



Evaluation of parent reminder-recall letters to promote human papillomavirus vaccination

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ABSTRACT

Objective: Human papillomavirus (HPV) vaccine uptake remains suboptimal. Our stepped-wedge cluster randomized trial found that reminder-recall letters sent to parents of age-eligible children significantly increased vaccine uptake compared to usual care. Subsequently, we conducted a process evaluation to assess the mechanisms of the letter's effectiveness. This study evaluated who remembered the letter, use of provided resources, and child vaccination status.

Methods: This cross-sectional evaluation included data from parents ($n = 1165$) of adolescents ages 11–12 from six primary care practices who received letters about their child's HPV vaccination status. From 2018 to 2022, parents were mailed reminder-recall letters and then sent questionnaires 12–15 months after receiving the letter. Questionnaires asked if parents recalled the letter, whether their child received a vaccination and, if not, reasons for not vaccinating, and attitudes and beliefs about HPV vaccination.

Results: A total of 1165 of 1991 questionnaires were completed (59 %). Over half (58 %) remembered the reminder-recall letter. Compared to those not remembering the letter, those who did were significantly more likely to have had their child vaccinated (56 % versus 44 %, $p < 0.05$). Of those who remembered the letter but did not vaccinate, the majority reported misperceptions about their child being too young (26 %) or concerns about vaccine safety (20 %). Of those who did not remember the letter and did not vaccinate, the primary reason was not knowing the child was due for vaccination (27 %).

Conclusions: Reminder-recall letters cued the majority of parents to complete HPV vaccination; however, vaccine misperceptions remain a challenge, indicating the need for additional communication strategies.

1. Introduction

Human papillomavirus (HPV) vaccine is routinely recommended for all males and females ages 11 to 12 years to protect against HPV-associated cancers. HPV vaccination rates in the United States of America (USA), however, consistently fall short of the 80 % national public health goal, leaving millions at risk for developing these cancers

(Office of Disease Prevention and Health Promotion. Increase the proportion of adolescents who get recommended doses of the HPV vaccine—IID-08, 2024; People, 2030; Pingali et al., 2024).

Merely offering the HPV vaccine to patients during clinic appointments has proven insufficient to achieve the high vaccination rates essential for realizing the population-wide benefits of HPV vaccination or for reducing the significant disparities that exist in HPV vaccination

Abbreviations: HPV, Human papillomavirus; QR, Quick response; URL, Uniform Resource Locator; USA, United States of America; SD, Standard deviation; OR, Odds ratio; aOR, Adjusted odds ratio.

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by race and ethnicity, socioeconomic status, and geographic region (Pingali et al., 2024). Numerous obstacles hinder timely vaccination, including limited clinic visits among age-eligible patients, deficient healthcare provider recommendations, patient discomfort associated with vaccinations, poor health literacy, and parents' lack of understanding and negative perceptions regarding the HPV vaccine and its recommended administration schedule (Opel et al., 2013; Opel et al., 2015; Opel and Omer, 2015; Opel et al., 2012; Brewer et al., 2017; Nyhan and Reifler, 2015; Nyhan et al., 2014; Galvin et al., 2023). The Community Preventive Services Task Force concluded that strong evidence exists for individual interventions, such as sending reminder-recall notifications to parents and audit-feedback reports to health care providers, but the strength of evidence on the combination of these evidence-based interventions remains less clear (Task Force on Community Preventive Services, 2000). For this reason, we conducted a stepped-wedge cluster randomized trial at six primary care practices in Southeast Minnesota, USA, to assess the individual impact of reminder-recall letters, provider audit-feedback reports, and the combination of both against usual care on uptake of adolescent HPV vaccination rates (Finney Rutten et al., 2024). We found that reminder-recall letters sent to parent/guardians of age-eligible children increased the odds of vaccine uptake by 1.56 times more than usual care and 2.03 times when combined with provider audit and feedback (which alone did not significantly improve vaccine uptake).

