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Patient reminder and recall interventions to improve immunization rates

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[Intervention Review]

Patient reminder and recall interventions to improve immunization rates

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ABSTRACT

Background

Immunization rates for children and adults are rising, but coverage levels have not reached optimal goals. As a result, vaccine-preventable diseases still occur. In an era of increasing complexity of immunization schedules, rising expectations about the performance of primary care, and large demands on primary care providers, it is important to understand and promote interventions that work in primary care settings to increase immunization coverage. One common theme across immunization programs in many nations involves the challenge of implementing a population-based approach and identifying all eligible recipients, for example the children who should receive the measles vaccine. However, this issue is gradually being addressed through the availability of immunization registries and electronic health records. A second common theme is identifying the best strategies to promote high vaccination rates. Three types of strategies have been studied: (1) patient-oriented interventions, such as patient reminder or recall, (2) provider interventions, and (3) system interventions, such as school laws. One of the most prominent intervention strategies, and perhaps best studied, involves patient reminder or recall systems. This is an update of a previously published review.

Objectives

To evaluate and compare the effectiveness of various types of patient reminder and recall interventions to improve receipt of immunizations.

Search methods

We searched CENTRAL, MEDLINE, Embase and CINAHL to January 2017. We also searched grey literature and trial registers to January 2017.

Selection criteria

We included randomized trials, controlled before and after studies, and interrupted time series evaluating immunization-focused patient reminder or recall interventions in children, adolescents, and adults who receive immunizations in any setting. We included no-intervention control groups, standard practice activities that did not include immunization patient reminder or recall, media-based activities aimed at promoting immunizations, or simple practice-based awareness campaigns. We included receipt of any immunizations as eligible outcome measures, excluding special travel immunizations. We excluded patients who were hospitalized for the duration of the study period.

Data collection and analysis

We used the standard methodological procedures expected by Cochrane and the Cochrane Effective Practice and Organisation of Care (EPOC) Group. We present results for individual studies as relative rates using risk ratios, and risk differences for randomized trials, and as absolute changes in percentage points for controlled before-after studies. We present pooled results for randomized trials using the random-effects model.

Main results

The 75 included studies involved child, adolescent, and adult participants in outpatient, community-based, primary care, and other settings in 10 countries.

Patient reminder or recall interventions, including telephone and autodialer calls, letters, postcards, text messages, combination of mail or telephone, or a combination of patient reminder or recall with outreach, probably improve the proportion of participants who receive immunization (risk ratio (RR) of 1.28, 95% confidence interval (CI) 1.23 to 1.35; risk difference of 8%) based on moderate certainty evidence from 55 studies with 138,625 participants.

Three types of single-method reminders improve receipt of immunizations based on high certainty evidence: the use of postcards (RR 1.18, 95% CI 1.08 to 1.30; eight studies; 27,734 participants), text messages (RR 1.29, 95% CI 1.15 to 1.44; six studies; 7772 participants), and autodialer (RR 1.17, 95% CI 1.03 to 1.32; five studies; 11,947 participants). Two types of single-method reminders probably improve receipt of immunizations based on moderate certainty evidence: the use of telephone calls (RR 1.75, 95% CI 1.20 to 2.54; seven studies; 9120 participants) and letters to patients (RR 1.29, 95% CI 1.21 to 1.38; 27 studies; 81,100 participants).

Based on high certainty evidence, reminders improve receipt of immunizations for childhood (RR 1.22, 95% CI 1.15 to 1.29; risk difference of 8%; 23 studies; 31,099 participants) and adolescent vaccinations (RR 1.29, 95% CI 1.17 to 1.42; *r*isk difference of 7%; 10 studies; 30,868 participants). Reminders probably improve receipt of vaccinations for childhood influenza (RR 1.51, 95% CI 1.14 to 1.99; risk difference of 22%; five studies; 9265 participants) and adult influenza (RR 1.29, 95% CI 1.17 to 1.43; risk difference of 9%; 15 studies; 59,328 participants) based on moderate certainty evidence. They may improve receipt of vaccinations for adult pneumococcus, tetanus, hepatitis B, and other non-influenza vaccinations based on low certainty evidence although the confidence interval includes no effect of these interventions (RR 2.08, 95% CI 0.91 to 4.78; four studies; 8065 participants).

Authors' conclusions

Patient reminder and recall systems, in primary care settings, are likely to be effective at improving the proportion of the target population who receive immunizations.

PLAIN LANGUAGE SUMMARY

Do strategies to remind people to have vaccinations increase the number of people who receive vaccinations?

Aim of this review

The aim of this review is to determine whether strategies to remind people to receive vaccinations increase the number of people who receive vaccinations. This is an update of a previously published Cochrane Review.

Key messages

Reminding people to receive their vaccinations increases vaccination rates across different populations.

What was studied

Vaccinations are used to prevent a number of diseases but there is wide variation in vaccination coverage across different regions and countries. This can lead to diseases that are otherwise preventable by vaccines, having a large effect on individuals and communities. Informing people of an upcoming vaccination or telling them that they have missed a vaccination might help to increase coverage and reduce the effect and impact of disease preventable by vaccine. We reviewed 75 studies to evaluate whether reminding people to get vaccinated worked. The studies we looked at were from different settings, such as rural areas, schools, private practices, and state health departments. Most studies were done in the USA. The studies included a range of different groups: infants and children, adolescents and adults requiring routine vaccination, as well as adults who required the influenza vaccine. In most of the studies reminders took the form of person to person telephone calls, automated calls, letters or postcards. In few recent studies text messaging was used.

Main results of the review

Our review found that reminding people to have vaccinations likely increases the number of people who receive vaccinations by an average of 8 percentage points, although there was variation in the results of the studies. Reminding people by telephone and autodialer calls, sending a letter or postcard, or sending a text message increased vaccinations. Combinations of reminders were also effective. Reminding

people over the telephone was more effective than the other types of reminders. The increases in vaccinations were observed among children, adolescents, and adults.

How up-to-date is this review?

We reviewed studies that were published to January 2017.

Summary of findings for the main comparison. Overview: Patient reminder or recall interventions for receipt of immunizations - any kind

Patient reminder or recall interventions compared with no patient reminder or recall for receipt of immunizations

Patient or population: children, adolescents, and adults with a need for routine immunizations, excluding travel immunizations

Settings: patient telephone reminder or recall interventions are typically received in the home; the interventions originate from outpatient departments of hospitals, community-based clinical settings, local and state public health departments, and other clinical settings

Intervention: patient reminder or recall interventions

Comparison: no-intervention control groups, standard practice activities that did not include immunization-focused patient reminder or recall interventions, media-based activities aimed at promoting immunizations, and simple practice-based immunization awareness campaigns

Intervention type	Outcome: received immunizations					
	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Without intervention	With intervention				
Patient reminder or recall summary measure	290 per 1000	371 per 1000 (357 to 392)	RR 1.28[a] (1.23 to 1.35)	138,625 (55)	Moderate[b]	—
Patient telephone reminder or recall	164 per 1000	287 per 1000 (197 to 417)	RR 1.75 (1.20 to 2.54)	9120 (7)	Moderate[c]	—
Patient letter reminder or recall	320 per 1000	412 per 1000 (387 to 442)	RR 1.29 (1.21 to 1.38)	81,100 (27)	Moderate[d]	—
Patient postcard reminder or recall	327 per 1000	386 per 1000 (353 to 425)	RR 1.18 (1.08 to 1.30)	27,734 (8)	High[e]	—
Patient text message reminder or recall	161 per 1000	208 per 1000 (185 to 232)	RR 1.29 (1.15 to 1.44)	7772 (6)	High	—

Patient autodialer message reminder or recall	365 per 1000	427 per 1000 (376 to 482)	RR 1.17 (1.03 to 1.32)	11,947 (5)	High	—
Combination of patient mail and telephone reminder or recall	277 per 1000	354 per 1000 (316 to 402)	RR 1.28 (1.14 to 1.45)	6506 (8)	Moderate[f]	—
Combination of patient reminder or recall with outreach intervention	360 per 1000	439 per 1000 (396 to 486)	RR 1.22 (1.10 to 1.35)	2701 (3)	High	—
Combination of patient reminder or recall with provider reminder intervention	202 per 1000	588 per 1000 (540 to 644)	RR 2.91 (2.67 to 3.19)	4120 (2)	Moderate[g]	—

*The basis for the **assumed risk,** e.g. the median control group risk across studies, is provided in footnotes. The **corresponding risk,** and its 95% confidence interval, is based on the assumed risk in the comparison group and the **relative effect** of the intervention, and its 95% CI.
CI: confidence interval; **RR:** risk ratio

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[a]It is important to note that this review is the third update of the initial review that was published in 2002; the results for each update have been relatively stable and consistent with the original review.
[b]We downgraded the certainty of the evidence by 1 point. GRADE was reduced by 0.5 points because of a small degree of inconsistency in outcomes. Generally, most included studies reported relatively small positive risk ratios, with several negative outliers and several with stronger positive effects; the patient reminder recall interventions also varied. We downgraded precision slightly (-0.5) because the confidence intervals were wide for several included studies.
[c]We downgraded the certainty of the evidence by 1 point. GRADE was reduced by 0.5 points because of a small degree of inconsistency in outcomes; the interventions were relatively homogeneous. We downgraded precision slightly (-0.5) because the confidence intervals were wide for a few included studies.
[d]We downgraded the certainty of the evidence by 1 point because of a small degree of inconsistency in outcomes (0.5 point); the interventions were relatively homogeneous. We downgraded precision slightly (-0.5) because the confidence intervals were wide for several included studies.
[e]We downgraded the certainty of the evidence by 0.5 points because of a high risk of bias for one or two of eight criteria for 15 studies.
[f]We downgraded the certainty of the evidence by 1 point. GRADE was reduced by 0.5 points because of a small degree of inconsistency in outcomes, with one outlier; the interventions were more varied than the single intervention types. We downgraded precision slightly (-0.5) because the confidence interval was wide for one outlier.
[g]We downgraded the certainty of the evidence by 1.5 points. GRADE was reduced by 0.5 points because of a moderate risk of bias in one of three comparisons within two studies. We downgraded precision by 1 point because of two wide confidence intervals in three comparisons.

