factor solution explained 61.1% of the variance in the data. Factor loadings for each question and Thompson’s scores for each risk condition are shown in Supplementary Table 31 and Supplementary Fig. 10.

Supplementary Table 31. Questions and factor loadings for Algorithm and Risk pre-tests.

Question	Algorithm study factor loading	Risk study factor loading
If you received this text message, how likely would you be to get your flu shot this year?	0.731	0.773
If you received this text message, how worried would you be about experiencing flu-related health complications if you do not get vaccinated?	0.732	0.751
If you received this text message, how high do you think your risk would be of having health complications related to the flu?	0.817	0.723
If you received this text message, how accurate would you think this assessment of risk is?	0.879	0.778
How much does this seem like an expert analysis of medical records?	0.775	0.729
How annoyed or grateful would you feel if you received this message?	0.746	0.748
If someone else received this text message, how likely do you think they would be to get their flu shot this year? (Risk study only)		0.597

The computer algorithm condition yielded the highest mean factor analysis score. We submitted factor analysis scores to an OLS regression to test whether they varied as a function of algorithm condition. After Tukey HSD correction, no pairwise comparisons reached statistical significance, but factor analysis scores were numerically, but not significantly, higher in the computer algorithm condition compared with the all three condition ($b = 0.255$, 95%CI [-0.026, 0.536], $t(598) = 2.334$, $p = .092$) and the artificial intelligence condition ($b = 0.257$, 95%CI [-0.027, 0.541], $t(598) = 2.331$, $p = .092$).

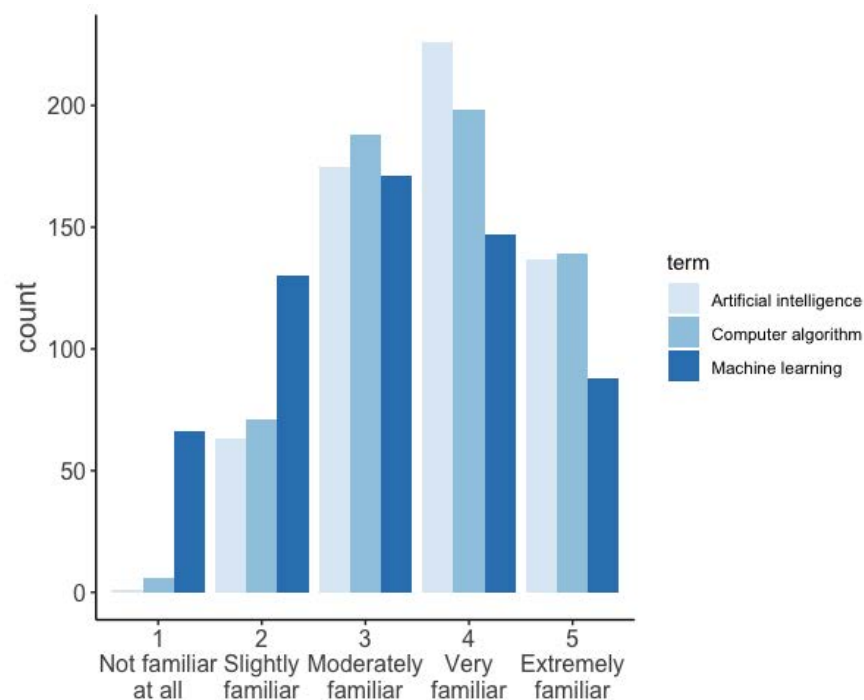


Supplementary Fig. 10. Factor analysis scores for each condition in the algorithm pre-test.

Mean Thompson's factor analysis scores for each condition in the algorithm pre-test with individual participant factor analysis scores shown as dots. Error bars indicate 95% confidence intervals.

Participants also reported their familiarity with the terms “computer algorithm,” “machine learning,” and “artificial intelligence” on a scale of 1 (not familiar at all) to 5 (extremely familiar). Participants were least familiar with “machine learning” (mean = 3.101, SD = 1.215), and they were slightly more familiar with “computer algorithm” (mean = 3.653, SD = 0.993) and “artificial intelligence” (mean = 3.723, SD = 0.936) (Supplementary Fig. 11).

We decided to use “computer algorithm” in our field study messages because it yielded the highest mean factor analysis score. Additionally, although it was not the most familiar term to participants, it also was not the least familiar.



Supplementary Fig. 11. Familiarity with terms related to computer algorithms.

Participant familiarity ratings with each algorithm term. All participants (N = 602) indicated their familiarity with each algorithm term, regardless of their assigned study condition.

9.3 Pre-test 1b: Risk framing

We also ran an MTurk pre-test to inform our description of the risk level in our messages. In this pre-test, we tested various ways to explain patients’ risk level in their messages. There were 2,170 participants in the study after removing one participant who reported being under the age of 18.

Participants were shown the following prompt:

Imagine that you are currently at risk of developing serious health complications, such as pneumonia or hospitalization, if you get the flu. You are also a patient with “Omega Health,” a network of hospitals and health clinics, and have agreed to receive text messages from them. You receive the following text message this September, at the beginning of flu season. Please read the text carefully and answer the questions that follow.

“Omega: Our analysis of your medical records indicates [RISK TEXT]. Help prevent this with a flu shot. To schedule your FREE flu shot, call 800-555-5555 or visit myOmega.org.”

Participants were randomized to a risk text condition. The RISK TEXT field above was populated with one of the conditions listed in Supplementary Table 32.

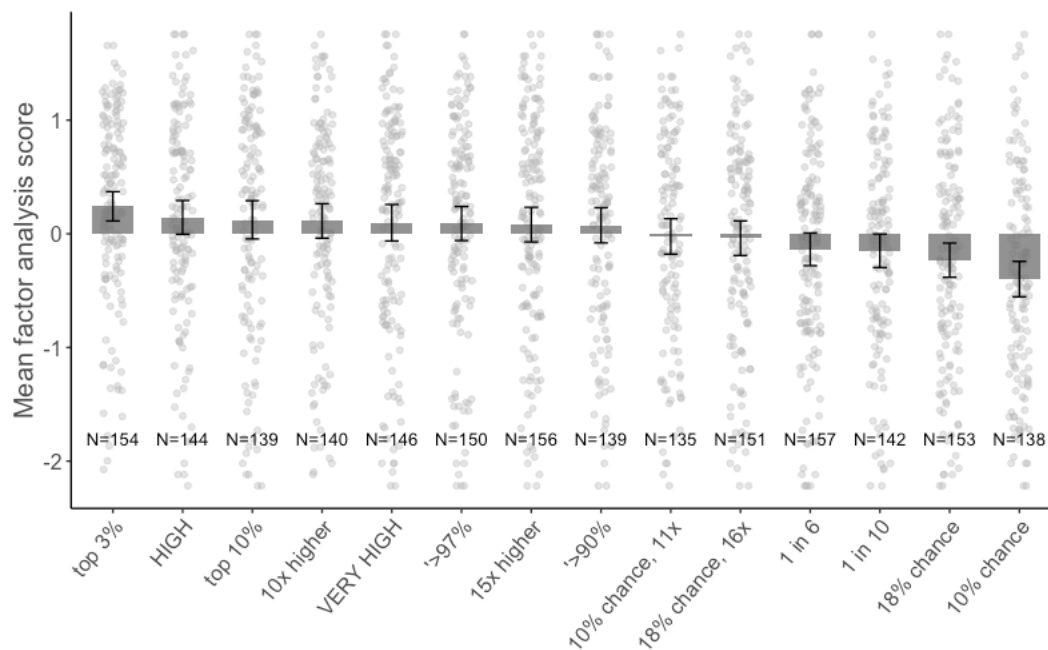
Supplementary Table 32. Risk text conditions and sample sizes included in the final analysis.