Reminder-recalls extend beyond the conventional clinical encounter by directly contacting patients or their parent/guardians outside of a clinical visit. This outreach strategy can overcome barriers such as infrequent adolescent primary care visits (Nordin et al., 2010; Acad. Pediatr., 2018) and low awareness about HPV vaccine among patients (Darden et al., 2013; Perkins et al., 2016). Reminder-recalls using USA mail, telephone calls, auto-dialers, text messaging, or outreach visits have been shown to be effective for increasing HPV vaccination rates (Cassidy et al., 2014; Matheson et al., 2014; Szilagyi et al., 2013; Kharbanda et al., 2011; Jacobson Vann et al., 2018). However, less is known about how recipients react to, interpret, and act on reminder-recall messages (Golden et al., 2014). Given the strong evidence supporting reminder-recall (Finney Rutten et al., 2024) strategies, we included in our clinical trial a process evaluation to contextualize potential causal mechanisms associated with vaccine uptake that could explain reasons for their effectiveness and identify opportunities for modifying these strategies for implementation into routine clinical care. Our aim in this evaluation, therefore, was to elicit parent or legal guardian feedback about their experiences specifically with the reminder-recall letter and their importance on HPV vaccination.

2. Methods

The protocol for our clinical trial and main results are published elsewhere (Finney Rutten et al., 2024; Finney Rutten et al., 2018). Briefly, we used a cluster randomized trial with a stepped-wedge factorial design to evaluate the individual and combined effects of two interventions on eligible children receiving at least one dose of HPV vaccine during the study step. Eligible children were those who turned 11- or 12-years-old and were due for a dose of HPV vaccine. Our interventions included reminder-recall letters sent to parent/guardians of eligible children and audit-feedback reports sent to healthcare providers at the participating primary care clinics. The stepped-wedge factorial design enabled evaluation of no intervention (Step 1), each intervention individually and in combination (Steps 2–3), and both interventions at all sites (Step 4) during the four year-long steps. This paper focuses, specifically, on the process evaluation of the parent/guardian reminder-recall letters.

At the beginning of each calendar month, starting April 2019, parent/guardians of children empaneled at the clinical practice sites that were randomly assigned to the reminder-recall intervention were sent the reminder-recall letters via postal mail ($n = 4464$). The letter

included a list of vaccinations that their children were due for (e.g., HPV, influenza, meningococcal conjugate ACWY vaccine, and the adolescent/adult tetanus-diphtheria-acellular pertussis vaccine) and provided a quick response (QR) code and a website address (URL) for accessing further information about the vaccines due. In the letter, we strongly urged parent/guardians to vaccinate their children as soon as possible, described the availability of convenient nurse visits and vaccines at express care sites, included information about the availability of topical anesthetics to reduce injection pain, and provided phone numbers for scheduling appointments.

Approximately 12 months after receiving the reminder-recall letter, parent/guardians were sent a 21-item questionnaire by postal mail to assess their recollection of receipt and response to the letter. We timed the questionnaires to: 1) maintain a uniform time for all parent/guardians to receive the questionnaire; and, 2) allow the reminder-recall trial period to end and avoid the chance that the questionnaire could act as an additional prompt for vaccination. We recognized the potential risk of recall bias but were more concerned about the potential of contaminating intervention strategies by contacting participants prior to the trial completion. Nonetheless, due to delays caused by the COVID-19 pandemic, some parent/guardians receiving interventions in Step 2 received the questionnaires 12 to 15 months after we mailed the reminder-recall letters.

The process evaluation questionnaire was sent to all parent/guardians who were mailed the reminder-recall letters in Step 2 of the intervention ($n = 647$) and to a random sample of parent/guardians from Step 3 ($n = 1528$) and Step 4 ($n = 1991$). Of the 4464 parent/guardians who were sent reminder-recall letters, 4166 were surveyed between September 2020 and August 2023 for the process evaluation (93.3 %). The initial mailing included a \$2 bill as a pre-incentive for completing the questionnaire. A second questionnaire (without incentive) was sent to non-responders one month after the initial mailing. The questionnaire was written at a Flesch-Kincaid 4th grade level and an approximate 3-min completion time. Reminder-recall letters for this trial did not overlap with adolescent vaccine campaigns from the Minnesota Department of Health during the same study period as it targeted older adolescents (personal communication with Minnesota Department of Health).