Summary of findings 2. Summary: Patient reminder or recall interventions by type of immunization

Patient reminder or recall intervention for receipt of immunization, by type of immunization

Patient or population: children, adolescents, and adults with a need for routine immunizations, excluding travel immunizations

Settings: patient reminder or recall interventions are typically received in the home; the interventions originate from outpatient departments of hospitals, community-based clinical settings, local and state public health departments, and other clinical settings

Interventions: patient reminder or recall interventions, including telephone calls, autodialer calls, letters, postcards, text messages, combination of mail or telephone, or combination of patient reminder or recall with outreach; this summary measure excludes patient reminder or recall interventions combined with provider reminders

Comparison: no-intervention control groups, standard practice activities that did not include immunization-focused patient reminder or recall interventions, media-based activities aimed at promoting immunizations, and simple practice-based immunization awareness campaigns

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Without intervention	With intervention				
Childhood immunizations	333 per 1000	406 per 1000 (383 to 430)	RR 1.22 (1.15 to 1.29)	31,099 (23)	High[a]	—
Childhood influenza immunizations	431 per 1000	651 per 1000 (491 to 857)	RR 1.51 (1.14 to 1.99)	9265 (5)	Moderate[b]	—
Adult immunizations - other than influenza or travel ('Other adult')	109 per 1000	227 per 1000 (99 to 521)	RR 2.08 (0.91 to 4.78)	8065 (4)	Low[c]	—
Adult influenza immunizations	292 per 1000	376 per 1000 (342 to 418)	RR 1.29 (1.17 to 1.43)	59,328 (15)	Moderate[d]	—
Adolescent immunizations	244 per 1000	314 per 1000 (285 to 346)	RR 1.29 (1.17 to 1.42)	30,868 (10)	High[e]	—

*The basis for the **assumed risk,** e.g. the median control group risk across studies, is provided in footnotes. The **corresponding risk,** and its 95% confidence interval, is based on the assumed risk in the comparison group and the **relative effect** of the intervention, and its 95% CI.
CI: confidence interval; **RR:** risk ratio

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

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[a]We did not downgrade the certainty of the evidence: no serious risk of bias, serious inconsistency, serious indirectness, or serious imprecision was identified among the 23 studies; however, one study was an outlier (RR 5.33).

[b]We downgraded the certainty of the evidence by 1.5 points because of some imprecision (-1) and inconsistency (-0.5). One of five studies had a wide confidence interval and effect sizes ranged from 1.08 to 4.6.

[c]We downgraded the certainty of the evidence by 2 points because of lack of agreement between studies (-1) and some imprecision (-1). Effect sizes ranged from 1.08 to 3.61 and two of five studies had wide confidence intervals.

[d]We downgraded the certainty of the evidence by 1.5 points because of some inconsistency in results (-0.5) and some imprecision (-1). Effect sizes ranged from 0.91 to 3.11 and one of 15 studies had a wide confidence interval.

[e]We did not downgrade the certainty of the evidence: no serious risk of bias, serious inconsistency, serious indirectness, or serious imprecision was identified among the 10 studies.

BACKGROUND

Description of the condition

Global coverage of routine immunizations varies widely (Hill 2016; European CDPC 2014; WHO 2016a). The global rate for three doses of diphtheria tetanus pertussis (DTP3) vaccine was estimated to be 86% in 2014, an increase of 66 percentage points since the 1980 level of 20% (WHO 2016a). However, approximately 18.7 million children did not receive DTP3 during 2014 (WHO 2016b). Rates vary by geographic area or country, with high levels of DTP3, ranging from 91% to 94% in the Americas, Europe, and the Western Pacific in 2014 (WHO 2016b). In 2014, the Eastern Mediterranean, South East Asia, and African regions had lower coverage rates of 73% to 84% (WHO 2016b). In the United States, immunization rates remain high and stable for infants and children, but coverage levels have not reached national goals for a number of vaccines, including the newer vaccinations introduced (Hill 2016; Seither 2016). Immunization rates remain nowhere near national coverage goals for influenza, human papillomavirus (HPV) vaccination, and adult vaccinations against herpes zoster or shingles and pneumococcal disease (Lu 2013; Reagan-Steiner 2016; Stokley 2014). Vaccination rates also vary by state, race, and ethnicity (CDC 2016a; Hill 2015; Reagan-Steiner 2015; Seither 2015; Williams 2015). For example, influenza immunization rates during the 2013 to 2014 influenza season varied by race or ethnicity, with reports of 46.7% among whites 19 years and older, compared with 36.5% among blacks, and 33.2% among Hispanics or Latinos (Williams 2016).

Burden of vaccine-preventable diseases

As a result of unmet immunization goals, vaccine-preventable diseases still have a significant effect in a number of countries (Clemmons 2015; European CDPC 2014; Williams 2016). This is evidenced by the continued occurrence of measles outbreaks, for example in Disneyland in California during 2015 (Clemmons 2015). In the European Union and three European Economic Area countries, 11,316 cases of measles were reported during 2012 (European CDPC 2014). The burden of vaccine-preventable illnesses has also included approximately 226,000 influenza-related hospitalizations, 3000 to 49,000 influenza-related deaths, and 13,500 cases of invasive pneumococcal disease that occur each year in the US (Williams 2016). In Europe, an estimated four to 50 million symptomatic cases of influenza occur each year, and 15,000 to 70,000 deaths have been attributed to influenza annually (European CDPC 2016). Further, human papillomavirus (HPV) vaccination rates in the US and in some other nations are far lower than optimal, leading to many new cases of HPV infection and ultimately HPV-related cancers (Viens 2016). Each year, 6.2 million persons are newly infected with HPV, and 26,000 new HPV-related cancers are diagnosed in the US (Jemal 2013; Weinstock 2004). Cancers attributable to HPV infections lead to more than USD 4 billion in annual medical expenses in the US (Markowitz 2014).

Description of the intervention

Patient reminders notify populations, patients, or their parents or legal guardians of vaccines that are due because of age or other risk factors (AHRQ 2015; Jacobson 2016; Jacobson Vann 2005). The notification is delivered to populations or patients. Patient recalls refer to notifications of vaccines that are past due. For example, a letter sent to a patient at 60 years of age, informing her that she is now due for the shingles vaccine, is a patient reminder (Hales 2014; Jacobson Vann 2005). The patient who receives a notice at age 61 years about the shingles vaccine is getting a recall because the patient is past due, but would still benefit from receiving a shingles vaccination. Reminders and recalls require the source of the notification, whether a care provider, health services organization, public health authority, or community organization, to have access to the patient's contact information to facilitate the notification. The notification may be delivered by letter, postcard, telephone call, computerized telephone call, or text message (AHRQ 2015). The process would require the source of the notification to have determined the individual patient's status, in terms of being recommended for the vaccine by nature of the patient's age or risk condition or both, and not being vaccinated at the time of the notification.

How the intervention might work

Patient reminder or recall interventions work by addressing the common reasons that immunizations may be missed, such as forgetting or missing appointments, not knowing immunization schedules (Ahmed 2013; AHRQ 2015), and having concerns about vaccinations. The success of the patient or reminder recall intervention depends upon several factors, such as accuracy or currency of contact information, accuracy and completeness of vaccination records, viability of contact medium, readability or comprehensibility of the contact medium or message by the patient or patient's parent or legal guardian or caretaker, beliefs and attitudes about vaccinations, and access to health services or vaccinations (Esposito 2014; Pereira 2012; Thomas 2014).

Why it is important to do this review

In an era of increasing complexity of immunization schedules (CDC 1999a), rising expectations about the performance of primary care, and large demands on primary care physicians, it is important to understand and promote interventions that work in primary care settings. One strategy involves patient reminder or recall systems, which was recommended by the Task Force on Community Preventive Services (CPS Task Force 2016) and the Standards for Immunization Practices (National Vaccine Advisory Committee 2014). Despite the successes made in vaccinating populations under-vaccination still occurs, resulting in vaccine-preventable deaths and illnesses (Clemmons 2015; European CDPC 2014; Williams 2016).

Experts recommend that care providers utilize reminder or recall systems (CPS Task Force 2016; National Vaccine Advisory Committee 2014); however, there is evidence to suggest that few primary care providers actually use immunization reminder or recall systems, or both (Kempe 2012c; Pereira 2012; Tierney 2003). In a national survey of pediatric practices, only 16% of responding practices utilized them (Tierney 2003).

A range of different types of reminders and systems of recall are being implemented. Ten countries, including a number in Europe, have adopted computerized immunization information services or registries (Groom 2014). Immunization registries offer the potential to become the backbone of patient reminder or recall systems by identifying the populations at risk, providing algorithms to determine who is eligible based on vaccination recommendations, and providing systems to send postcards, letters, autodialer messages, and text message reminders (Kempe 2012c).

Centralized systems can include health systems, health maintenance organizations, practice 'networks' that share electronic health records, and state or national immunization registries. Several recent studies have demonstrated that centralized reminder and recall systems sent from health systems rather than from practices can raise immunization rates (Hofstetter 2015a; Hofstetter 2015b; Kempe 2013; Kempe 2015; Stockwell 2012a; Stockwell 2015; Szilagyi 2013). This strategy is intriguing because of the economies of scale that can be obtained from centralized reminder and recall.

This is an update of Jacobson Vann 2005 and Jacobson Vann 2008.

OBJECTIVES

To evaluate and compare the effectiveness of various types of patient reminder and recall interventions to improve receipt of immunizations.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomized trials, controlled before and after studies, and interrupted time series studies. We included good quality, controlled, non-randomized studies to provide a sufficiently large number of studies to assess each intervention sub-type. We excluded observational studies in which participants self-selected to intervention groups. We reviewed the methods of each study to determine the study design, not relying on the authors' specified designs. We accepted a study that randomly selected intervention participants and selected matched controls in a non-random fashion as a controlled before-after design if pre-intervention and post-intervention immunization data were collected. Due to limited resources, we excluded non-English language publications.

Types of participants

We included as participants children, from birth to 18 years, or adults who receive immunizations in any setting, including academic or non-academic, and developed or developing countries. We excluded studies of patients who were hospitalized for the study duration.

Types of interventions

We included patient reminder or recall interventions, or both, that either reminded patients of upcoming immunizations or immunization visits that were due (reminders) or overdue (recall). Reminder and recall systems could be delivered by telephone, letter, postcard, text message, automatic electronic telephone calls (autodialer), within a secure online patient portal system, or in person, for example, a care provider giving a face-to-face reminder during a home visit, but not a clinic visit. Reminder and recall cues could also vary in specificity, number, and whether combined with other interventions, such as provider reminders or outreach. Specificity may vary from generic immunization reminders to personal reminders that address patient-specific immunization needs. Frequency may be one-time or multiple reminders. We included studies with multiple interventions if at least one study arm included immunization patient reminders or recall. We added text messages and messages occurring within patient portal systems in the current update.