Condition name	Risk text	N
1 in 10	that 1 in 10 Omega patients like you will experience flu-related hospitalization or even death this year	142
1 in 6	that 1 in 6 Omega patients like you will experience hospitalization or even death this year	157
'>90%	that you are at GREATER RISK than 90% of Omega patients for flu-related hospitalization or even death	139
'>97%	that you are at GREATER RISK than 97% of Omega patients for flu-related hospitalization or even death	150
HIGH	that you are at HIGH RISK for flu-related hospitalization or even death	144
VERY HIGH	that you are at VERY HIGH RISK for flu-related hospitalization or even death	146
10% chance	that you have a 10% chance of flu-related hospitalization or even death this year	138
10% chance, 11x	that you have a 10% chance of flu-related hospitalization or even death, which is about 11 times the risk for most other Omega patients	135
18% chance	that you have an 18% chance of flu-related hospitalization or even death this year	153
18% chance, 16x	that you have an 18% chance of flu-related hospitalization or even death, which is about 16 times the risk of most other Omega patients	151
10x higher	that your risk of flu-related hospitalization or even death is 10 TIMES HIGHER than most other Omega patients	140
15x higher	that your risk of flu-related hospitalization or even death is 15 TIMES HIGHER than most other Omega patients	156
top 10%	that, among Omega patients, you are in the TOP 10% of RISK for flu-related hospitalization or even death	139
top 3%	that, among Omega patients, you are in the TOP 3% of RISK for flu-related hospitalization or even death	154

We removed from analysis 3 participants who got an old survey version that included a typo, 37 who failed an attention check, 49 who finished the survey in under 2 minutes, 14 who indicated they did not want us to use their responses in data analysis, and 23 who did not complete the survey, leaving 2,044 participants in the final analysis.

Next, to determine the most effective risk wording, we used the same methods described in the risk pre-test to run a factor analysis on participants' responses to the 7 questions in Supplementary Table 31. Participants responded to all questions on a scale from 1, indicating not at all (e.g., "not at all likely" to get a flu shot), to 5 indicating extremely (e.g., "extremely likely" to get a flu shot).

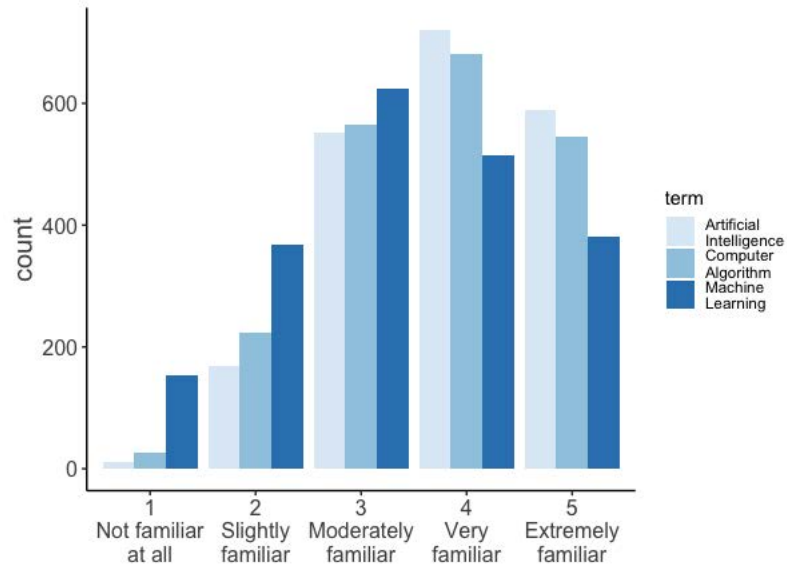
Cronbach's alpha was .885 for question responses. As with the risk pre-test, a 1-factor solution was most appropriate for the algorithm data according to the Kaiser rule. The 1-factor solution explained 53.4% of the variance in the data. Factor loadings are shown in Supplementary 31 and mean scores for each risk condition are shown in Supplementary Fig. 12. The three conditions with the highest scores were top 3%, top 10%, and high risk. This pre-test informed the decision to tell the top 3% of risk that they were in the top 3%, and to randomize patients in the top 4–10% to be told they were in the top 10% or that they were at high risk.



Supplementary Fig. 12. Mean factor analysis scores for risk pre-test.

Mean Thompson's factor analysis scores for each condition in the risk pre-test with individual participant factor analysis scores shown as dots. Error bars indicate 95% confidence intervals.

As an additional test of algorithm wording, we asked patients in the risk pre-test their level of familiarity with the terms "artificial intelligence," "computer algorithm," and "machine learning." Results were similar to what we observed in the algorithm pre-test (Supplementary Fig. 13): participants were least familiar with "machine learning" (mean = 3.293, SD = 1.181) and were more familiar with "computer algorithm" (mean = 3.733, SD = 1.013) and "artificial intelligence" (mean = 3.838, SD = 0.954).



Supplementary Fig. 13. Familiarity with terms related to computer algorithms.

Participant familiarity ratings with each algorithm term. All participants ($n = 2044$) indicated their familiarity with each algorithm term.

9.4 Study 2 Pre-test

Prior to Study 2, we conducted another pre-test on MTurk to inform the nature and quantity of risk reasons included in our high-risk messages. Using a similar method to the Study 1 pre-tests, we tested perceptions of our messages if the risk reasons presented were *specific* or *general*. We also tested message perception when 1, 2 or 3 reasons were presented.

The study included 933 participants. As in pre-test 1a, we targeted participants ages 50 or older, because people are likely to have more health conditions as they age and therefore to be at higher risk. Although participants ages 50+ were targeted, 58 participants reported being under age 50. Participant demographics are listed in Supplementary Tables 33–35.

Supplementary Table 33. Baseline characteristics for Study 2 pre-test participants: Age, sex, and race/ethnicity.

	Overall (n = 933)
Age	
Mean (SD)	57.4 (7.93)
Median [Min, Max]	57.0 [24.0, 83.0]
Missing	35 (3.8%)
Sex	
Female	577 (61.8%)
Male	321 (34.4%)
Other	2 (0.2%)
No response	33 (3.5%)
Race/Ethnicity	
Asian	18 (1.9%)
Black/African American	72 (7.7%)
Hispanic or Latino	20 (2.1%)
White	753 (80.7%)
Other	9 (1.0%)
More than one race	27 (2.9%)
No response	34 (3.6%)

Supplementary Table 34. Baseline characteristics for Study 2 pre-test participants: Education, income, political ideology, and religion.

	Overall (n = 933)
Highest level of education	
Less than High School	1 (0.1%)
High School Degree	85 (9.1%)
Some College	301 (32.3%)
Four-Year College Degree	279 (29.9%)
Some Graduate School	39 (4.2%)
Graduate Degree	194 (20.8%)
No response	34 (3.6%)
Annual household income	
Less than \$20,000	92 (9.9%)
Between \$20,000 and \$40,000	209 (22.4%)
Between \$40,000 and \$60,000	184 (19.7%)
Between \$60,000 and \$80,000	131 (14.0%)
Between \$80,000 and \$100,000	105 (11.3%)
More than \$100,000	169 (18.1%)
No response	43 (4.6%)
Political ideology	
Very Conservative	118 (12.6%)
Conservative	238 (25.5%)
Moderate	221 (23.7%)
Liberal	242 (25.9%)
Very Liberal	74 (7.9%)
No response	40 (4.3%)
Religion	
Buddhist	9 (1.0%)
Christian - Catholic	174 (18.6%)
Christian - Protestant	291 (31.2%)
Christian - Other	119 (12.8%)
Hindu	2 (0.2%)
Jewish	19 (2.0%)
Muslim	7 (0.8%)
Non-religious	222 (23.8%)
Other	52 (5.6%)
No response	38 (4.1%)

Supplementary Table 35. Baseline characteristics for Study 2 pre-test participants: Questions about comorbidities and flu vaccination.

	Overall (n = 933)
How frequently do they get the flu shot	
Never	276 (29.6%)
Some years	160 (17.1%)
Almost every year	139 (14.9%)
Every year	333 (35.7%)
No response	25 (2.7%)
Do they plan to get a flu shot this year	
Not at all likely	239 (25.6%)
Somewhat likely	87 (9.3%)
Moderately likely	83 (8.9%)
Very likely	124 (13.3%)
Extremely likely	375 (40.2%)
No response	25 (2.7%)
Perceived risk of flu complications in real life	
Very low risk	163 (17.5%)
Somewhat low risk	262 (28.1%)
Medium risk	260 (27.9%)
Somewhat high risk	161 (17.3%)
Very high risk	62 (6.6%)
Missing	25 (2.7%)

In this pre-test, patients were presented with the following instructions:

Imagine that you are currently at risk of developing serious health complications, such as pneumonia or hospitalization, if you get the flu. You are also a patient with "Omega Health," a network of hospitals and health clinics, and have agreed to receive letters from them. You receive the following letter from your primary care doctor in September, at the beginning of flu season. Please read the letter carefully and answer the questions that follow.