2.1. Measures

In addition to demographic characteristics of the child (i.e., sex, race/ethnicity) and the parent/guardian (i.e., relationship to child, sex, age, race/ethnicity, marital status, education, housing, and employment), parent/guardians were asked about their recollection of the reminder-recall letter (“Did you receive a letter from Mayo Clinic in the last year reminding you that your child was due for certain vaccines?”) and whether their child had received the HPV vaccination in the last 12 months (1 = yes, 2 = no, 3 = I don’t recall). We also asked them if they used the QR code and/or the URL to access further information about the vaccines due (1 = Yes, only the QR code; 2 = Yes, only the URL; 3 = Yes, both the QR code and URL; 4 = No); whether they scheduled an appointment for the child to receive the HPV vaccine (1 = yes; 2 = no); and if they did, the type of vaccination appointment scheduled (e.g., nurse visit, well-child visit). If their child had not received the HPV vaccine, they were asked to designate their main reason for not vaccinating from a pre-specified list of reasons and to rate the likelihood that their child would receive the HPV vaccine in the next 12 months (1 = “Not likely at all” to 4 = “Very likely”). These reasons were then categorized into barriers related to: 1) awareness about HPV and vaccines and access to vaccination or pain control (e.g., time constraints, delays due to COVID-19, fear of needles/pain control); and, 2) misperceptions about HPV vaccine (e.g., child will not need it, HPV vaccine is not safe, child is too young).

We also assessed parent/guardian attitudes and beliefs about HPV vaccination using summed scores from a five-item modified version of

the Carolina HPV Immunization and Attitudes and Beliefs Scale (Gowda et al., 2012; McRee et al., 2010; Dempsey et al., 2014). Using a 5-point Likert scale (1 = “Strongly disagree” to 5 = “Strongly agree”), parent/guardians were asked to respond to the following statements: “Most people who are important to me would support getting the HPV vaccine for my child” (injunctive social norm), “Other parents in my community are getting their children the HPV vaccine” (descriptive social norm), “The HPV vaccine might cause lasting health problems” (perceived harm), “I don’t have enough information about the HPV vaccine to decide whether to give it to my child” (uncertainty), and “The HPV vaccine is effective in preventing several cancers” (effectiveness). General vaccine confidence was measured with summed scores from three items adapted from the Vaccination Confidence Scale (Gilkey et al., 2016; Gilkey et al., 2014) using the same 5-point Likert scale: “Vaccines are necessary to protect the health of children who are the age of my child” (necessity), “Vaccines do a good job in preventing the diseases they are intended to prevent” (effectiveness), and “Vaccines are safe” (safety).

2.2. Data analysis

We summarized respondents’ sociodemographic characteristics, including sex, race, education, and employment status. We then compared participants’ recollection of the reminder-recall letters by their sociodemographic characteristics and their child’s self-reported HPV vaccination status using Fisher’s exact test, and Welch’s two-sample *t*-test. We examined whether participants’ vaccine confidence and HPV vaccine attitudes and beliefs differed by reminder-letter recollection using Welch’s two-sample *t*-test.

Among participants who remembered receiving the reminder-recall letter, we summarized their use of the QR code and URL, and the types of vaccination appointments they scheduled. For participants who reported that their child had not received the HPV vaccination in the last 12 months, we summarized the self-reported main reason for non-vaccination. We then examined the association between vaccination intention among these participants and their recollection of reminder-recall letter using Chi-squared tests. Additionally, we examined the association between reminder-recall letter recollection and self-reported main reason for non-vaccination using binary logistic regression, adjusting for child and parent/guardian demographic characteristics, including education level, employment status, and marital status. We also examined the associations between these participants’ vaccination intention and their scores on the Vaccine Confidence Scale and the HPV Vaccine Attitudes and Beliefs Scale using ordinal logistic regression, adjusting for the same demographic factors (Gowda et al., 2012; McRee et al., 2010; Dempsey et al., 2014). Finally, we examined the association between self-reported main reason for non-vaccination and vaccination intention using ordinal logistic regression, adjusting for the same demographic factors. No violation of the proportional odds assumption was observed. Statistical analyses were conducted in R version 4.3.1 (R_Core_Team, 2023) in March 2024. R package “tidyverse” (Wickham et al., 2019) was used for data management, “MASS” (Venables and Ripley, 2002) was used for fitting ordinal logistic models, and “brant” (Schlegel et al., 2019) was used to test the proportional odds assumption. *P*-values <0.05 were considered statistically significant. The Mayo Clinic Institutional Review Board (IRB) reviewed and approved the process evaluation protocol and the survey materials used (17–010626).