Control activities

We included no-intervention control groups, standard practice activities that did not include immunization-focused patient reminder or recall interventions, media-based activities aimed at promoting immunizations, and simple practice-based immunization awareness campaigns.

Types of outcome measures

Our primary outcome measure was receipt of immunizations. We selected this outcome measure over other possible outcomes because of certain limitations, for example: the total number of vaccines would vary based on country, age group, and other factors; the proportion of the population that received all vaccines would depend on the specific population, such as age group; and on-time vaccination is restrictive and is not expected to support clinicians' efforts to optimize receipt of vaccinations.

We accepted outcomes for individual vaccinations or standard combinations of recommended vaccinations, such as all recommended vaccinations by a specific date or age. If outcomes for a study were measured at multiple time points, we selected the outcomes designated as primary by the study authors. If unclear, we averaged outcomes over time periods.

We excluded immunizations that were sought for purposes of traveling to a destination where the disease may be widespread, and immunization orders or visits that did not also measure immunization status.

Search methods for identification of studies

We conducted searches of electronic databases, references lists of articles and reviews, grey literature, clinical trials websites, and identified articles from our team members, those already in use by our team for other clinical, teaching or project work, and experts in the field.

Electronic searches

For this update, we conducted a series of searches between February 2013 and 31 January 2017. We revised all our search strategies in January 2017 in order to reduce excess retrieval of papers and update the study design filter. We searched the Database of Abstracts of Reviews of Effects (DARE) for related systematic reviews and the following databases for primary studies on 31 January 2017:

- Cochrane Central Register of Controlled Trials (CENTRAL; 2016, Issue 11) in the *Cochrane Library*;
- Health Technology Assessment Database (HTA; 2016, Issue 4) in the *Cochrane Library*;
- NHS Economic Evaluation Database (NHSEED; 2015, Issue 2) in the *Cochrane Library*;
- MEDLINE Ovid, including Epub Ahead of Print, In-Process & Other Non-Indexed Citations: 1946 to 31 January 2017;
- Embase Ovid: 1974 to 30 January 2017;
- CINAHL EBSCO (Cumulative Index to Nursing and Allied Health Literature): 1981 to 31 January 2017.

The search strategies are presented in full in Appendix 1. Details of the previous search strategies are available in Jacobson Vann 2005 and Jacobson Vann 2008.

Searching other resources

We searched the reference lists of articles and reviews, and the files of study collaborators, for additional studies. Potentially relevant studies were also identified by experts in the field and by prior knowledge.

We conducted a grey literature search utilizing the sources below:

- Agency for Healthcare Research and Quality website (www.ahrq.gov): searched March 2016;
- ClinicalTrials.gov (www.clinicaltrials.gov): searched to February 2017;
- World Health Organization International Clinical Trials Registry Platform (apps.who.int/trialsearch): searched 31 January 2017.

We also:

- screened abstracts and conference proceedings (e.g. handsearching);
- reviewed the reference lists of included studies, relevant systematic reviews, and primary studies;
- contacted researchers with expertise relevant to the review topic or EPOC interventions.

Data collection and analysis

Selection of studies

One review author (JJV) screened all titles and abstracts, and two review authors (RMJ, TCB) independently reviewed half of all titles and abstracts.

Data extraction and management

Two review authors (JJV, RMJ, TCB) independently read and abstracted each potentially relevant study to assess for inclusion using a checklist developed by the Cochrane Effective Practice and Organisation of Care Group (EPOC) (EPOC 2017), and a supplemental form to collect new data elements to meet revised Cochrane guidelines. For each included study, we collected information on study design, study duration, intervention description, outcome measures, study findings, study setting, provider characteristics, participant characteristics, unit of allocation, unit of analysis, ethical approval, power or sample size calculations, and risk of bias assessments (EPOC 2017; Higgins 2011). We attempted to contact study authors when the data presented were not sufficiently detailed to include them in the analyses. One review author (JJV) compared both abstracts for each study and identified disagreements on inclusion and abstraction results. We resolved disagreements between review authors on study inclusion and abstraction results by a formal reconciliation process to achieve consensus.

We tracked the review process and status of each article and managed the study-level data using Excel spreadsheets (Excel 2005). We assigned unique study identification numbers to support the tracking process. In the current update, we further tracked the major study activities and timelines in a project management system.

We entered dichotomous data from included randomized trials into RevMan 5 analysis data tables for intervention type, an overall summary measure, and participant-immunization category: routine childhood, child influenza, other adult, adult influenza, and adolescent vaccinations.

Assessment of risk of bias in included studies

We assessed the risk of bias of the included studies using the Cochrane 'Risk of bias' tool (Higgins 2011). We scored each criterion, for each study, as low risk, unclear risk, or high risk of bias. We assessed the risk for the following.

- Selection bias: random sequence generation, allocation concealment, and baseline measurement.
- Performance bias: blinding of participants and personnel.
- Detection bias: blinding of outcome assessment.
- Attrition bias: incomplete outcome data.
- Reporting bias: selective reporting.
- Other bias: other sources of bias.

The results of our assessment are reported in the 'Risk of bias' tables (Characteristics of included studies), and are summarized by type of bias in our results (Risk of bias in included studies).

Measures of treatment effect

We used RevMan 5 to analyze data from randomized trials using risk ratios (RRs). We also computed absolute changes in immunizations received, as percentage point differences between pre-intervention and post-intervention measures because absolute changes are clinically meaningful to practitioners who make decisions about the types of interventions to adopt in their clinical practices. We computed absolute differences as post-intervention immunization proportions minus pre-intervention immunization proportions for each study group. We compared differences between study groups.

Unit of analysis issues

We did not combine data from randomized trials that allocated families, households, practices, or other clusters with trials that allocated individuals.

Dealing with missing data

When the reported data were insufficient to conduct our meta-analyses, we attempted to contact study authors to obtain additional data, and analyzed all the available data (Pigott 2001). We excluded studies from the review if no relevant data were reported, based on the study protocol and minimum methodological inclusion criteria.

Assessment of heterogeneity

We used random-effects models if Cochrane's Q test detected significant heterogeneity across studies. This test has low sensitivity, so we used a 0.1 significance level.

Assessment of reporting biases

We assessed for possible reporting biases, including publication bias, using a funnel plot (Egger 1997b). We created a funnel plot for the patient reminder or recall summary measure using the metafor package in R version 3.2.3 (Viechtbauer 2010), and also in RevMan 5 (Analysis 1.1), plotting the standard errors of log RRs against RRs (Sterne 2001). We also included a 95% confidence region based on a random-effects model, where absence of bias is indicated by the

inclusion of approximately 95% of the studies within this region (Sterne 2004).

Data synthesis

We combined published data using random-effects meta-analysis for the number of people receiving immunizations. We grouped trials by population, including routine childhood, child influenza, other adult, adult influenza, and adolescent vaccinations, and the type of intervention. For studies with more than one patient reminder or with similar intervention types, such as two postcards groups with different messages, we combined intervention group data. For randomized trials with outcomes reported in multiple outcome categories, we reported each outcome separately by reminder type and combined data for the summary measure. For randomized trials with interventions delivered over time and multiple data collection points, we used average sample sizes.

We calculated risk ratios (RRs) and 95% confidence intervals (CIs) in RevMan for individual studies or study comparisons to assess the effect of patient reminder or recall interventions on receipt of immunizations. We computed pooled RRs and risk differences for each intervention type, and stratified the results within each intervention type by the five participant-immunization categories. For example, we computed an overall pooled random-effects RR for letter interventions, then stratified relevant study comparisons for participant-immunization category.

Summary of findings

We summarized the findings of the main intervention comparison(s) for the most important outcome(s), specifically receipt of immunizations for each intervention type and participant-immunization categories in two 'Summary of findings' tables. Two review authors (JJV, JKAA) independently assessed the certainty of the evidence or confidence in the estimate (high, moderate, low, and very low) for each outcome and intervention type using GRADE (BMJ 2016; Ryan 2016; Schünemann 2011). Our assessment included study design, risk of bias, inconsistency of effect size, indirectness, imprecision, and other considerations, including publication bias (EPOC 2017b). We present the certainty of evidence assessment results in GRADE evidence profiles (Appendix 2) and the 'Summary of findings' tables (Summary of findings for the main comparison; Summary of findings 2).

Subgroup analysis and investigation of heterogeneity

We structured the table of comparisons in RevMan 5 to examine study results, using RRs, by type of patient reminder or recall intervention and created subcategories within each intervention type, to perform subgroup analyses by each of the five participant-immunization categories.

Sensitivity analysis

We conducted sensitivity analyses for the patient reminder or recall summary measure to assess the effects of two separate methodological decisions in this review. First, we assessed the effect of including versus excluding studies from our analysis with a high risk of bias rating for random sequence generation, allocation concealment, and/or incomplete outcome data. Second, we assessed the effect of defining our primary outcome as receipt of any needed immunizations, whether one or all needed immunizations, by omitting studies from the patient reminder or recall summary measure that defined outcomes as up-to-date with all needed immunizations.