Letter

I am writing with important information about your health: A computer algorithm-based analysis of your medical records indicates that you are at high risk for health complications related to the flu, based in part on your past or current:

- [REASON(S)]

This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization. However, getting your flu shot will greatly reduce these risks. I encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at no cost to you:

- Call 800-555-5555 or visit myOmega.org to schedule.
- Ask for the flu shot at your upcoming doctor's appointment.
- Or visit omega.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Omega will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Participants were randomized to be shown *specific* reasons or *general* reasons. They were also randomized to see 1, 2, or 3 reasons. For each cell in the 2x3 experiment, we generated 6 reason sets (Supplementary Table 36). (Due to a coding error, there were only 5 reason sets in the 3 general reasons condition.) These reason sets were generated based on the most frequently co-occurring general and specific reasons in a retrospective patient dataset from the 2020–21 flu season. We began by identifying sets of 3 frequently co-occurring general and specific reasons, and then reduced the reasons for 2- and 1-reason sets.

Supplementary Table 36. Reason sets in the study 2 pre-test.

Set	One General	Two General	Three General	One Specific	Two Specific	Three Specific
1	• [Lab / Laboratory] test result(s)	• [Lab / Laboratory] test result(s) • [Medical / Health] service(s)	• [Lab / Laboratory] test result(s) • [Medical / Health] condition(s) • Vital sign(s)	• [Lab / Laboratory] blood cell count(s)	• [Lab / Laboratory] blood cell count(s) • [Medical / Health] condition(s) related to breathing	• [Lab / Laboratory] test(s) for immune health • [Medical / Health] complication(s) • Oxygen levels
2	• [Medical / Health] condition(s)	• [Lab / Laboratory] test result(s) • Medicine(s)	• [Medical / Health] condition(s) • [Lab / Laboratory] test result(s) • [Medical / Health] service(s)	• [Lab / Laboratory] test(s) for immune health	• [Lab / Laboratory] blood cell count(s) • Oxygen levels	• [Medical / Health] complication(s) • [Lab / Laboratory] test(s) for immune health • [Medical / Health] service(s)
3	• [Medical / Health] procedure(s)	• [Lab / Laboratory] test result(s) • Vital sign(s)	• [Medical / Health] condition(s) • [Lab / Laboratory] test result(s) • Vital sign(s)	• [Medical / Health] complication(s)	• [Lab / Laboratory] test(s) for immune health • [Medical / Health] service(s)	• [Medical / Health] condition(s) related to breathing • [Lab / Laboratory] blood cell count(s) • Medicine(s) related to breathing
4	• [Medical / Health] service(s)	• [Medical / Health] condition(s) • [Lab / Laboratory] test result(s)	• [Medical / Health] condition(s) • [Medical / Health] service(s) • [Lab / Laboratory] test result(s)	• [Medical / Health] condition(s) related to breathing	• [Medical / Health] complication(s) • [Lab / Laboratory] test(s) for immune health	• [Medical / Health] condition(s) related to breathing • [Lab / Laboratory] blood cell count(s) • Oxygen levels
5	• Medicine(s)	• [Medical / Health] condition(s) • [Medical / Health] service(s)	• [Medical / Health] condition(s) • [Medical / Health] service(s) • Vital sign(s)	• Medicine(s) related to breathing	• [Medical / Health] condition(s) related to breathing • [Medical / Health] service(s)	• [Medical / Health] condition(s) related to breathing • [Medical / Health] service(s) • [Lab / Laboratory] blood cell count(s)
6	• Vital sign(s)	• [Medical / Health] service(s) • [Lab / Laboratory] test result(s)		• Oxygen levels	• [Medical / Health] service(s) • [Lab / Laboratory] blood cell count(s)	• [Medical / Health] condition(s) related to breathing • [Medical / Health] service(s) • Oxygen levels

In generating the sets of reasons, we tried to include a variety of reasons, while minimizing sets that included the same reasons in a different order. Broadly, we considered “general” reasons to be ones that did not refer to a type of test or condition (e.g., “Lab test result(s)”), whereas specific reasons mentioned a type of test or condition (e.g., “Lab blood cell count(s)”).

We also attempted to roughly equate the reasons presented across general and specific reason sets where possible (e.g., for the specific reason “Medical condition related to breathing,” we included the general reason “Medical condition”). However, there was inevitably more overlap in the general reason set compared with the specific reason set, because there were fewer general reasons overall.

In this pre-test, we randomized patients to see either the word “lab” or “laboratory,” (e.g., “lab test results” vs. “laboratory test results”), and the word “health” or the word “medical” (e.g., “health conditions” vs. “medical conditions”) in reasons throughout the survey, to test which wording was best received. Similar to the pre-tests for Study 1, participants responded to the 8 questions listed in Supplementary Table 37 regarding the letter. Participants responded to all questions on a scale from 1, indicating not at all (e.g., “not at all likely” to get a flu shot), to 5 indicating extremely (e.g., “extremely likely” to get a flu shot).

Supplementary Table 37. Questions from Study 2 pre-test and factor loading for factor analysis.

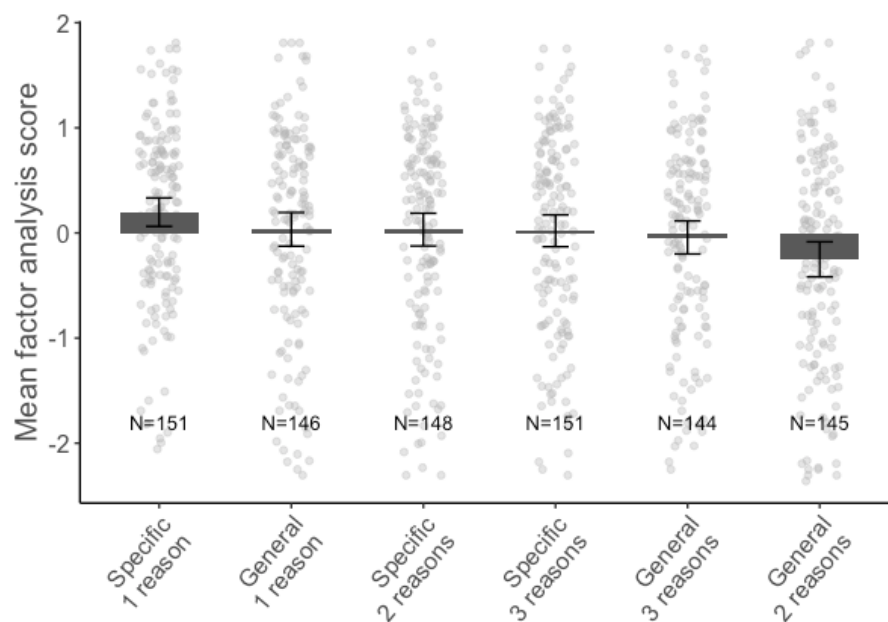
Question	Factor loading
If you received this letter, how likely would you be to get your flu shot this year?	0.785
If you received this letter, how worried would you be about having flu-related health complications if you did not get vaccinated?	0.750
If you received this letter, how high do you think your risk would be of having flu-related health complications if you did not get vaccinated?	0.783
If you received this letter, how accurate would you think this assessment of risk is?	0.889
How much does this seem like an expert analysis of medical records?	0.816
If you received this letter, how much would it seem like it was personalized?	0.661
How annoyed or grateful would you feel if you received this letter?	0.778
If someone else received this letter, how likely do you think they would be to get their flu shot this year?	0.510

Prior to analysis, we removed 33 participants who did not complete the survey, 8 who failed an attention check, 5 who requested that we not use their data in analysis, and 2 who spent less than 2 minutes on the survey, leaving 885 participants in the final analyses.

Supplementary Table 38. Number of participants in each study condition.

Specificity	Number of reasons	N
General	1	146
General	2	145
General	3	144
Specific	1	151
Specific	2	148
Specific	3	151

Cronbach's alpha for the 8 questions in Supplementary Table 37 was .909. We submitted responses to a factor analysis using the same methods as pre-tests 1a and 1b. A 1-factor solution was most appropriate for the data according to the Kaiser rule.



Supplementary Fig. 14. Mean factor analysis scores for each reason type (general, specific) and number of reasons (1, 2, or 3).

Mean Thompson's factor analysis scores for each condition in the risk pre-test with individual participant factor analysis scores shown as dots. Error bars indicate 95% confidence intervals. Error bars indicate 95% confidence intervals.

Mean Thompson's factor analysis scores are shown in Supplementary Fig. 14. We ran a regression on the resulting factor analysis scores as a function of specificity and the number of reasons. We found that specific reasons yielded higher factor analysis scores than general reasons ($b = 0.170$, 95% CI [0.043, 0.296], $t(881) = 2.638$, $p = .008$), influencing our decision to use specific reasons rather than general reasons. In our initial coding of reasons, we considered "[Medical / Health] complication(s)" to be a specific reason. However, some may consider it to

be a general reason. Regression results did not change when this reason was recoded as general instead of specific.