3. Results

A total of 1165 parent/guardians among the 4166 surveyed responded to the questionnaire (response rate: 28.0 %). Most were mothers (86.7 %), white (93.1 %), college graduates (43.1 %), employed for pay (89.3 %), and had a child who was male (53.5 %) and white (92.4 %) (Table 1). About half of parent/guardians (58.5 %, *n* = 681) remembered receiving the reminder-recall letter, with more parent/

Table 1

Distribution of sample demographics by recall of reminder letter among children and parent/guardians in Minnesota participating in a process evaluation of an HPV intervention from 2018 to 2022 (*n* = 1165).

| Demographic variable | Recall of reminder letter ^a | | p-value ^b |
|---|--|------------|----------------------|
| | Yes, n (%) | No, n (%) | |
| Total | 681 (58.5) | 484 (41.6) | |
| Child’s sex | | | 0.04 |
| Female | 291 (43.5) | 240 (49.9) | |
| Male | 377 (56.4) | 239 (49.7) | |
| Other | 1 (0.2) | 2 (0.4) | |
| Child’s race/ethnicity ^c | | | |
| Hispanic/Latino/Latina | 16 (2.4) | 18 (3.8) | 0.18 |
| White | 624 (91.6) | 452 (93.4) | 0.27 |
| Black/African American | 25 (3.7) | 11 (2.3) | 0.17 |
| American Indian | 7 (1.0) | 0 | 0.05 |
| Alaska Native | 0 | 0 | |
| Asian | 47 (6.9) | 39 (8.1) | 0.46 |
| Native Hawaiian | 0 | 0 | |
| Pacific Islander | 1 (0.2) | 4 (0.8) | 0.17 |
| Parent/guardian relationship to child | | | 0.50 |
| Mother | 587 (86.2) | 422 (87.4) | |
| Father | 92 (13.5) | 58 (12.0) | |
| Other | 2 (0.3) | 3 (0.6) | |
| Sex of parent/guardian | | | 0.42 |
| Female | 588 (86.6) | 423 (87.6) | |
| Male | 91 (13.4) | 59 (12.2) | |
| Other | 0 | 1 (0.2) | |
| Parent/guardian age (in years) | | | 0.83 |
| Mean (SD) | 43.13 (5.1) | 43.2 (5.2) | |
| Median [range] | 43 [29–69] | 43 [28–73] | |
| Parent/guardian race/ethnicity ^c | | | |
| Hispanic/Latino/Latina | 11 (1.6) | 5 (1.0) | 0.40 |
| White | 636 (93.4) | 448 (92.6) | 0.58 |
| Black/African American | 10 (1.5) | 8 (1.7) | 0.80 |
| American Indian | 6 (0.88) | 0 | 0.05 |
| Alaska Native | 0 | 0 | |
| Asian | 32 (4.7) | 27 (5.6) | 0.50 |
| Native Hawaiian | 0 | 0 | |
| Pacific Islander | 1 (0.2) | 3 (0.6) | 0.31 |
| Parent/guardian marital status | | | 0.88 |
| Married/unmarried couple | 602 (88.9) | 435 (90.6) | |
| Single/divorced/widowed | 75 (11.1) | 45 (9.4) | |
| Parent/guardian education | | | 0.20 |
| High school graduate or lower | 19 (2.8) | 16 (3.3) | |
| Some college or technical school | 111 (16.3) | 95 (19.6) | |
| College graduate | 310 (45.6) | 192 (39.7) | |
| College and postgraduate schooling | 240 (35.3) | 181 (37.4) | |
| Housing | | | 0.58 |
| Own | 644 (94.6) | 462 (95.5) | |
| Rent | 33 (4.9) | 18 (3.7) | |
| Other | 4 (0.6) | 4 (0.8) | |
| Parent/guardian employment | | | 0.56 |
| Employed for wages/self-employed | 596 (88.8) | 428 (89.9) | |
| Unemployed/homemaker/student/retired/unable to work | 75 (11.2) | 48 (10.1) | |

^a One participant was missing a response to whether they recalled receiving a letter.