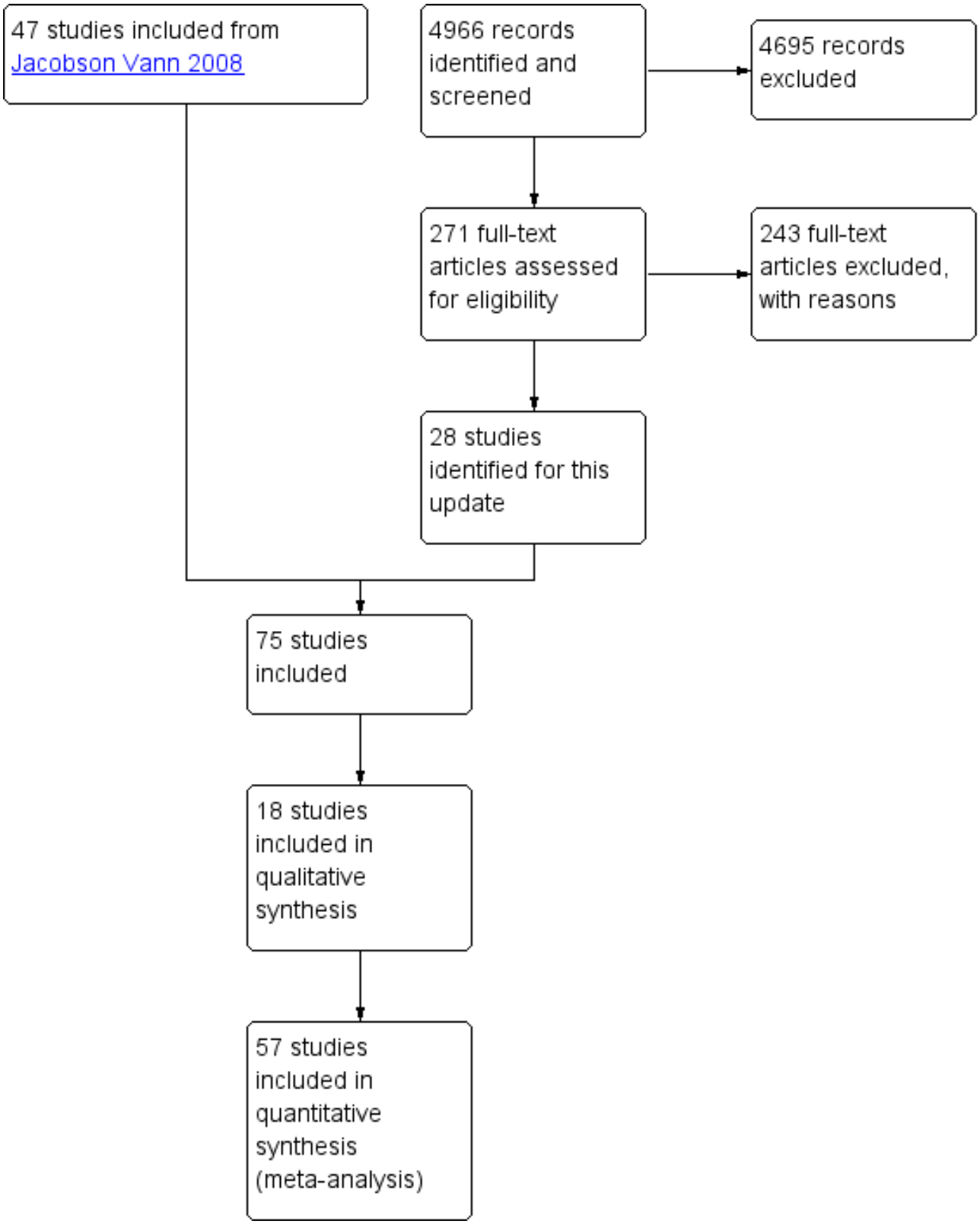
RESULTS

Description of studies

Results of the search

We reviewed 4966 studies for potential inclusion in this review update and retrieved and screened 271 full texts (Figure 1). We included 75 studies, 28 of which we identified during this update (Bangure 2015; Brigham 2012; Brown 2016; CDC 2012; Chao 2015; Daley 2002; Dini 2000; Dombkowski 2012; Dombkowski 2014; Haji 2016; Hambidge 2009; Humiston 2011; Lemstra 2011; Marron 1998; Mason 2000; McCaul 2002; Moniz 2013; O'Leary 2015; Rand 2015; Rand 2017; Roca 2012; Staras 2015; Stockwell 2012a; Suh 2012; Szilagyi 2011; Szilagyi 2013; Vivier 2000; Winston 2007) (Characteristics of included studies).

Figure 1. Study flow diagram.



Included studies

See Characteristics of included studies for full details.

Study designs

Of the 75 included studies, five used a controlled before and after design (LeBaron 1998; Lemstra 2011; Lieu 1998; Margolis 1992;

Stockwell 2012a). The remaining studies used a randomized trial design. One controlled before-after study randomized intervention participants to four study groups; control participants were not randomized (Lieu 1998).

Fifteen studies allocated participants by area, practice, provider, or family and analyzed data at the patient level. Three studies clustered allocation by local government area, community, practice, or provider and analyzed at the individual person level (Brown 2016; Buffington 1991; Ornstein 1991). Twelve studies clustered families, including married couples or siblings, and conducted analyses at the patient level (Dini 2000; Frame 1994; Haji 2016; Lukasik 1987; McDowell 1986; Puech 1998; Rodewald 1999; Rosser 1991; Rosser 1992; Spaulding 1991; Szilagyi 2011; Szilagyi 2013). One of the 12 studies also analyzed data at the family level; however, it did not present specific family-level data (McDowell 1986).

Settings

Studies were performed in diverse settings, ranging from urban to rural, and public to private to university-based. Examples of study settings are state health departments, health maintenance organizations (HMO), public health departments, urban teaching facilities, private practices, senior centers, rural practices, and schools. Fifty-eight studies were performed in the US. The remainder were conducted in Australia (two) (Ferson 1995; Puech 1998), Canada (six) (Hogg 1998; Lemstra 2011; Lukasik 1987; McDowell 1986; Rosser 1991; Rosser 1992), Denmark (one) (Nexoe 1997), New Zealand (two) (Satterthwaite 1997; Soljak 1987), the UK (two) (Hull 2002; Mason 2000), Spain (one) (Roca 2012), Zimbabwe (one) (Bangure 2015), Kenya (one) (Haji 2016), and Nigeria (one) (Brown 2016).

Participants

We classified participants into five categories based on the types of immunizations received and broad age groups: infants and children needing routine immunizations, children needing influenza vaccination, adolescents, adults needing routine immunizations, and adults needing influenza vaccination. Twenty-nine of the included studies examined routine vaccinations of infants and children (Alto 1994; Bangure 2015; Brown 2016; Campbell 1994; CDC 2012; Daley 2002; Daley 2004b; Dini 2000; Dombkowski 2014; Ferson 1995; Haji 2016; Hambidge 2009; Irigoyen 2006; Kempe 2001; LeBaron 1998; LeBaron 2004; Lemstra 2011; Lieu 1997; Lieu 1998; Linkins 1994; Mason 2000; Oeffinger 1992; Rodewald 1999; Soljak 1987; Stehr-Green 1993; Tollestrup 1991; Vivier 2000; Wood 1998; Young 1980); and five studied influenza vaccinations among children and infants (Daley 2004a; Dombkowski 2012; Kempe 2005; Kemper 1993; Szilagyi 1992). Twenty-four studies assessed the effectiveness of patient reminder or recall interventions on receipt of adult influenza immunizations (Baker 1998; Becker 1989; Brimberry 1988; Buchner 1987; Buffington 1991; Carter 1986; Hogg 1998; Hull 2002; Humiston 2011; Larson 1982; Lukasik 1987; Margolis 1992; McCaul 2002; McDowell 1986; Moniz 2013; Moran 1992; Mullooly 1987; Nexoe 1997; Puech 1998; Roca 2012; Rosser 1991; Satterthwaite 1997; Siebers 1985; Spaulding 1991). Eight assessed the effectiveness of patient reminder or recall on receipt of any or all of adult vaccinations, including tetanus, pneumococcal, hepatitis B, diphtheria tetanus pertussis (DTP), *Haemophilus influenzae* type B (Hib), measles, mumps, rubella (MMR), and trivalent oral polio vaccine (TOPV) (Frame 1994; Hogg 1998; Ornstein 1991; Rosser 1991; Rosser 1992; Sansom 2003; Siebers 1985; Winston 2007). Twelve studies examined the effect of patient reminder or recall on receipt of adolescent immunizations (Brigham 2012; Chao 2015; Marron 1998; O'Leary 2015; Rand 2015; Rand 2017; Staras 2015; Stockwell 2012a; Suh 2012; Szilagyi 2006; Szilagyi 2011; Szilagyi 2013). The total number of studies described by target population-immunization category exceeds the 75 included studies because several studies examined more than one category.

Interventions

Fourteen studies examined the effect of immunization reminder person-to-person telephone calls on receipt of immunizations (Brigham 2012; Brimberry 1988; Brown 2016; Ferson 1995; Frame 1994; Hull 2002; Lemstra 2011; Lukasik 1987; McDowell 1986; Rosser 1991; Rosser 1992; Sansom 2003; Vivier 2000; Winston 2007). Thirty-two studies examined the effect of immunization reminder or recall letters to patients or parents on receipt of immunization (Brimberry 1988; Campbell 1994; Carter 1986; CDC 2012; Chao 2015; Daley 2004a; Dini 2000; Dombkowski 2012; Dombkowski 2014; Hogg 1998; Kempe 2005; Kemper 1993; Lieu 1997; Lieu 1998; Marron 1998; Mason 2000; McCaul 2002; McDowell 1986; Moran 1992; Mullooly 1987; Nexoe 1997; Oeffinger 1992; Ornstein 1991; Roca 2012; Rosser 1991; Rosser 1992; Satterthwaite 1997; Siebers 1985; Szilagyi 1992; Szilagyi 2013; Vivier 2000; Young 1980). Ten studies assessed the effect of immunization reminder or recall postcards on immunization receipt (Baker 1998; Buchner 1987; Campbell 1994; Irigoyen 2006; Larson 1982; Puech 1998; Soljak 1987; Spaulding 1991; Staras 2015; Tollestrup 1991). Six studies examined the effect of text messages on immunization receipt (Bangure 2015; Haji 2016; Moniz 2013; O'Leary 2015; Rand 2017; Stockwell 2012a). Seven studies assessed the effect of immunization reminder or recall autodialer interventions on immunization receipt (Dini 2000; Lieu 1998; Linkins 1994; Rand 2017; Stehr-Green 1993; Szilagyi 2006; Szilagyi 2013). Nine studies examined the effect of some combination of letter or postcard plus telephone or autodialer on immunization receipt (Alto 1994; Daley 2002; Daley 2004b; Dini 2000; Kempe 2001; LeBaron 1998; Lieu 1998; Suh 2012; Vivier 2000). Seven studies examined the effect of some combination of patient reminder or recall with outreach on immunization receipt (Hambidge 2009; LeBaron 1998; LeBaron 2004; Lemstra 2011; Rodewald 1999; Szilagyi 2011; Wood 1998). We also included six randomized trials that examined the effect of provider reminders, combined with patient reminder or recall interventions, on immunization receipt (Becker 1989; Buffington 1991; Frame 1994; Humiston 2011; Ornstein 1991; Rodewald 1999), and one controlled before-after study (Margolis 1992). The duration of the intervention, per participant, ranged from a momentary reminder or recall at a point in time to interventions delivered intermittently over an approximate one-year time period for multiple vaccinations. The total number of studies sorted by intervention type exceeds the 75 included studies because many studies had more than one intervention arm.

Excluded studies

We briefly describe the reasons individual studies were excluded from our review in the Characteristics of excluded studies table.

Risk of bias in included studies

The risk of bias is summarized for all included studies in Figure 2. Full details of our assessment of risk of bias for each study is

provided in the 'Risk of bias' tables in the Characteristics of included studies.

Figure 2. 'Risk of bias' summary: review authors' judgements about each risk of bias item for each included study.