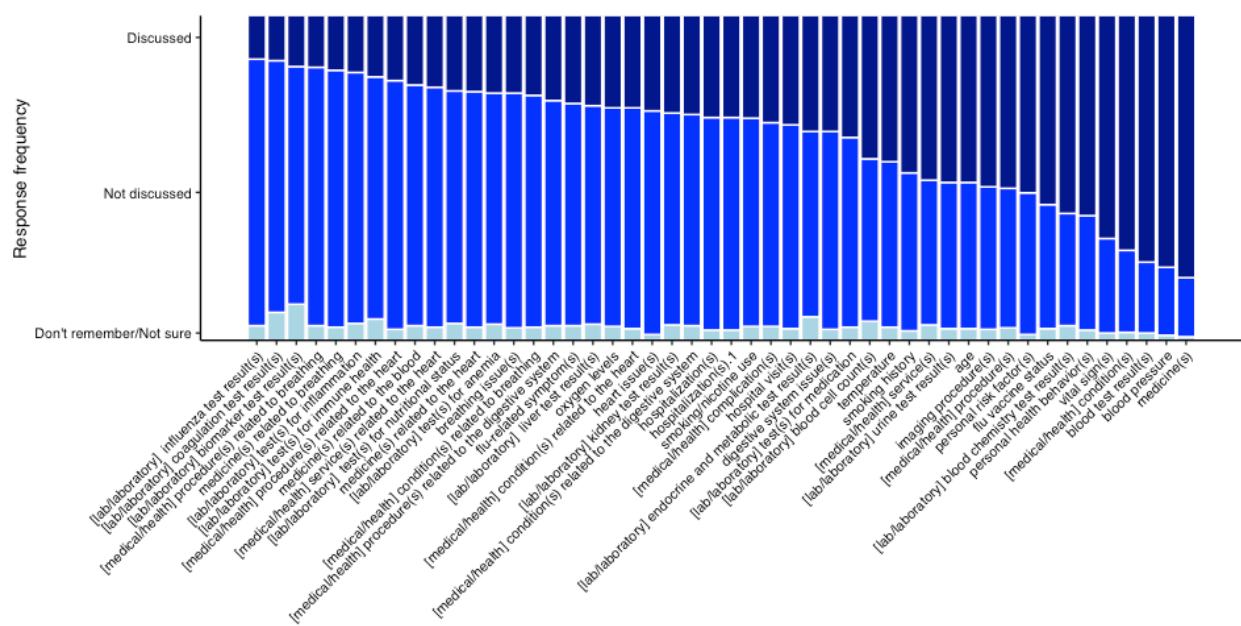
Additionally, scores were significantly higher for letters containing one reason (ignoring whether general or specific) compared with two reasons ($b = 0.226$, 95% CI [0.041, 0.410], $t(881) = 2.862$, Tukey HSD corrected $p = .012$). Three reasons yielded scores that were not significantly different from one reason ($b = 0.129$, 95% CI [-0.056, 0.314], $t(881) = 1.642$, Tukey HSD corrected $p = .228$) or two reasons ($b = 0.096$, 95% CI [-0.089, 0.282], $t(881) = 1.221$, Tukey HSD corrected $p = .441$). Based on these data, we decided to randomize patients to receive 1 or 3 reasons.

We tested whether patients would be more responsive to the word “lab” or the word “laboratory” (e.g., “lab test” vs. “laboratory test”). To this end, half of participants ($n = 443$) saw the word “lab” and the other half ($n = 442$) saw the word “laboratory” throughout the survey. Factor analysis scores were numerically, but not significantly, higher for those who saw the word lab ($b = 0.114$, 95% CI [-0.013, 0.240], $t(883) = 1.755$, $p = .080$), so we used this word in implementation.

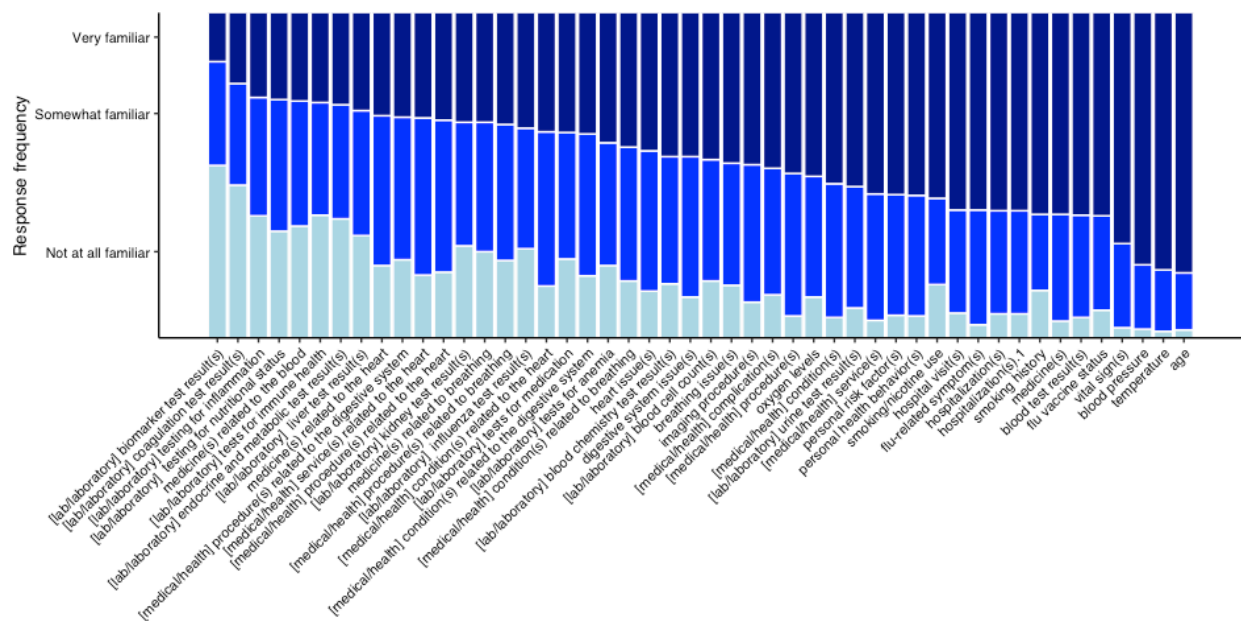
Similarly, we tested whether the word “health” or “medical” was more effective (e.g. “health condition” and “medical condition”) by showing half of participants ($n = 442$) the word “health” and the other half ($n = 443$) “medical” throughout the survey. Factor analysis scores were numerically, but not significantly, higher for those who saw the word medical ($b = 0.107$, 95% CI [-0.020, 0.234], $t(883) = 1.661$, $p = .097$). Therefore, we used the word “medical” in the field study.

Finally, participants were shown a long list of reasons we considered using for the field study. Half of participants rated how familiar or unfamiliar they were with each reason ($n = 444$). The other half indicated whether or not they had discussed each of the reasons with their doctor in the past ($n = 437$). (Due to a coding error, “hospitalizations” was included twice in the list.)

Although many of the reasons had not been discussed in participants’ past doctors appointments (Supplementary Fig. 15), every reason in the list was at least somewhat or very familiar to 47% or more participants (Supplementary Fig. 16). Because we determined specific reasons were more effective than general reasons, and because familiarity was reasonable for all the terms, we decided not to remove any reasons from being presented to patients in the field study.



Supplementary Fig. 15. Frequency of participant selection for each available response option to whether or not they have discussed each reason with a doctor. Each bar includes responses from 437 participants.



Supplementary Fig. 16. Frequency of participant selection for each available response option to whether or not they have discussed each reason with a doctor. Each bar includes responses from 444 participants.

10 Post-test manipulation check

We conducted a survey experiment as a post-test manipulation check after the field studies were completed. The goal of this study was to estimate the extent to which patients in the field study noticed our key manipulation for conditions across which we did not observe a significant difference in our primary outcome variable (flu vaccination).

Specifically, in Studies 1–3 reported in the main text, there were no systematic statistically significant differences in flu vaccination between patients who were told they were (1) at high risk with no explanation of how their risk was determined (high risk only), (2) at high risk based on a review of their medical records (high risk medical records), and (3) at high risk based on a computer algorithm-based analysis of their medical records (high risk algorithm). In this survey, we showed participants one of several versions of the messages in the conditions listed above, modified from the field study materials only to remove identifying information (e.g., the name of the health system). We then tested participants' accuracy in identifying how their risk was determined based on the message they saw.