^b . *p*-values from Chi-squared test, Fisher’s exact test, or Welch two-sample *t*-test.

^c Respondents could select multiple race options.

guardians who had a male versus female child remembering receipt of the letter (56.4 % versus 43.5 %, $p = 0.04$).

Parent/guardians' recollection of the letter was significantly associated with their child receiving versus not receiving the HPV vaccine in the past 12 months (56.1 % versus 44.0 %, $p = 0.02$), but not with their vaccine confidence (mean [SD] = 4.5 [0.81] versus 4.6 [0.75]; $p = 0.06$), as measured by the Vaccination Confidence Scale, or by responses to the Carolina HPV Immunization and Attitudes and Beliefs scale (mean [SD] = 4.0 [0.78] versus 4.0 [0.76]; $p = 0.98$).

Among parent/guardians who remembered the letter ($n = 681$), about half reported scheduling an appointment for a vaccination (53.7 %). Most did not seek additional information about vaccination through the QR code or URL (91.3 %). Among those who did schedule appointments, most were completed during a well-child visit (54.9 %) or nurse visit (30.5 %) (Table 2).

Among parent/guardians whose child did not receive the HPV vaccine in the past 12 months ($n = 469$), remembering the letter was not significantly associated with their likelihood of vaccinating their child in the next 12 months ($p = 0.67$). Among those who remembered receiving the letter but did not have their child vaccinated ($n = 294$), the most frequently reported reasons for not vaccinating were misperceptions about their child being too young for vaccination (25.6 %), concerns about HPV vaccine safety (20.1 %), and time constraints (12.1 %) (Table 3). Among those who did not remember receiving the letter and did not have their child vaccinated ($n = 175$), the most frequently reported reason for not vaccinating was that they did not know the child was due for vaccination (27.0 %). These parent/guardians reported similar misperceptions about their child being too young for vaccination (19.8 %) and concerns about HPV vaccine safety (16.8 %), as compared to those who remembered receiving the letter. Results from the multivariate regression analyses indicated that among parent/guardians who did not vaccinate their child for HPV in the last 12 months, those who remembered the letter were more likely to report HPV vaccine misperceptions than awareness or access barriers to vaccination compared to those who did not recall the letter both before and after adjusting for demographic factors (adjusted odds ratio [aOR] = 1.76, 95 % CI 1.15, 2.70) (Table 4). Parent/guardians who reported HPV vaccine misperceptions had lower intentions to vaccinate their child against HPV (aOR = 0.07, 95 % CI 0.04, 0.11) compared to those who reported awareness or access barriers. Additional analyses showed the likelihood of vaccinating their child in the next 12 months was associated with

Table 2

The distribution of parents/guardians participating in a process evaluation of an HPV intervention in Minnesota from 2018 to 2022 who recalled getting a reminder letter and their letter-related behavioral actions ($n = 681$).

| Behavioral action | Response | n (%) |
|---|--------------------|------------|
| Scheduled appointment | Yes | 363 (53.7) |
| | No | 313 (46.3) |
| | Missing | 5 |
| | | |
| Sought additional information | Used QR code only | 9 (1.3) |
| | Used URL only | 28 (4.2) |
| | Used QR and URL | 21 (3.1) |
| | Neither QR nor URL | 611 (91.3) |
| | Missing | 12 |
| | | |
| | | |
| Appointment site (if scheduled appointment = yes) | Nurse visit | 110 (30.5) |
| | Well child | 198 (54.9) |
| | Sick child | 1 (0.3) |
| | Follow up visit | 7 (1.9) |
| | Express care | 15 (4.2) |
| | Other | 16 (4.4) |
| | I don't know | 14 (3.9) |
| | Missing | 2 |
| | | |
| | | |

Table 3

The distribution of parents/guardians participating in a process evaluation of an HPV intervention in Minnesota from 2018 to 2022 and had not vaccinated their child in the last 12 months by their recall of the reminder letter and reasons for not vaccinating ($n = 469$).