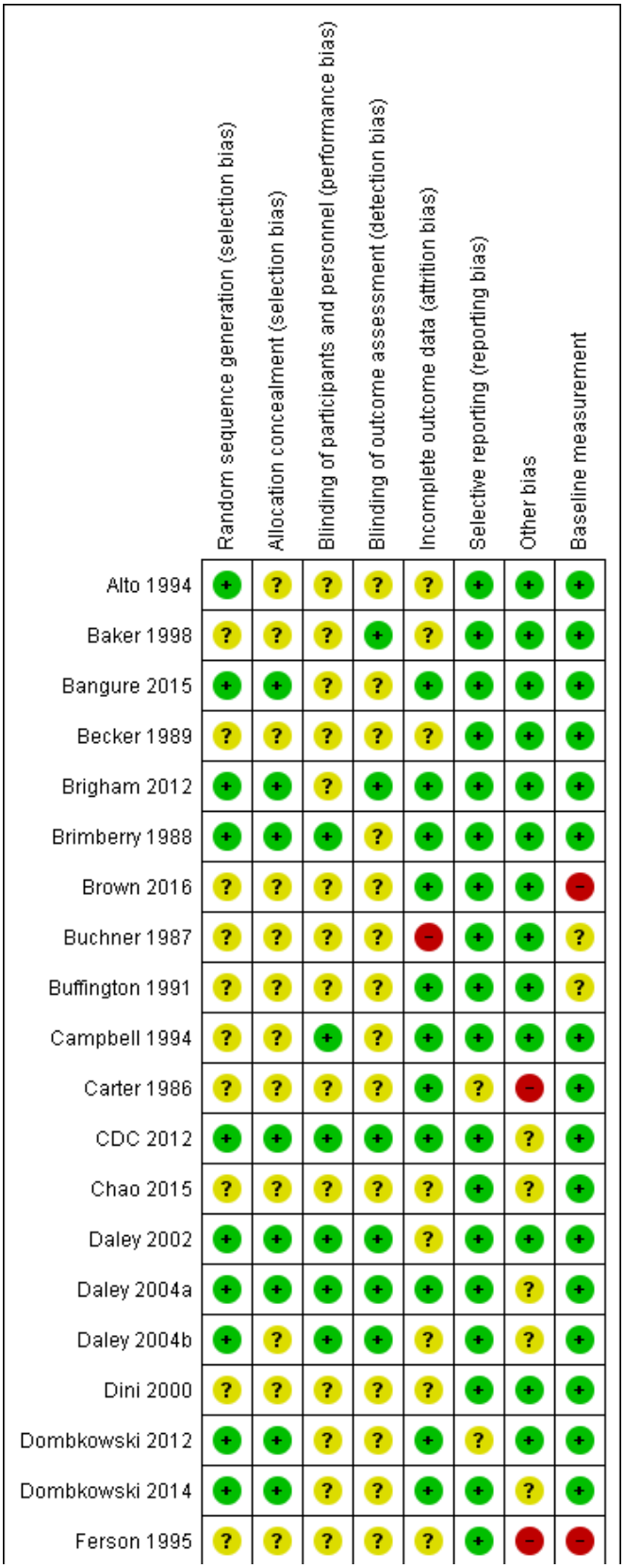


Figure 2. (Continued)

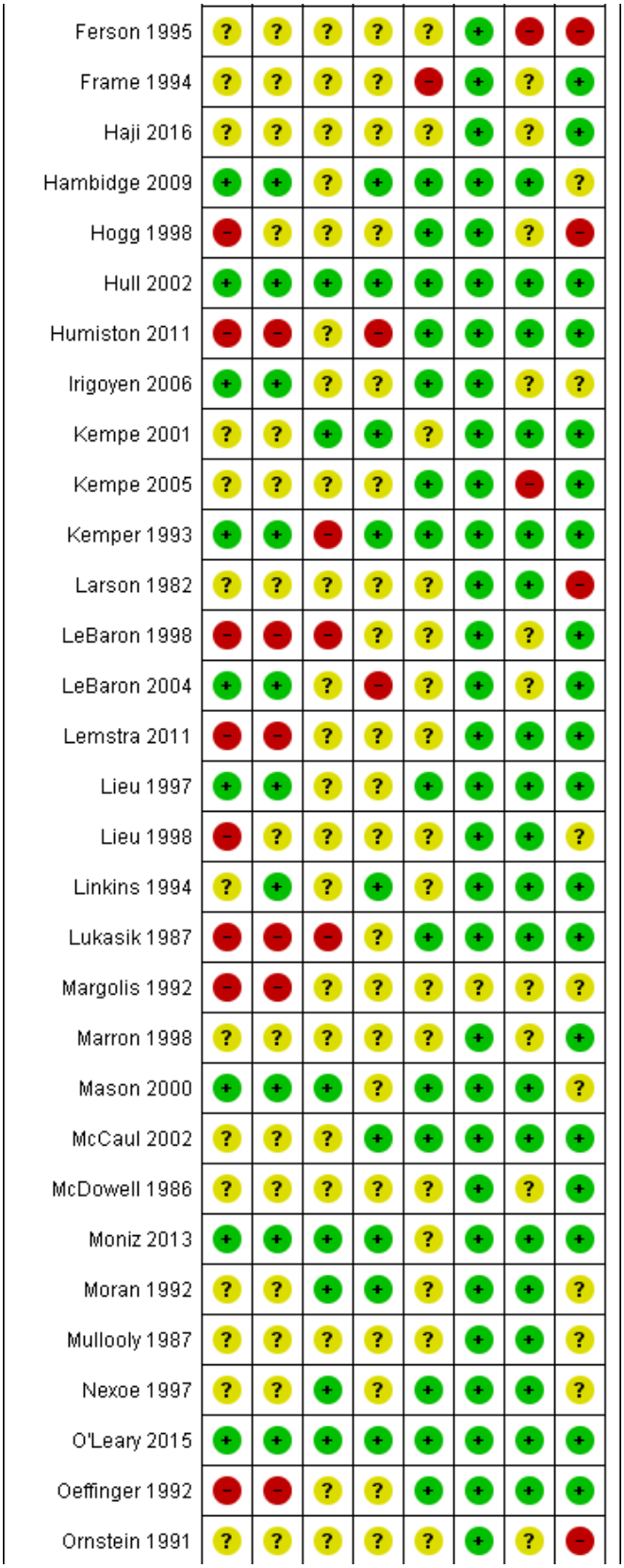
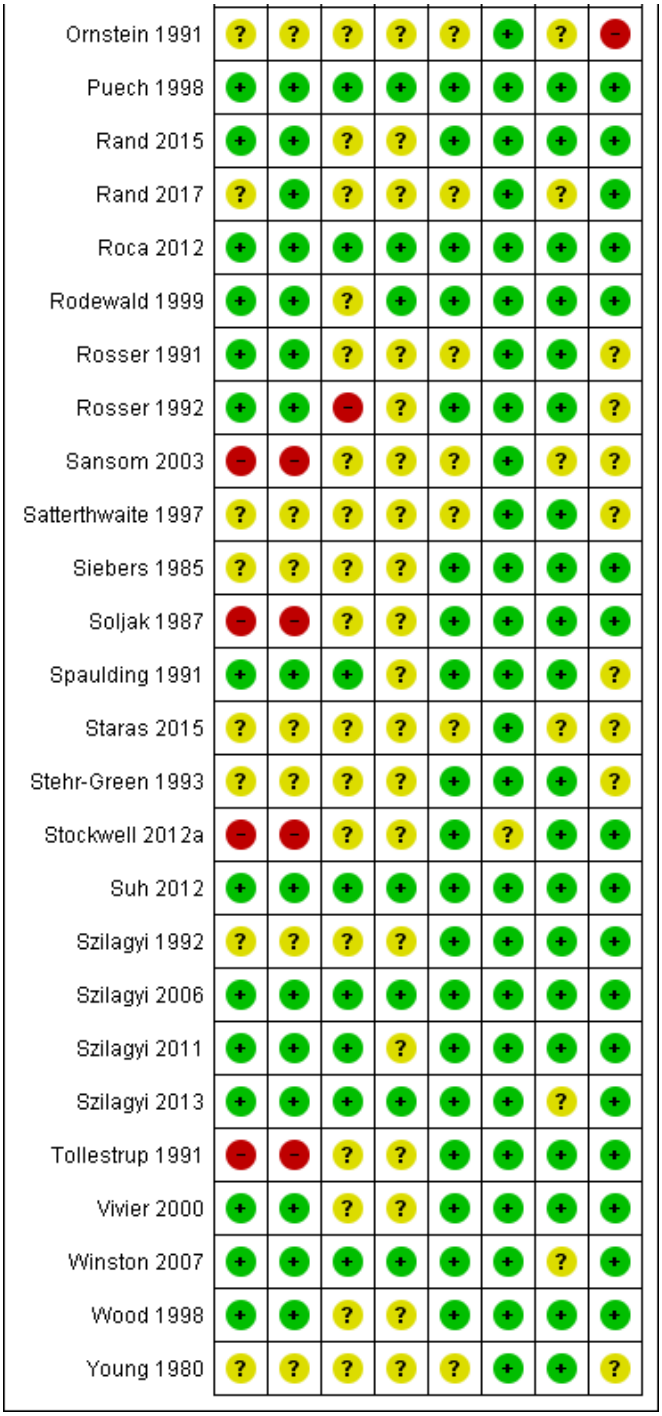


Figure 2. (Continued)



Allocation

Random sequence generation

We classified the potential risk for selection bias, based on random sequence allocation assessment, as low risk in 44.0 per cent (33 studies; Alto 1994; Bangure 2015; Brigham 2012; Brimberry 1988; CDC 2012; Daley 2002; Daley 2004a; Daley 2004b; Dombkowski 2012; Dombkowski 2014; Haji 2016; Hambidge 2009; Hull 2002; Irigoyen 2006; Kemper 1993; LeBaron 2004; Lieu 1997; Mason 2000; Moniz 2013; O'Leary 2015; Puech 1998; Rand 2015; Rand 2017; Roca 2012; Rodewald 1999; Rosser 1991; Rosser 1992; Spaulding 1991; Staras 2015; Suh 2012; Szilagyi 2006; Szilagyi 2011; Szilagyi 2013; Vivier 2000; Winston 2007; Wood 1998). We classified the risk as unclear for 40.0 per cent (30 studies; Baker 1998; Becker 1989; Brown 2016; Buchner 1987; Buffington 1991; Campbell 1994; Carter 1986; Chao 2015; Dini 2000; Ferson 1995; Frame 1994; Kempe 2001; Kempe 2005; Larson 1982; Linkins 1994; Marron 1998; McCaul 2002; McDowell 1986; Moran 1992; Mullooly 1987; Nexoe 1997; Ornstein 1991; Satterthwaite 1997; Siebers 1985; Stehr-Green 1993; Szilagyi 1992; Young 1980), and high risk for 16.0 per cent (12 studies;

Hogg 1998; Humiston 2011; LeBaron 1998; Lemstra 2011; Lieu 1998; Lukasik 1987; Margolis 1992; Oeffinger 1992; Sansom 2003; Soljak 1987; Stockwell 2012a; Tollestrup 1991).