Methods

The study was run on Prolific and included 2,159 participants (after removing one participant who reported their age was under 18). The study was preregistered on OSF at <https://osf.io/q69pj> on April 3, 2024.

Similar to pre-test 1a and pre-test 2, we attempted to include only participants ages 50 and older using Prolific filtering criteria. However, 33 participants reported being under 50. Participant demographics are listed in Supplementary Tables 39 and 40. Notably, median participant age was 58, similar to the median age for patients in our field studies (Study 1: 60, Study 2: 55, Study 3: 55, Study 4: 58).

Supplementary Table 39. Baseline characteristics for post-test participants: Age, sex, and race/ethnicity.

	Overall (N=2159)
Age	
Mean (SD)	58.9 (7.61)
Median [Min, Max]	58.0 [23.00, 94.0]
Missing	62 (2.9%)
Sex	
Female	1289 (59.7%)
Male	809 (37.5%)
Other	6 (0.3%)
No response	56 (2.6%)
Race/Ethnicity	
Asian	53 (2.5%)
Black/African-American	255 (11.8%)
Hispanic or Latino	37 (1.7%)
White	1673 (77.5%)
Other	24 (1.1%)
More than one race	60 (2.8%)
No response	57 (2.6%)
Highest level of education	
Less than High School	6 (0.3%)
High School Degree	200 (9.3%)
Some College	617 (28.6%)
Four-Year College Degree	742 (34.4%)
Some Graduate School	64 (3.0%)
Graduate Degree	475 (22.0%)
No response	55 (2.5%)
Annual household income	
Less than \$20,000	190 (8.8%)
Between \$20,000 and \$40,000	392 (18.2%)
Between \$40,000 and \$60,000	316 (14.6%)
Between \$60,000 and \$80,000	319 (14.8%)
Between \$80,000 and \$100,000	264 (12.2%)
More than \$100,000	609 (28.2%)
No response	69 (3.2%)

Supplementary Table 40. Baseline characteristics for post-test participants: Political ideology, political party, and religion.

	Overall (N=2159)
Political ideology	
Very Conservative	151 (7.0%)
Conservative	451 (20.9%)
Moderate	512 (23.7%)
Liberal	682 (31.6%)
Very Liberal	290 (13.4%)
No response	73 (3.4%)
Political party	
Strong Republican	145 (6.7%)
Republican	366 (17.0%)
Independent (but lean Republican)	141 (6.5%)
Independent	262 (12.1%)
Independent (but lean Democrat)	250 (11.6%)
Democrat	479 (22.2%)
Strong Democrat	443 (20.5%)
No response	73 (3.4%)
Religion	
Buddhist	21 (0.9%)
Christian - Catholic	359 (16.6%)
Christian - Protestant	634 (29.4%)
Christian - Other	227 (10.5%)
Hindu	8 (0.4%)
Jewish	62 (2.9%)
Muslim	10 (0.5%)
Non-religious	666 (30.8%)
Other	104 (4.8%)
No response	69 (3.2%)

Participants were shown one of the messages from the study, which varied systematically by risk determination (high risk only, high risk medical record, high risk algorithm). The messages varied on two other dimensions that paralleled the field studies. First, the messages varied in their content to mimic that of the study modality (letter vs. SMS format; we opted not to test patient portal messages because they were very similar in length and content to the letters). Second, medical record review and computer algorithm analysis messages varied in the number of risk reasons (0, 1, or 3) because Study 2 messages included 1 or 3 individualized reasons the patient was determined to be at high risk, while messages in Studies 1 and 3 included zero reasons (i.e., they did not mention reasons at all). For the 1-reason condition, we used the most frequent top reason included in the 1-reason condition for

patients in Study 2 (Medical condition(s) related to breathing). Similarly, for the 3-reason condition, we used the most frequent combination of 3 reasons for patients in Study 2 (Medical service(s), Medical complication(s), Lab blood cell count(s)). The manipulation was between-subjects: each patient only saw and responded to a question about only one message.

Our preregistered sample size included 700 participants per risk determination condition (High risk only, High risk medical record, High risk algorithm), with those 700 further subdivided by modality (letter, SMS) content and number of risk reasons (0, 1, 3). Assuming 80% expected mean accuracy across the three top-level conditions, 700 participants allowed for a 3% margin of error (95% confidence intervals); analyses within letter or SMS variations (350 participants each, within each condition) allowed for a 4.2% margin of error.

More precisely, probability of randomization to the arms and features within arms was as follows:

1. High risk only, letter: 16.67%
2. High risk only, SMS: 16.67%
3. High risk medical records, 0 reasons, letter, 8.33%
4. High risk medical records, 1 reason, letter: 4.17%
5. High risk medical records, 3 reasons, letter: 4.17%
6. High risk medical records, 0 reasons, SMS, 8.33%
7. High risk medical records, 1 reason, SMS: 4.17%
8. High risk medical records, 3 reasons, SMS: 4.17%
9. High risk algorithm, 0 reasons, letter, 8.33%
10. High risk algorithm, 1 reason, letter: 4.17%
11. High risk algorithm, 3 reasons, letter: 4.17%
12. High risk algorithm, 0 reasons, SMS, 8.33%
13. High risk algorithm, 1 reason, SMS: 4.17%
14. High risk algorithm, 3 reasons, SMS: 4.17%

This randomization scheme was chosen to approximate the rate of inclusion of each variable within the field studies. Separately, participants were evenly randomized to be told they were at “high risk” or in the top 3%, 10%, or 20% of risk in their messages (mimicking the variety of language about risk levels in our field study messages).

The survey included only one question of interest:

On the last page, you read a hypothetical message about your risk for flu and flu-related complications.

What did the message say about how your risk level was determined?

- *My risk level was based on a review of my medical records*
- *My risk level was based on a computer algorithm-based analysis of my medical records*
- *The message did not say how my risk level was determined*

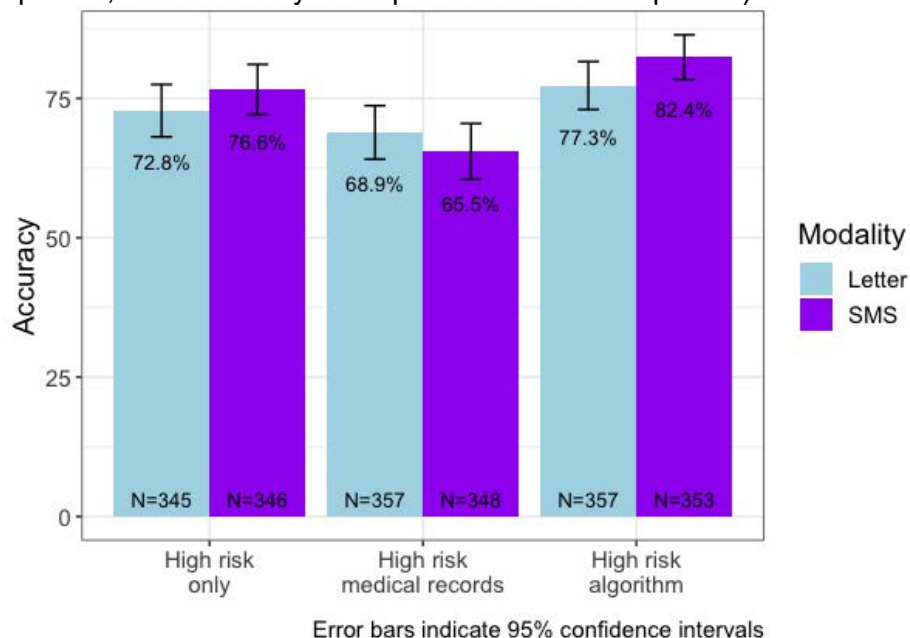
This question was shown on the page following the message, with no possibility to go backwards in the survey, so participants had to rely on their memory to respond.

Per our preregistration, 53 participants were excluded from our primary analysis for responding incorrectly to a multiple-choice attention check question on the page following the question of interest (“If you are paying attention to this question, select “Moderately surprising”; $N = 2$ incorrect responses, $N = 51$ no response).

Following the question of interest and multiple-choice attention check, participants responded to demographic questions. Finally, participants responded to the following free-response question: “In 1–2 complete sentences, tell us why you did or did not get a flu shot this year.” This question was included as a second attention check. We preregistered robustness check, where we analyzed the data excluding the participants whose responses to this question indicated low-effort responding (e.g., gibberish text [such as “blah blah blah”, “ghfth”], generic text [such as “it is the best”], or likely AI-generated text). In this robustness check analysis, we also removed the 5% of participants who spent the least amount of time on the page that displayed the message within each condition (with condition defined as risk determination level and modality, since the messages varied in length by these variables).