| Behavioral action | Response | Recall of reminder letter | | p-value ^a |
|---|--|---------------------------|-----------------------|----------------------|
| | | Yes (n = 294) n (%) | No (n = 175) n (%) | |
| Likelihood of vaccinating in next 12 months | Very likely | 110 (37.8) | 66 (38.6) | 0.67 |
| | Somewhat likely | 61 (21.0) | 43 (25.2) | |
| | Not too likely | 34 (11.7) | 17 (9.9) | |
| | Not likely at all | 86 (29.6) | 45 (26.3) | |
| | Missing | 3 | 4 | |
| Reason not vaccinated | Awareness & access barriers | | | |
| | Did not know child due | 12 (4.2) | 45 (27.0) | |
| | Provider did not recommend | 3 (1.0) | 0 (0) | |
| | Delayed because of COVID | 13 (4.5) | 7 (4.2) | |
| | No time/too busy/forgot/had other priorities | 35 (12.1) | 10 (6.0) | |
| | Plan to vaccinate at next visit | 22 (7.6) | 9 (5.4) | |
| | No insurance | 1 (0.4) | 0 | |
| | Needle fear/pain | 12 (4.2) | 4 (2.4) | |
| | Subtotal | 98 (33.9) | 75 (44.9) | |
| | HPV vaccine misperceptions | | | |
| | Believe child will not need | 29 (10.0) | 12 (7.2) | |
| | Believe HPV vaccine not safe | 58 (20.1) | 33 (19.8) | |
| | Child too young | 74 (25.6) | 28 (16.8) | |
| | Against family values | 20 (6.9) | 8 (4.8) | |
| | Concern about encouraging child sexual activity | 6 (2.1) | 2 (1.2) | |
| | Subtotal | 187 (64.7) | 83 (49.7) | |
| | Other | | | |
| | Believe child completed/started series (but reported no to HPV vaccination status) | 2 (0.7) | 9 (5.4) | |
| | No reason provided | 2 (0.7) | 0 | |
| | Subtotal | 4 (1.4) | 9 (5.4) | |
| | Grand Total | 289 | 167 | |
| | Missing | 5 | 8 | |

^a . p-value from chi-squared test.

vaccine confidence (aOR = 1.93, 95 % CI 1.45, 2.59) and attitudes and beliefs (aOR = 5.11, 95 % CI 3.68, 7.19) even after adjusting for demographic factors (Table 5).

4. Discussion

We sought to assess the mechanisms by which our reminder-recall letter intervention influenced HPV vaccine uptake. We observed that 12–15 months after receiving the reminder-recall letter, about half of parent/guardians remembered receiving the letter, scheduled a vaccine appointment, and had their child vaccinated. However, appointment scheduling was not associated with parent/guardians' vaccine confidence, attitudes, or beliefs, which indicates that reminder-recall letters were effective as a behavioral nudge for improving vaccine uptake but

Table 4

Unadjusted and adjusted multivariable logistic regression model testing the association between recall of the reminder letter and reporting HPV vaccine misperception among parents/guardians who had not vaccinated their children in last 12 months and participated in a process evaluation of an HPV intervention in Minnesota from 2018 to 2022.^a

| Reporting an HPV vaccine misperception as the main reason (Reference: Reporting an awareness or access barrier as the main reason) | | |
|--|---------------------------------|--|
| | Unadjusted OR (95 % CI) n = 443 | Adjusted OR (95 % CI) ^b n = 418 |
| Recall of the reminder letter | | |
| No/Don't remember | Reference | Reference |
| Yes | 1.72 (1.16, 2.57) | 1.76 (1.15, 2.70) |

^a Result from binary logistic regression; Participants who reported a reason in the Other category (n = 13) were excluded from the analysis.

^b The model is adjusted for sex of child, parent age, sex of parent, parent education, employment and marital status.