Allocation concealment

We classified the potential risk for selection bias, based on concealment of allocation, as low risk in 44.0 per cent (33 studies) (Bangure 2015; Brigham 2012; Brimberry 1988; CDC 2012; Daley 2002; Daley 2004a; Dombkowski 2012; Dombkowski 2014; Hambidge 2009; Hull 2002; Irigoyen 2006; Kemper 1993; LeBaron 2004 Lieu 1997; Linkins 1994; Mason 2000; Moniz 2013; O'Leary 2015; Puech 1998; Rand 2015; Rand 2017; Roca 2012; Rodewald 1999; Rosser 1991; Rosser 1992; Spaulding 1991; Suh 2012; Szilagyi 2006; Szilagyi 2011; Szilagyi 2013; Vivier 2000; Winston 2007; Wood 1998). We classified allocation concealment as unclear risk in 42.7 per cent (32 studies) (Alto 1994; Baker 1998; Becker 1989; Brown 2016; Buchner 1987; Buffington 1991; Campbell 1994; Carter 1986; Chao 2015; Daley 2004b; Dini 2000; Ferson 1995; Frame 1994; Haji 2016; Hogg 1998; Kempe 2001; Kempe 2005; Larson 1982; Lieu 1998; Marron 1998; McCaul 2002; McDowell 1986; Moran 1992; Mullooly 1987; Nexoe 1997; Ornstein 1991; Satterthwaite 1997; Siebers 1985; Staras 2015; Stehr-Green 1993; Szilagyi 1992; Young 1980), and we classified it as high risk in 13.3 per cent (10 studies; Humiston 2011; LeBaron 1998; Lemstra 2011; Lukasik 1987; Margolis 1992; Oeffinger 1992; Sansom 2003; Soljak 1987; Stockwell 2012a; Tollestrup 1991).

Baseline measurement

We classified the risk for selection bias, based on baseline measurement of outcomes and participant characteristics, as low risk in 69.3 per cent (52 studies) (Alto 1994; Baker 1998; Bangure 2015; Becker 1989; Brigham 2012; Brimberry 1988; Campbell 1994; Carter 1986; CDC 2012; Chao 2015; Daley 2002; Daley 2004a; Daley 2004b; Dini 2000; Dombkowski 2012; Dombkowski 2014; Frame 1994; Haji 2016; Hull 2002; Humiston 2011; Kempe 2001; Kempe 2005; Kemper 1993; LeBaron 1998; LeBaron 2004; Lemstra 2011; Lieu 1997; Linkins 1994; Lukasik 1987; Marron 1998; McCaul 2002; McDowell 1986; Moniz 2013; Oeffinger 1992; O'Leary 2015; Puech 1998; Rand 2015; Rand 2017; Roca 2012; Rodewald 1999; Siebers 1985; Soljak 1987; Stockwell 2012a; Suh 2012; Szilagyi 1992; Szilagyi 2006; Szilagyi 2011; Szilagyi 2013; Tollestrup 1991; Vivier 2000; Winston 2007; Wood 1998). We classified the risk as unclear in 24.0 per cent (18 studies) (Buchner 1987; Buffington 1991; Hambidge 2009; Irigoyen 2006; Lieu 1998; Margolis 1992; Mason 2000; Moran 1992; Mullooly 1987; Nexoe 1997; Rosser 1991; Rosser 1992; Sansom 2003; Satterthwaite 1997; Spaulding 1991; Staras 2015; Stehr-Green 1993; Young 1980), and we classified it as high risk in 6.7 per cent (five studies) (Brown 2016; Ferson 1995; Hogg 1998; Larson 1982; Ornstein 1991).

Blinding

We classified the potential risk for performance bias, based on blinding of participants and personnel, as low risk in 28.0 per cent (21 studies) (Brimberry 1988; Campbell 1994; CDC 2012; Daley 2002; Daley 2004a; Daley 2004b; Hull 2002; Kempe 2001; Mason 2000; Moniz 2013; Moran 1992; Nexoe 1997; O'Leary 2015; Puech 1998; Roca 2012; Spaulding 1991; Suh 2012; Szilagyi 2006; Szilagyi 2011; Szilagyi 2013; Winston 2007). We classified the risk of performance bias, based on blinding of participants and personnel, as unclear in 66.7 per cent (50 studies) (Alto 1994; Baker 1998; Bangure 2015; Becker 1989; Brigham 2012; Brown 2016; Buchner 1987; Buffington 1991; Carter 1986; Chao 2015; Dini 2000; Dombkowski 2012; Dombkowski 2014; Ferson 1995; Frame 1994; Haji 2016; Hambidge 2009; Hogg 1998; Humiston 2011; Irigoyen 2006; Kempe 2005; Larson 1982; LeBaron 2004; Lemstra 2011; Lieu 1997; Lieu 1998; Linkins 1994; Margolis 1992; Marron 1998; McCaul 2002; McDowell 1986; Mullooly 1987; Oeffinger 1992; Ornstein 1991; Rand 2015; Rand 2017; Rodewald 1999; Rosser 1991; Sansom 2003; Satterthwaite 1997; Siebers 1985; Soljak 1987; Staras 2015; Stehr-Green 1993; Stockwell 2012a; Szilagyi 1992; Tollestrup 1991; Vivier 2000; Wood 1998; Young 1980), and we classified it as high risk in 5.3 per cent (four studies; Kemper 1993; LeBaron 1998; Lukasik 1987; Rosser 1992).

We classified the potential risk for detection bias, based on blinded assessment of primary outcomes, as low risk in 29.3 per cent (22 studies) (Baker 1998; Brigham 2012; CDC 2012; Daley 2002; Daley 2004a; Daley 2004b; Hambidge 2009; Hull 2002; Kempe 2001; Kemper 1993; Linkins 1994; McCaul 2002; Moniz 2013; Moran 1992; O'Leary 2015; Puech 1998; Roca 2012; Rodewald 1999; Suh 2012; Szilagyi 2006; Szilagyi 2013; Winston 2007). We classified the risk of detection bias as unclear in 68.0 per cent (51 studies) (Alto 1994; Bangure 2015; Becker 1989; Brimberry 1988; Brown 2016; Buchner 1987; Buffington 1991; Campbell 1994; Carter 1986; Chao 2015; Dini 2000; Dombkowski 2012; Dombkowski 2014; Ferson 1995; Frame 1994; Haji 2016; Hogg 1998; Irigoyen 2006; Kempe 2005; Larson 1982; LeBaron 1998; Lemstra 2011; Lieu 1997; Lieu 1998; Lukasik 1987; Margolis 1992; Marron 1998; Mason 2000; McDowell 1986; Mullooly 1987; Nexoe 1997; Oeffinger 1992; Ornstein 1991; Rand 2015; Rand 2017; Rosser 1991; Rosser 1992; Sansom 2003; Satterthwaite 1997; Siebers 1985; Soljak 1987; Spaulding 1991; Staras 2015; Stehr-Green 1993; Stockwell 2012a; Szilagyi 1992; Szilagyi 2011; Tollestrup 1991; Vivier 2000; Wood 1998; Young 1980), and we classified it as high risk in 2.7 per cent (two studies; Humiston 2011; LeBaron 2004).

Incomplete outcome data

We classified the potential risk for attrition bias, based on the degree of participant follow-up and complete outcome data, as low risk in 58.7 per cent (44 studies) (Bangure 2015; Brigham 2012; Brimberry 1988; Brown 2016; Buffington 1991; Campbell 1994, Carter 1986; CDC 2012; Daley 2004a; Dombkowski 2012; Dombkowski 2014; Hambidge 2009; Hogg 1998; Hull 2002; Humiston 2011; Irigoyen 2006; Kempe 2005; Kemper 1993; Lieu 1997; Lukasik 1987; Mason 2000; McCaul 2002; Nexoe 1997; Oeffinger 1992; O'Leary 2015; Puech 1998; Rand 2015; Roca 2012; Rodewald 1999; Rosser 1992; Siebers 1985; Soljak 1987; Spaulding 1991; Stehr-Green 1993; Stockwell 2012a; Suh 2012; Szilagyi 1992; Szilagyi 2006; Szilagyi 2011; Szilagyi 2013; Tollestrup 1991; Vivier 2000; Winston 2007; Wood 1998). We classified the risk for attrition bias as unclear in 38.7 per cent (29 studies) (Alto 1994; Baker 1998; Becker 1989; Chao 2015; Daley 2002; Daley 2004b; Dini 2000; Ferson 1995; Haji 2016; Kempe 2001; Larson 1982; LeBaron 1998; LeBaron 2004; Lemstra 2011; Lieu 1998; Linkins 1994; Margolis 1992; Marron 1998; McDowell 1986; Moniz 2013; Moran 1992; Mullooly 1987; Ornstein 1991; Rand 2017; Rosser 1991; Sansom 2003; Satterthwaite 1997; Staras 2015; Young 1980), and high risk in 2.7 per cent (two studies) (Buchner 1987; Frame 1994).

Selective reporting

We classified the potential risk for reporting bias, based on selective reporting of outcomes, as low risk in 94.7 per cent (71 studies)

and as unclear risk in 5.3 per cent (four studies) (Carter 1986; Dombkowski 2012; Margolis 1992; Stockwell 2012a).