Results

Accuracy was computed as the mean proportion of patients who correctly identified the risk determination shown in their risk message. Overall accuracy was 73.9% [95%CI: 72.1, 75.8], with variation as a function risk determination condition and modality (Supplementary Fig. 17). Accuracy in our study falls broadly within the range reported for previous studies with similar manipulation checks, though on the lower end, with some reporting accuracy very similar to ours (e.g., 78% accuracy for a question with two response options⁶; 90 out of 120 participants [75%] responded correctly to questions with three response options⁷) and others showing higher accuracy (e.g., 90% [Study 1] or 89% [Study 2] accurate on a question with four response options⁸; 98% accuracy for a question with three options⁹).



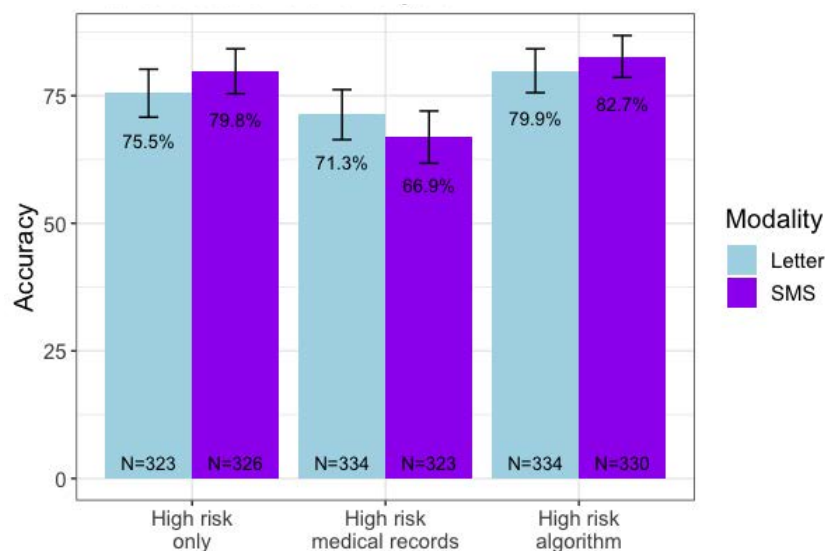
Supplementary Fig. 17. Mean accuracy in identifying the risk determination in the message shown in the Prolific post-test by the risk determination actually in the message and the modality of the message. Error bars indicate 95% confidence intervals.

We ran an OLS regression to test for accuracy differences across arms, with predictors for risk determination (High risk only, High risk medical record, High risk algorithm), modality (letter, SMS) and their interaction. The regression with the interaction term did not significantly improve upon the model including only main effects of risk determination and modality ($F(2,2100) = 1.953, p = .142$), so we removed the interaction from the regression.

After Tukey HSD correction, we found that accuracy was significantly higher in the High risk algorithm arm compared with the High risk medical records arm ($b = 0.126$ [95% CI: 0.072, 0.181], $t(2102) = 5.440$, $p < .001$), and marginally higher in High risk algorithm than the High risk only arm ($b = 0.052$ [95% CI: -0.003, 0.107], $t(2102) = 2.227$, $p = .067$). Additionally, accuracy was higher for High risk only vs. High risk medical records ($b = 0.074$ [95% CI: 0.020, 0.129], $t(2102) = 3.180$, $p = .004$). There was not a significant main effect of modality on accuracy ($b = 0.019$ [95% CI: -0.019, 0.056], $t(2102) = 0.974$, $p = .330$).

Results suggest that patients in our field studies were likely to have noticed our manipulation, especially the High risk algorithm arm, at least to the extent that the Prolific participants were representative of our high risk Geisinger patient population. Notably, participants were most accurate in the condition that mentioned the algorithm, that our lack of observed algorithm in the field study was not due to patients not noticing the mention of algorithms.

A preregistered robustness check included 1,970 participants, with 135 participants removed for being in the bottom 5% of time spent on the message page for their condition ($N = 108$), for low-effort responding to the free-response attention check ($N = 23$), or for both ($N = 4$). Results for this robustness check is shown in Supplementary Fig. 18. As expected, mean accuracy increased (to 76.1% [95%CI: 74.1, 77.9], compared with 73.9% in the primary analysis), but the overall pattern of accuracy by experimental arm remained the same.



Supplementary Fig. 18. Robustness check of accuracy in identifying the risk determination in the message shown in the Prolific post-test.

Patients were removed from this analysis if they were in the fastest 5% in their condition for time spent on the message page, or if they gave a low-effort response to a free response attention check test by the risk determination actually in the message and the modality of the message. Error bars represent 95% indicate intervals.

These post-test results suggest it is unlikely that non-attention, especially to the algorithm language, explains the absence of algorithm aversion or appreciation effects in our findings. Instead, we think algorithm aversion or appreciation was not observed in our field study because (1) algorithm aversion/appreciation effects are too small meaningfully affect behavior in real-world settings, using the methods real health systems would use to disclose algorithm

involvement in healthcare, or (2) algorithm aversion/appreciation truly do not influence real-world behaviors of interest in this domain.

11 Nudge message text

11.1 Nudge message summary

Supplementary Table 41. Nudge intervention message text.

Arm	Studies	Beginnings of letters and portal messages	Text messages
Active control	Studies 2 & 3	We are writing with important health information: <i>The flu can lead to dangerous complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: It's flu season. You can prevent flu and flu-related complications like pneumonia or even hospitalization by getting a flu shot. To schedule your NO-COST flu shot, visit MyGeisinger.org or call 800-275-6401. Text HELP for info, STOP to quit. Msg & data rates may apply.
High risk only	Studies 1, 2 & 3	We are writing with important information about your health: Among Geisinger patients, you are in the top [3% / 10% / 20%] of risk for health complications related to the flu. <i>This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: Among Geisinger patients, you are in the TOP [3% / 10% / 20%] of RISK for flu-related complications like pneumonia or even hospitalization. Help prevent complications with a flu shot. To schedule your NO-COST flu shot, visit MyGeisinger.org or call 800-275-6401. Text HELP for info, STOP to quit. Msg & data rates may apply.
	Study 1 (for those assigned to the "high risk" risk description)	We are writing with important information about your health: You are at high risk for health complications related to the flu. <i>This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: You are at HIGH RISK for flu-related complications like pneumonia or even hospitalization. Help prevent complications with a flu shot. To schedule your NO-COST flu shot, visit MyGeisinger.org or call 800-275-6401. Text HELP for info, STOP to quit. Msg & data rates may apply.
High risk medical records	Studies 1 & 3	We are writing with important information about your health: Our review of your medical records indicates that, among Geisinger patients, you are in top [3% / 10% / 20%] of risk for health complications related to the flu. <i>This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: A review of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10% / 20%] of RISK for flu and flu-related complications like pneumonia or even hospitalization. Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.

	Study 1 (for those assigned to the “high risk” risk description)	We are writing with important information about your health: Our review of your medical records indicates that you are at high risk for health complications related to the flu. <i>This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: A review of your medical records indicates that you are at HIGH RISK for flu and flu-related complications like pneumonia or even hospitalization. Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.
	Study 2	I am writing with important information about your health: A review of your medical records indicates that, among Geisinger patients, you are in the top [3% / 10%] of risk for health complications related to the flu, based in part on your past or current: • <u>Medical service(s)</u> • <u>Medical complication(s)</u> • <u>Lab blood cell count(s)</u> <i>This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: A review of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10% / 20%] of RISK for flu and flu-related complications like pneumonia or even hospitalization based on medical service(s), medical complication(s), and lab blood cell count(s) Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.
High risk algorithm	Studies 1 & 3	We are writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the top [3% / 10% / 20%] of risk for health complications related to the flu. <i>This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: A computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10% / 20%] of RISK for flu and flu-related complications like pneumonia or even hospitalization. Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.
	Study 1	We are writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that you are at high risk for health complications related to the flu. <i>This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: A computer algorithm-based analysis of your medical records indicates that you are at HIGH RISK for flu and flu-related complications like pneumonia or even hospitalization. Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.

Study 2	I am writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the top [3% / 10%] of risk for health complications related to the flu, based in part on your past or current: • <u>Medical service(s)</u> • <u>Medical complication(s)</u> • <u>Lab blood cell count(s)</u> <i>This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.</i>	Geisinger: A computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10% / 20%] of RISK for flu and flu-related complications like pneumonia or even hospitalization based on medical service(s), medical complication(s), and lab blood cell count(s). Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.
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Notes: The “Beginning of letters and portal messages” column shows the first portion of the message (following “Dear [NAME],”) for both letters and portal messages. The calls to action that followed, regarding how to get a flu shot at Geisinger, were the same for all patients within each study and modality. Full message text for all conditions can be found in SI Sections 11.2–11.5.