Table 5

Unadjusted and adjusted multivariable logistic regression models testing the association between HPV vaccination intention and 1) reason for not vaccinating and 2) the Vaccine Confidence Scale score and HPV Vaccine Attitude and Belief Scale score among parents/guardians who had not vaccinated their children in last 12 months and participated in a process evaluation of an HPV intervention in Minnesota from 2018 to 2022.^a

| | HPV vaccination intention | |
|--|---------------------------|------------------------------------|
| | Unadjusted OR (95 % CI) | Adjusted OR ^b (95 % CI) |
| Model 1: ^c | n = 442 | n = 417 |
| Main reason for no HPV vaccination | | |
| Awareness or access barrier | Reference | Reference |
| HPV vaccine misperception | 0.07 (0.05, 0.11) | 0.07 (0.04, 0.11) |
| Model 2: | n = 461 | n = 435 |
| Vaccine Confidence Scale score | 1.73 (1.34, 2.25) | 1.93 (1.45, 2.59) |
| HPV Vaccine Attitude and Beliefs Scale score | 4.85 (3.59, 6.63) | 5.11 (3.68, 7.19) |

^a .Results from ordinal logistic regression. HPV vaccination intention coded as 1 = Not likely at all, 2 = Not too likely, 3 = Somewhat likely, 4 = Very likely.

^b .Models were adjusted for sex of child, parent age, sex of parent, parent education, employment and marital status.

^c .Participants who reported a reason in the Other category (n = 13) were excluded from the analysis.

likely had limited impact on shifting vaccine-related attitudes and beliefs. This finding is consistent with previous interventions that reported reminder-recall letters to increase adolescent vaccination rates (Szilagyi et al., 2013; Suh et al., 2012) and extends these previous findings with the observed non-significant association between reminder-recall letters and intermediate outcomes, including vaccine attitudes and beliefs. Furthermore, most parent/guardians who remembered the letter did not access additional vaccine information through the QR code or URL provided in the letter, suggesting that the reminder-recall letter simply served as a prompt for scheduling an appointment for a well-child or nurse visit.

Our findings on parent/guardians who have not vaccinated their child similarly suggest the limited effectiveness of reminder-recall letters in promoting HPV vaccination among these parent/guardians. In addition to the non-significant association between parent/guardians' recollection of the letter and their vaccination intention, the most common reasons parent/guardians reported for not vaccinating were that their child was too young for HPV vaccination and that they had concerns about HPV vaccine safety. These concerns are consistent with the rising trend from 2015 to 2018 in parent/guardians citing HPV

vaccine safety concerns as a reason for non-vaccination (Sonawane et al., 2021) despite strong vaccine safety surveillance and evidence of effectiveness and safety (US Centers for Disease Control and Prevention, 2024). Additionally, we found that parents/guardians' intention to vaccinate their children in the next 12 months was associated with general vaccine confidence and positive attitudes and beliefs about the HPV vaccine, underscoring the continued need to strengthen parent/guardians' confidence in the HPV vaccine, reinforcing positive attitudes and normative beliefs about HPV vaccine and improving the four domains of health literacy (i.e., access, understanding, appraisal and application) that relate to HPV vaccination (Galvin et al., 2023). With national guidelines permitting HPV vaccination at age 9 years (Meites et al., 2019), future reminder-recall letter interventions should also consider highlighting eligibility for HPV vaccine initiation starting at age 9 and its associated benefits, such as stronger protection and fewer required doses compared to starting at age 15 or later (Meites et al., 2019). Addressing parent/guardians' vaccine misperceptions is critical for strengthening their HPV vaccine confidence (Shah et al., 2021) and intention to vaccinate, as observed in our study. Using social proof strategies (Cialdini and Goldstein, 2004), such as sharing testimonials or stories from parents in the same community who initially had doubts about the vaccine but ultimately decided to vaccinate may help reduce hesitancy. Additionally, including a list of frequently asked questions in the reminder-recall letters to addresses popular myths and misperceptions about the HPV vaccine with concise, fact-based responses might also be effective. Of note is our finding that HPV vaccine misperceptions were more frequently reported among parent/guardians who remembered versus did not remember the letter, even though vaccine misperceptions were cited as a main reason for non-vaccination among both groups. This finding suggests that, while reminder-recall letters may be effective in increasing parent/guardians' awareness of HPV vaccination and the ease of scheduling a vaccination visit, they may not be effective in addressing misperceptions among those who are already hesitant to HPV vaccination (Szilagyi et al., 2024). Targeted strategies to correct vaccine misperceptions are thus needed. Among parent/guardians who did not recall receiving the reminder-recall letter, a significant barrier to HPV vaccination is simply not being aware that their child was due, suggesting a need to refine the reminder-recall letter to be more memorable to parent/guardians and utilize additional communication channels to ensure that parent/guardians are informed about the vaccination schedule until their children complete their vaccination series (Cunningham-Erves et al., 2024).