Other potential sources of bias

We classified the risk for other sources of bias as low risk in 69.3 per cent (52 studies) (Alto 1994; Baker 1998; Bangure 2015; Becker 1989; Brigham 2012; Brimberry 1988; Brown 2016; Buchner 1987; Buffington 1991; Campbell 1994; Daley 2002; Dini 2000; Dombkowski 2012; Hambidge 2009; Hull 2002; Humiston 2011; Kempe 2001; Kemper 1993; Larson 1982; Lemstra 2011; Lieu 1997; Lieu 1998; Linkins 1994; Lukasik 1987; Mason 2000; McCaul 2002; Moniz 2013; Moran 1992; Mullooly 1987; Nexoe 1997; Oeffinger 1992; O'Leary 2015; Puech 1998; Rand 2015; Roca 2012; Rodewald 1999; Rosser 1991; Rosser 1992; Satterthwaite 1997; Siebers 1985; Soljak 1987; Spaulding 1991; Stehr-Green 1993; Stockwell 2012a; Suh 2012; Szilagyi 1992; Szilagyi 2006; Szilagyi 2011; Tollestrup 1991; Vivier 2000; Wood 1998; Young 1980). We classified the risk as unclear in 26.7 per cent (20 studies) (CDC 2012; Chao 2015; Daley 2004a; Daley 2004b; Dombkowski 2014; Frame 1994; Haji 2016; Hogg 1998; Irigoyen 2006; LeBaron 1998; LeBaron 2004; Margolis 1992; Marron 1998; McDowell 1986; Ornstein 1991; Rand 2017; Sansom 2003;Staras 2015; Szilagyi 2013; Winston 2007), and high risk in 4.0 per cent (three studies) (Carter 1986; Ferson 1995; Kempe 2005). For details of other sources of bias, please refer to Characteristics of included studies.

Effects of interventions

See: **Summary of findings for the main comparison** Overview: Patient reminder or recall interventions for receipt of immunizations - any kind; **Summary of findings 2** Summary: Patient reminder or recall interventions by type of immunization

Patient reminder or recall

See Summary of findings for the main comparison and Summary of findings 2.

Patient reminder or recall interventions, which are patient-focused, probably increase the number of immunizations (risk ratio (RR) 1.28, 95% confidence interval (CI) 1.23 to 1.35; 55 trials; 138,625 participants) with moderate certainty evidence (Summary of findings for the main comparison; Analysis 1.1).

Fourteen studies were included in the review but not included in the meta-analyses because these studies generally randomized families, households, practices, or communities (Brown 2016; Dini 2000; Frame 1994; Haji 2016; Lukasik 1987; McDowell 1986; Ornstein 1991; Puech 1998; Rodewald 1999; Rosser 1991; Rosser 1992; Spaulding 1991; Szilagyi 2011; Szilagyi 2013). In seven of these 14 studies, the proportion of intervention group participants receiving immunizations was at least 20 percentage points higher than among controls (Brown 2016; Lukasik 1987; McDowell 1986; Rodewald 1999; Rosser 1991; Rosser 1992); in six studies intervention effects ranged from at least 10 to less than 20 percentage points (Buffington 1991; Haji 2016; McDowell 1986; Ornstein 1991; Spaulding 1991; Szilagyi 2011); and in four studies the intervention effect sizes were less than a 10 percentage point increase over controls (Dini 2000; Ornstein 1991; Puech 1998; Szilagyi 2013). Three additional studies are also analyzed separately because they are controlled before-after studies (LeBaron 1998; Lemstra 2011; Margolis 1992). Differences in improvements, among controlled before and after studies, in pre-intervention to post-intervention immunization rates between intervention and control groups did not exceed 15 percentage points. Three studies were not included in the summary meta-analyses because they combined patient and provider reminders (Becker 1989; Buffington 1991; Humiston 2011).

Different types of reminder or recall systems

Patient telephone reminder or recall interventions

Fourteen included studies evaluated the effect of telephone reminder or recall interventions on receipt of immunizations. Of these studies, seven (9120 participants) were included in the meta-analysis (Brigham 2012; Brimberry 1988; Ferson 1995; Hull 2002; Sansom 2003; Vivier 2000; Winston 2007). The RR was 1.75 (95% CI 1.20 to 2.54) (Analysis 2.1). One study was not included because it had a controlled before-after study design with unequal baseline immunization levels (Lemstra 2011).

In all seven studies not included in the meta-analyses (Brown 2016; Frame 1994; Lemstra 2011; Lukasik 1987; McDowell 1986; Rosser 1991; Rosser 1992), receipt of immunizations was higher among participants in the intervention group compared with control participants. In the five studies with adult participants (Frame 1994; Lukasik 1987; McDowell 1986; Rosser 1991; Rosser 1992), influenza, tetanus diphtheria (Td), and tetanus immunization rates were 20.0 to 27.2 percentage points higher among intervention participants compared with controls. In one controlled before-after study of children who had not received two MMR vaccinations by two years of age, pre-intervention to post-intervention increases in immunization receipt was 3.9 percentage points higher among children in the telephone reminder group compared with controls (Lemstra 2011).

Patient telephone reminder or recall interventions probably improve receipt of immunizations based on moderate certainty evidence (Summary of findings for the main comparison).

Patient letter reminder or recall interventions

Letter reminder or recall interventions were evaluated in 32 included studies and more than 40 per cent of the comparisons overall. Of these, we included 26 studies (81,100 participants) in the meta-analyses (Brimberry 1988; Campbell 1994; Carter 1986; CDC 2012; Chao 2015; Daley 2004a; Dombkowski 2012; Dombkowski 2014; Hogg 1998; Kempe 2005; Kemper 1993; Lieu 1997; Lieu 1998; Marron 1998; Mason 2000; McCaul 2002; Moran 1992; Mullooly 1987; Nexoe 1997; Oeffinger 1992; Roca 2012; Satterthwaite 1997; Siebers 1985; Szilagyi 1992; Vivier 2000; Young 1980). Intervention participants in letter reminder or recall groups were 1.29 times more likely to receive immunizations than control group participants (95% CI 1.21 to 1.38) (Analysis 3.1). Six studies were excluded from meta-analyses because they allocated families, households, clinicians, or practices (Dini 2000; McDowell 1986; Ornstein 1991; Rosser 1991; Rosser 1992; Szilagyi 2013).

The effectiveness of letter reminder and recall interventions in improving receipt of immunizations varied between and within target population and immunization categories. All five comparisons for letter reminder or recall interventions increased child influenza vaccination rates (Daley 2004a; Dombkowski 2012; Kempe 2005; Kemper 1993; Szilagyi 1992); risk ratios ranged from 1.08 (95% CI 1.03 to 1.12) to 4.60 (95% CI 1.66 to 12.74). Eight of nine comparisons involving childhood immunizations increased

immunization rates (Campbell 1994; CDC 2012; Lieu 1997; Lieu 1998; Mason 2000; Oeffinger 1992; Vivier 2000; Young 1980); RRs for letter interventions and childhood vaccinations ranged from 0.85 (95% CI 0.80 to 0.90) to 5.07 (95% CI 1.14 to 22.60). Nine of 11 comparisons involving adult influenza vaccinations increased immunization rates (Baker 1998; Brimberry 1988; Carter 1986; McCaul 2002; Mullooly 1987; Nexoe 1997; Roca 2012; Satterthwaite 1997; Siebers 1985); risk ratios ranged from 0.91 (95% CI 0.70 to 1.19) to 3.11 (95% CI 1.16 to 8.36). Studies recruiting adults increased other immunizations (RR 3.13, 95% CI 1.44 to 6.84) (Hogg 1998; Siebers 1985). Those recruiting adolescents also increased immunizations (RR 1.91, 95% CI 0.71 to 5.11) (Chao 2015; Marron 1998). One randomized trial evaluated the effectiveness of a mailed informational letter on hepatitis B vaccination rates among freshman college students (RR 3.31, 95% CI 1.81 to 6.05) (Marron 1998). The letter was sent to both students and parents; the mailing also included a reminder card with a hepatitis B logo and the appointment telephone number. Vaccination rates for the first hepatitis B dose were 8.1 percentage points higher among participants compared with controls and 10.1 percentage points higher for the second dose. However, control group hepatitis B vaccination rates were very low: 3.6 per cent and 1.9 per cent for the first and second doses respectively.

In the six studies that we excluded from meta-analyses because they allocated families, households, clinicians, or practices, receipt of immunizations was higher among participants in intervention groups compared with control groups (Dini 2000; McDowell 1986; Ornstein 1991; Rosser 1991; Rosser 1992; Szilagyi 2013). In the three studies and four comparisons with adult participants, influenza and tetanus immunization outcomes were 25.3 to 27.4 percentage points higher among intervention participants compared with controls (McDowell 1986; Rosser 1991; Rosser 1992). In one study of adolescents routine vaccination outcomes were 6 percentage points higher among comparison participants compared with controls (Szilagyi 2013). In one study of childhood vaccinations outcomes were 7.3 percentage points higher among intervention participants compared with controls (Dini 2000).

For studies of letter reminder or recall interventions, we assigned a GRADE of moderate when assessing the certainty of evidence (Summary of findings for the main comparison), because of inconsistency in the findings, variation in the delivery and content of letter reminder or recall interventions, and imprecision attributable to wide confidence intervals for several studies (Appendix 2). Patient letter reminder or recall interventions probably improve receipt of immunizations.

Patient postcard reminder or recall interventions

Postcard reminder or recall interventions were evaluated in 10 included studies. Of these, we included eight in the meta-analyses (27,734 participants) (Baker 1998; Buchner 1987; Campbell 1994; Irigoyen 2006; Larson 1982; Soljak 1987; Staras 2015; Tollestrup 1991). We excluded two studies from meta-analyses because they allocated couples or families (Puech 1998; Spaulding 1991). Participants in postcard reminder or recall intervention groups, for the seven studies, were more likely to receive immunization (RR 1.18, 95% CI 1.08 to 1.30) (Analysis 4.1).

Two studies that we excluded from meta-analyses reported an increase in adult influenza immunization rates of 9.5 and 16.1 percentage points higher in the intervention groups compared with controls, respectively (Puech 1998; Spaulding 1991). Patient postcard reminder or recall interventions improve receipt of immunizations, with a high certainty of evidence (Summary of findings for the main comparison).

Patient text message reminder or recall interventions

Seven studies with text message interventions were included, and data from six contributed to the meta-analysis (7772 participants) (Bangure 2015; Haji 2016; Moniz 2013; O'Leary 2015; Rand 2015; Rand 2017; Stockwell 2012a). Participants in the text message groups were more likely to receive immunizations than control group participants (RR 1.29, 95% CI 1.15 to 1.44) (Analysis 5.1).

Patient text message reminder or recall interventions improve receipt of immunizations based on high certainty evidence (Summary of findings for the main comparison) (Appendix 2).

Patient autodialer reminder or recall interventions

Seven studies evaluated the effectiveness of autodialer reminder or recall interventions on receipt of immunizations. Among the five studies included in meta-analyses (11,947 participants), participants in the autodialer intervention groups were more likely to receive immunizations than control group participants (RR 1.17, 95% CI 1.03 to 1.32 (Analysis 6.1) (Lieu 1998; Linkins 1994; Rand 2017; Stehr-Green 1993; Szilagyi 2006). All five studies reported positive findings. Two autodialer studies were not included in the meta-analyses and are reported qualitatively because they allocated families or households (Dini 2000; Szilagyi 2013).