In Study 2, letters and portal messages were signed by the patient’s PCP and were written in first person singular (“I am writing”) rather than plural (“We are writing...”), which was used for Studies 1 and 3. To simplify the table, singular tense is not shown for Study 2 in Active control or High risk only conditions.

Study 2 high risk medical records and high risk algorithm conditions show the three-reason condition above. However, half of the patients were sent messages with only one reason. The reasons displayed above represent the most frequently occurring combination of three risk reasons for patients in the study. The full list of reasons is available in SI Section 12.

Key: *Study arm and risk manipulation*; Risk reason presentation; *Letter/portal elaboration on complications*

11.2 Study 1

11.2.1 Letters

High risk only, top 3% or top 10% framing:

Dear [NAME],

We are writing with important information about your health: Among Geisinger patients, you are in the [**top 3%** / **top 10%**] **of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit geisinger.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

— Your Geisinger Health Team

High risk only, high risk framing:

Dear [NAME],

We are writing with important information about your health: You are at **high risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit geisinger.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

High risk medical records, top 3% or top 10% framing:

Dear [NAME],

We are writing with important information about your health: Our review of your medical records indicates that, among Geisinger patients, you are in the [**top 3% / top 10%**] **of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit [geisinger.org/flu](https://www.geisinger.org/flu) for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

High risk medical records, high risk framing:

Dear [NAME],

We are writing with important information about your health: Our review of your medical records indicates that you are at **high risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit [geisinger.org/flu](https://www.geisinger.org/flu) for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

High risk algorithm, top 3% or top 10% framing:

Dear [NAME],

We are writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the [**top 3% / top 10%**] **of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit geisinger.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

— Your Geisinger Health Team

High risk algorithm, high risk framing:

Dear [NAME],

We are writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that you are at **high risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit geisinger.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

— Your Geisinger Health Team

11.2.2 Portal messages

High risk only, top 3% or top 10% framing:

Subject line: New information about risks specific to your health status

Dear [NAME],

We are writing with important information about your health: Among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

High risk only, high risk framing:

Subject line: New information about risks specific to your health status

Dear [NAME],

We are writing with important information about your health: You are at **high risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

High risk medical records top 3% or top 10% framing:

Subject line: New information about risks specific to your health status

Dear [NAME],

We are writing with important information about your health: Our review of your medical records indicates that, among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

High risk medical records, high risk framing:

Subject line: New information about risks specific to your health status

Dear [NAME],

We are writing with important information about your health: Our review of your medical records indicates that you are at **high risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

High risk algorithm, top 3% or top 10% framing:

Subject line: New information about risks specific to your health status

Dear [NAME],

We are writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

High risk algorithm, high risk framing:

Subject line: New information about risks specific to your health status

Dear [NAME],

We are writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that you are at **high risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Health Team

11.2.3 SMS Messages

High risk only, top 3% or top 10% framing:

Geisinger: Among Geisinger patients, you are in the TOP [3% / 10%] of RISK for flu-related complications like pneumonia or even hospitalization. Help prevent this with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information

High risk only, high risk framing:

Geisinger: You are considered to be at HIGH RISK for flu-related complications like pneumonia or even hospitalization. Help prevent this with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information

High risk medical records, top 3% or top 10% framing:

Geisinger: Our review of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10%] of RISK for flu-related complications like pneumonia or even hospitalization. Help prevent this with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information

High risk medical records, high risk framing:

Geisinger: Our review of your medical records indicates that you are at HIGH RISK for flu-related complications like pneumonia or even hospitalization. Help prevent this with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information

High risk algorithm, top 3% or top 10% framing:

Geisinger: Our computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10%] of RISK for flu-related complications like pneumonia or even hospitalization. Help prevent this with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information

High risk algorithm, high risk framing:

Geisinger: Our computer algorithm-based analysis of your medical records indicates that you are at HIGH RISK for flu-related complications like pneumonia or even hospitalization. Help prevent this with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information

11.3 Study 2

11.3.1 Letters

Active control:

Dear [NAME],

I am writing with important health information: The flu can lead to dangerous complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. I encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit geisinger.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Sincerely,
[PCP on file]

High risk only:

Dear [NAME],

I am writing with important information about your health: Among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu, based in part on your past or current:

- [reason1]
- [reason2]
- [reason3]

This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. I encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit geisinger.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Sincerely,
[PCP on file]

High risk medical records:

Dear [NAME],

I am writing with important information about your health: A review of your medical records indicates that, among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu, based in part on your past or current:

- [reason1]
- [reason2]
- [reason3]

This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. I encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit geisinger.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Sincerely,
[PCP on file]

High risk algorithm:

Dear [NAME],

I am writing with important information about your health: A computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu, based in part on your past or current:

- [reason1]
- [reason2]
- [reason3]

This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. I encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Call **800-275-6401** or visit **myGeisinger.org** to schedule
- Ask for the flu shot at your upcoming doctor's appointment
- Or visit geisinger.org/flu for a list of dates, times and locations for drive-thru or walk-in flu shot clinics.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Sincerely,
[PCP on file]

11.3.2 Portal messages

Active control:

Subject line: Information about preventing flu complications with a flu shot

Dear [FIRST_NAME],

I am writing with important health information: The flu can lead to dangerous complications like pneumonia, other respiratory illness, or even hospitalization. I recently sent you a letter in the mail about these risks.

However, getting your flu shot will greatly **reduce these risks**. I encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Sincerely,

[PCP]
Geisinger

High risk only:

Subject line: New information about risks specific to your health status

Dear [FIRST_NAME],

I am writing with important information about your health: Among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu. I recently sent you a letter in the mail noting that you are considered high risk.

This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. I encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Sincerely,

[PCP]
Geisinger

High risk medical records:

Subject line: New information about risks specific to your health status

Dear [FIRST_NAME],

I am writing with important information about your health: A review of your medical records indicates that, among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu. I recently sent you a letter in the mail noting [one / three] of the main reasons you are considered high risk.

This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. I encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Sincerely,

[PCP]
Geisinger

High risk algorithm:

Subject line: New information about risks specific to your health status

Dear [FIRST_NAME],

I am writing with important information about your health: A computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu. I recently sent you a letter in the mail noting [one / three] of the main reasons you are considered high risk.

This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. I encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Annual Flu Shot*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

Sincerely,

[PCP]
Geisinger

11.3.3 SMS Messages

Active control:

Geisinger: It's flu season. You can prevent flu and flu-related complications like pneumonia or even hospitalization by getting a flu shot.

To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.

High risk only:

Geisinger: Among Geisinger patients, you are in the TOP [3% / 10%] of RISK for flu and flu-related complications like pneumonia or even hospitalization.

Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.

High risk medical records:

Geisinger: A review of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10%] of RISK for flu and flu-related complications like pneumonia or even hospitalization based on [Reason(s)].

Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.

High risk algorithm:

Geisinger: A computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10%] of RISK for flu and flu-related complications like pneumonia or even hospitalization based on [Reason(s)].

Help prevent complications with a flu shot. To schedule your NO-COST flu shot, call 800-275-6401 or visit myGeisinger.org. Text HELP for information.

11.4 Study 3

11.4.1 Letters

Active control:

Dear [FIRST_NAME],

We are writing with important health information: The flu can lead to dangerous complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Ask for the flu shot at an upcoming doctor's appointment
- Visit **Geisinger.org/flufacts** for a list of dates, times and locations for drive-thru or walk-in flu shot clinics
- Visit **MyGeisinger.org** or call **800-275-6401** to schedule

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Visit Geisinger.org/flufacts and click on Read flu FAQs for more information and talk to your doctor with any concerns.

High risk only:

Dear [FIRST_NAME],

We are writing with important information about your health: Among Geisinger patients, you are in the **top 20% of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Ask for the flu shot at an upcoming doctor's appointment
- Visit **Geisinger.org/flufacts** for a list of dates, times and locations for drive-thru or walk-in flu shot clinics
- Visit **MyGeisinger.org** or call **800-275-6401** to schedule

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Visit Geisinger.org/flufacts and click on Read flu FAQs for more information and talk to your doctor with any concerns.