In summary, reminder-recall letters are an effective outreach strategy for promoting HPV vaccination, especially when a substantial proportion of parent/guardians who did not remember the letter and did not vaccinate their child had reported not knowing their child was due for vaccinations. More than half of our parent/guardians who remembered the letter scheduled a well-child or nurse visit appointment, which suggests that reminder-recall letters can support efforts seeking to increase comprehensive primary care and implement standing orders. However, we note that our clinical trial was implemented in six primary care practices in Southeast Minnesota that were primarily located in urban settings. It is possible that the effectiveness of reminder-recall letter modality and content could vary in other contexts and should, therefore, be replicated in non-urban settings and with more diverse patient populations.

This study had additional limitations. Most notably, parent/guardians who recalled the recall-reminder letter or responded to the process evaluation questionnaire may differ systematically from those who did not, and any response bias may be associated with differences in either vaccine uptake or vaccine confidence or attitudes and beliefs about the HPV vaccine. This is an important limitation of any process evaluation, especially when, as here, the questionnaire is timed to be administered after trial completion to avoid impacting the measured outcomes. While this problem should be considered when interpreting the results, there is still value in evaluating the experience of those who participated in the

study. Another potential limitation is the possibility that our process evaluation findings on reminder-recall letters for HPV vaccination may not be generalizable for reminder-recall letters for other vaccines, for other types of preventive services, or for patient populations that differ demographically from our predominately White and non-Hispanic sample or live outside of our study area. Also, to maintain compliance with our IRB protocol, the process evaluation questionnaire was administered without identifying information to link back to the medical records of patients. In other words, parent/guardians who reported vaccinating their children may not have actually done so. Therefore, our findings relied on parent/guardians' self-reports 12–15 months after receiving the letter, which may be subject to social desirability and recall issues. Future studies could examine the causal pathway between reminder-recall letter intervention and vaccination uptake that is verified with electronic health record data. Such a study could test the potential mediating effect of parent/guardians' use and perceptions of the letter, as well as vaccination attitudes and beliefs, on all adolescent vaccine completion rates. This could provide meaningful insights into whether parents/guardians who received and recalled a letter for all due vaccinations act on some recommended vaccinations but not others. Qualitative studies could also be used to more deeply understand actionable strategies to address barriers and misperceptions about HPV and other adolescent vaccines.

5. Conclusion

Reminder-recall letters were an effective prompt for HPV vaccine appointment scheduling among the majority of parent/guardians who recalled receiving the reminder-recall letter and did not seek additional information about the vaccine. However, our reminder-recall intervention had limited impact on parent/guardians who had misperceptions about and decided against HPV vaccination. Additional efforts to address vaccine misperceptions are needed to bolster the positive effects of reminder-recall letters on promoting HPV vaccination.

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CRediT authorship contribution statement

Joan M. Griffin: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis. **Xuan Zhu:** Writing – review & editing, Writing – original draft, Formal analysis. **Wei Yi Kong:** Writing – review & editing, Writing – original draft. **Robert M. Jacobson:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Kathy L. MacLaughlin:** Writing – review & editing. **Jennifer L. St. Sauver:** Writing – review & editing. **Jeph Herrin:** Writing – review & editing, Supervision, Formal analysis. **Gregory D. Jenkins:** Writing – review & editing, Data curation. **Nicole L. Larson:** Writing – review & editing, Project administration. **Lila J. Finney Rutten:** Writing – review & editing, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Joan Griffin reports a relationship with Exact Sciences Corporation that

includes: consulting or advisory. Lila Rutten and Xuan Zhu reports a relationship with Exact Sciences Corporation that includes: consulting or advisory. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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