High risk medical records:

Dear [FIRST_NAME],

We are writing with important information about your health: Our review of your medical records indicates that, among Geisinger patients, you are in the **top 20% of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Ask for the flu shot at an upcoming doctor's appointment
- Visit **Geisinger.org/flufacts** for a list of dates, times and locations for drive-thru or walk-in flu shot clinics
- Visit **MyGeisinger.org** or call **800-275-6401** to schedule

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Visit Geisinger.org/flufacts and click on Read flu FAQs for more information and talk to your doctor with any concerns.

High risk algorithm:

Dear [FIRST_NAME],

We are writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the **top 20% of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Ask for the flu shot at an upcoming doctor's appointment
- Visit **Geisinger.org/flufacts** for a list of dates, times and locations for drive-thru or walk-in flu shot clinics
- Visit **MyGeisinger.org** or call **800-275-6401** to schedule

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Visit Geisinger.org/flufacts and click on Read flu FAQs for more information and talk to your doctor with any concerns.

11.4.2 Portal messages

Active Control:

Subject line: Information about preventing flu complications with a flu shot

Dear [FIRST_NAME],

We are writing with important health information: The flu can lead to dangerous complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Flu Vaccine*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Click here and select Read flu FAQs for more information and talk to your doctor with any concerns.

High risk only:

Subject line: New information about risks specific to your health status

Dear [FIRST_NAME],

We are writing with important information about your health: Among Geisinger patients, you are in the **top 20% of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Flu Vaccine*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Click here and select Read flu FAQs for more information and talk to your doctor with any concerns.

High risk medical records:

Subject line: New information about risks specific to your health status

Dear [FIRST_NAME],

We are writing with important information about your health: Our review of your medical records indicates that, among Geisinger patients, you are in the **top 20% of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Flu Vaccine*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Click here and select Read flu FAQs for more information and talk to your doctor with any concerns.

High risk algorithm:

Subject line: New information about risks specific to your health status

Dear [FIRST_NAME],

We are writing with important information about your health: Our computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the **top 20% of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Flu Vaccine*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Click here and select Read flu FAQs for more information and talk to your doctor with any concerns.

11.4.3 SMS Messages

Active Control:

Geisinger: It's flu season. You can prevent flu and flu-related complications like pneumonia or even hospitalization by getting a flu shot.

To schedule your NO-COST flu shot, visit MyGeisinger.org or call 800-275-6401. Text HELP for info, STOP to quit. Msg & data rates may apply

High risk only:

Geisinger: Among Geisinger patients, you are in the TOP 20% of RISK for flu-related complications like pneumonia or even hospitalization.

Help prevent complications with a flu shot. To schedule your NO-COST flu shot, visit MyGeisinger.org or call 800-275-6401. Text HELP for info, STOP to quit. Msg & data rates may apply

High risk medical records:

Geisinger: A review of your medical records indicates that, among Geisinger patients, you are in the TOP 20% of RISK for flu-related complications like pneumonia or even hospitalization

Help prevent complications with a flu shot. To schedule your NO-COST flu shot, visit MyGeisinger.org or call 800-275-6401. Text HELP for info, STOP to quit. Msg & data rates may apply

High risk algorithm:

Geisinger: A computer algorithm-based analysis of your medical records indicates that, among Geisinger patients, you are in the TOP 20% of RISK for flu-related complications like pneumonia or even hospitalization.

Help prevent complications with a flu shot. To schedule your NO-COST flu shot, visit MyGeisinger.org or call 800-275-6401. Text HELP for info, STOP to quit. Msg & data rates may apply

11.5 Study 4

11.5.1 Letters

Dear [NAME],

We are writing with important information about your health: Our review of your medical records indicates that, among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

Here are three ways you can get your flu shot — at **no cost** to you:

- Ask for the flu shot at an upcoming doctor's appointment
- Visit **Geisinger.org/flufacts** for a list of dates, times and locations for drive-thru or walk-in flu shot clinics
- Visit **MyGeisinger.org** or call **800-275-6401** to schedule

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

— Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should — even people with allergies. Visit Geisinger.org/flufacts and click on Read flu FAQs for more information and talk to your doctor with any concerns.

11.5.2 Portal messages

Subject line: New information about risks specific to your health status

Dear [FIRST_NAME],

We are writing with important information about your health: Our review of your medical records indicates that, among Geisinger patients, you are in the **top [3% / 10%] of risk** for health complications related to the flu. This means that you are more likely than most people to become infected with the flu and experience complications like pneumonia, other respiratory illness, or even hospitalization.

However, getting your flu shot will greatly **reduce these risks**. We encourage you to do so as soon as possible.

To schedule your flu shot – at **no cost** to you – click here and select *Flu Vaccine*.

Geisinger will not charge you for your flu shot. The sooner you get your shot, the sooner you will be protected against these unnecessary additional risks.

– Your Geisinger Care Team

Note: Most people who think they shouldn't get a flu shot actually can and should – even people with allergies. Click here and select Read flu FAQs for more information and talk to your doctor with any concerns.

11.5.3 SMS Messages

Geisinger: A review of your medical records indicates that, among Geisinger patients, you are in the TOP [3% / 10%] of RISK for flu-related complications like pneumonia or even hospitalization

Help prevent complications with a flu shot. To schedule your NO-COST flu shot, visit MyGeisinger.org or call 800-275-6401. Text HELP for information

12 Risk reasons included in Study 2

To generate the risk reasons, Medial EarlySign first ran its “But Why” algorithms, which were developed to explain the prediction for each individual by its contributing factors. As these features are numerous and often have mathematical rather than clinical interpretation, the study team worked with Medial to group these features and assign them more intuitive or clinical interpretations that would be intelligible to patients. This process yielded 41 unique risk reasons. Of those reasons, 31 were ultimately included in the top 3 risk reasons for participants (and thus were included in risk messages for one or more patients):

- Age
- Blood pressure
- Flu vaccine status
- Flu-related symptom(s)
- Imaging
- Lab biomarker test(s)
- Lab blood cell count(s)
- Lab blood chemistry test(s)
- Lab coagulation test(s)
- Lab endocrine and metabolic test(s)
- Lab kidney test(s)
- Lab liver test(s)
- Lab test(s) for immune health
- Lab urine test(s)
- Medical complication(s)
- Medical condition(s)
- Medical condition(s) related to breathing
- Medical condition(s) related to the digestive system
- Medical condition(s) related to the heart
- Medical procedure(s)
- Medical procedure(s) related to breathing
- Medical procedure(s) related to the heart
- Medical service(s)
- Medicine(s)
- Medicine(s) related to breathing
- Medicine(s) related to the blood
- Medicine(s) related to the heart
- Oxygen levels
- Smoking/nicotine use
- Temperature
- Vital signs

13 References

Use the "Insert Citation" button to add citations to this document.

1. Coppock, A. randomizr: Easy-to-Use Tools for Common Forms of Random Assignment and Sampling. Preprint at <https://declaredesign.org/r/randomizr/> (2024).
2. Linos, E., Lasky-Fink, J., Larkin, C., Moore, L. & Kirkman, E. The formality effect. *Nat. Hum. Behav.* **8**, 300–310 (2024).
3. Hong, N., Root, A. & Handel, B. The Role of Information and Nudges on Advance Directives and End-of-Life Planning: Evidence From a Randomized Trial. *Medical Care Research and Review* **80**, 283–292 (2023).
4. Gomila, R. Logistic or linear? Estimating causal effects of experimental treatments on binary outcomes using regression analysis. *J. Exp. Psychol. Gen.* **150**, 700–709 (2021).
5. Hellevik, O. Linear versus logistic regression when the dependent variable is a dichotomy. *Qual. Quant.* **43**, 59–74 (2009).
6. Rudert, S. C., Reutner, L., Greifeneder, R. & Walker, M. Faced with exclusion: Perceived facial warmth and competence influence moral judgments of social exclusion. *J. Exp. Soc. Psychol.* **68**, 101–112 (2017).
7. La Macchia, S. T., Louis, W. R., Hornsey, M. J. & Leonardelli, G. J. In Small We Trust: Lay Theories About Small and Large Groups. *Pers. Soc. Psychol. Bull.* **42**, 1321–1334 (2016).
8. Clark, J. K., Thiemb, K. C., Hoover, A. E. & Habashi, M. M. Gender stereotypes and intellectual performance: Stigma consciousness as a buffer against stereotype validation. *J. Exp. Soc. Psychol.* **68**, 185–191 (2017).
9. Mann, T. C. & Ferguson, M. J. Reversing implicit first impressions through reinterpretation after a two-day delay. *J. Exp. Soc. Psychol.* **68**, 122–127 (2017).