One study assessed the effect of autodialer reminder and recall messages on immunization coverage during the first two years of life for children who had received the first dose of DTP or poliovirus vaccines (Dini 2000). One reminder message was sent before a scheduled immunization visit; a weekly recall message was sent after the scheduled date for up to four weeks. Immunization receipt, at 24 months of age, was 8.4 percentage points higher among the autodialer group compared with the no notification control group. A second study evaluated the effect of centralized autodialer reminder and recall interventions on immunization receipt among low-income adolescents (Szilagyi 2013). Messages were sent at 10-week intervals for Tdap vaccine, MCV4 and the first dose of human papillomavirus (HPV) vaccine, and at five-week intervals for HPV-2 and HPV-3. Immunization receipt at the end of the study was 3 percentage points higher among autodialer participants compared with controls.

Patient autodialer message reminder or recall interventions improve receipt of immunizations based on high certainty evidence (Summary of findings for the main comparison) (Appendix 2).

Patient portal-based reminder or recall interventions

No studies with immunization reminder or recall interventions within secure online patient portal systems met our inclusion criteria.

Combination patient mail and telephone reminder or recall interventions ('mail and phone')

Interventions that included a combination of postcards or letters and telephone or autodialer messages were evaluated in nine included studies. Of these studies, we included eight in meta-analyses (6506 participants) (Alto 1994; Daley 2002; Daley 2004b;

Kempe 2001; LeBaron 2004; Lieu 1998; Suh 2012; Vivier 2000). We excluded one study from analyses because it allocated children within a household (Dini 2000). Intervention participants that received this combination intervention were 1.28 times more likely to receive immunizations than control group participants (95% CI 1.14 to 1.45) (Analysis 7.1). The study not included in meta-analyses evaluated the effect of autodialer messages, followed by letters, on receipt of all needed immunizations at 24 months of age (Dini 2000). Immunization receipt was 9.3 percentage points higher among intervention children compared with controls.

A combination of patient mail and telephone reminder or recall interventions probably improves receipt of immunizations with moderate certainty of the evidence (Summary of findings for the main comparison).

Combination patient reminder or recall with outreach interventions

Seven studies examined the effect of combined patient reminder and outreach interventions on immunization outcomes. Of these studies, we included three in meta-analyses (2701 participants) (Hambidge 2009; LeBaron 2004; Wood 1998). We excluded two from analyses for allocating families or households (Rodewald 1999; Szilagyi 2011). We excluded two studies with controlled before and after study designs (LeBaron 1998; Lemstra 2011). Intervention participants for three studies included in the meta-analysis were more likely to receive immunizations than control group participants (RR 1.22, 95% CI 1.10 to 1.35) (Analysis 8.1). Three of four studies not included in meta-analysis reported pre-intervention to post-intervention increases in receipt of vaccinations that were 12.3 to 21.0 percentage points higher among intervention participants compared with control participants (LeBaron 1998; Rodewald 1999; Szilagyi 2011). The fourth study not included in analyses compared telephone reminders combined with an offer to have a public health nurse vaccinate the child during a home visit to a telephone reminder only control group (Lemstra 2011).

A combination of patient reminder or recall with outreach interventions improves receipt of immunizations based on high certainty evidence; however, the small number of studies in this subgroup is a potential concern (Summary of findings for the main comparison) (Appendix 2).

Combination patient reminder or recall and provider reminder interventions

Six studies assessed the effect of patient reminder or recall combined with provider reminder interventions on receipt of immunizations (Becker 1989; Buffington 1991; Humiston 2011; Margolis 1992; Ornstein 1991; Rodewald 1999). We included three comparisons from two of the six studies in the meta-analyses (4120 participants) (Becker 1989; Humiston 2011). Intervention group participants were more likely to receive immunizations than control group participants (RR 2.91, 95% CI 2.67 to 3.19) (Analysis 9.1). We excluded four studies from analyses: three randomized trials because they randomized practices, providers, families, or households (Buffington 1991; Ornstein 1991; Rodewald 1999), and one controlled before and after study (Margolis 1992). The three randomized trials not included in the meta-analyses reported increases in immunization receipt that were 13.4 to 21 percentage points higher among intervention groups compared with control groups. The controlled before and after study reported mixed results that varied by clinic, with the following pre-intervention to post-intervention changes in immunization outcomes: a 16 percentage point increase in one intervention clinic; a 5 percentage point decrease in a second intervention clinic; a 3 percentage point increase in one control clinic; and a 4 percentage point decrease in a second control clinic (Margolis 1992).

A combination of patient reminder or recall with provider reminder interventions probably improves receipt of immunizations based on moderate certainty evidence (Summary of findings for the main comparison) (Appendix 2).

Patient reminder or recall interventions in different immunization types and patient populations

Childhood immunizations

Childhood immunizations, excluding influenza vaccinations, were the focus of 29 included studies. In the 23 studies included in the meta-analysis (31,099 participants), children in reminder or recall intervention groups were more likely to receive routine immunizations than children in control groups (RR 1.22, 95% CI 1.15 to 1.29) (Analysis 1.1).

We excluded four eligible randomized trials from the meta-analyses because they allocated households, families, practices, or geographic areas (Brown 2016; Dini 2000; Haji 2016; Rodewald 1999). In one of these studies immunization receipt at 24 months of age was 7.3 to 9.3 percentage points higher in the intervention groups than in the control group (Dini 2000). In the second study, immunization receipt was 21 percentage points higher in the intervention groups compared with the control group (Rodewald 1999). Two controlled before-after studies were not included in the meta-analysis (LeBaron 1998; Lemstra 2011). One reported a 15 percentage point increase in immunization rates among intervention participants and no change in the control group (LeBaron 1998). The other controlled before and after study enrolled children who had not received two MMR vaccinations by two years of age; the pre-intervention to post-intervention increase in MMR vaccination receipt was 6.6 percentage points in the intervention group and 2.7 percentage points in the control group (Lemstra 2011).

Patient reminder or recall interventions improve receipt of childhood vaccinations based on high certainty evidence (Summary of findings 2) (Appendix 2).

Childhood influenza immunizations

Five included studies (9265 participants), focusing on childhood influenza vaccinations, reported an increase in immunizations (RR 1.51, 95% CI 1.14 to 1.99) (Analysis 1.1) (Daley 2004a; Dombkowski 2012; Kempe 2005; Kemper 1993; Szilagyi 1992). In three studies improvement in receipt of influenza immunization was 17 to 26 percentage points higher among intervention groups compared with controls (Daley 2004a; Kemper 1993; Szilagyi 1992). One study examined the effect of patient reminder and recall letters on receipt of influenza vaccination for healthy six- to 23-month old children (Kempe 2005), in contrast to the previous studies, which targeted children with high-risk conditions. This study reported the lowest RR (1.08, 95% CI 1.03 to 1.12) of this subgroup analysis and reported several limitations, including a vaccine shortage, a pandemic with extensive media coverage, and the use of a telephone survey prior to the intervention to assess attitudes and intentions regarding

influenza vaccination (Kempe 2005). Another study tested the effect of letter reminders on increasing influenza vaccination rates among children, aged 24 to 60 months, with chronic conditions and served by local health departments (Dombkowski 2012). The post-intervention immunization rates were higher among the intervention group compared with the control group (RR 1.26, 95% CI 1.10 to 1.46; risk difference of 6.5%).

Patient reminder or recall interventions probably improve receipt of childhood influenza vaccinations with moderate certainty of evidence (Summary of findings 2) (Appendix 2).

Adult immunizations – other than influenza or travel ('other adult')

Eight included randomized trials (8065 participants) examined the relationship between patient reminder or recall interventions and routine adult immunizations, including tetanus, pneumococcal, hepatitis B, DTP, Hib, MMR, and TOPV (Frame 1994; Hogg 1998; Ornstein 1991; Rosser 1991; Rosser 1992; Sansom 2003; Siebers 1985; Winston 2007). The RR for the four studies included in the meta-analyses was 2.08 (95% CI 0.91 to 4.78) (Analysis 1.1) (Hogg 1998; Sansom 2003; Siebers 1985; Winston 2007).

We excluded four of the eight included randomized trials from meta-analyses because they allocated families or providers (Frame 1994; Ornstein 1991; Rosser 1991; Rosser 1992). In three of these studies the tetanus or Td immunization rates among participants in the letter or telephone intervention groups were at least 20 percentage points higher than for controls (Frame 1994; Rosser 1991; Rosser 1992). The fourth study evaluated the effect of a computer-generated letter, alone or combined with provider reminders, on rates of adult tetanus vaccination rates (Ornstein 1991). The post-intervention vaccination rates were 3.6 percentage points higher in the letter only group compared with controls; this increased to 13.4 percentage points when the letter was combined with provider reminders (Ornstein 1991).

Patient reminder or recall interventions may improve receipt of adult vaccinations other than influenza and travel based on low certainty evidence (Summary of findings 2) (Appendix 2).

Adult influenza immunizations

Twenty-four included studies examined the relationship between patient reminder or recall interventions and receipt of adult influenza immunizations. Of these, we included 15 studies in the meta-analysis (59,328 participants) (Baker 1998; Brimberry 1988; Buchner 1987; Carter 1986; Hogg 1998; Hull 2002; Larson 1982; McCaul 2002; Moniz 2013; Moran 1992; Mullooly 1987; Nexoe 1997; Roca 2012; Satterthwaite 1997; Siebers 1985). We included two studies in the patient reminder or recall combined with provider reminders analysis (Becker 1989; Humiston 2011). We excluded six randomized trials from analyses because they randomized households, families, clinicians, or practices (Buffington 1991; Lukasik 1987; McDowell 1986; Puech 1998; Rosser 1991; Spaulding 1991), which could not be adjusted for in our analyses. We excluded one controlled before and after study from meta-analysis. The pooled random-effects RR for the 15 studies in this subgroup analysis was 1.29 (95% CI 1.17 to 1.43) (Analysis 1.1). Among the 15 analyzed studies, risk ratios ranged from 0.91 (95% CI 0.70 to 1.09) to 3.11 (95% CI 1.16 to 3.86). The median OR for the six studies that allocated households, families, clinicians, or practices was 3.08 (Buffington 1991; Lukasik 1987; McDowell 1986; Puech 1998; Rosser 1991; Spaulding 1991).

Patient reminder or recall interventions probably improve receipt of adult influenza vaccinations based on moderate certainty evidence (Summary of findings 2) (Appendix 2).

Adolescent immunizations

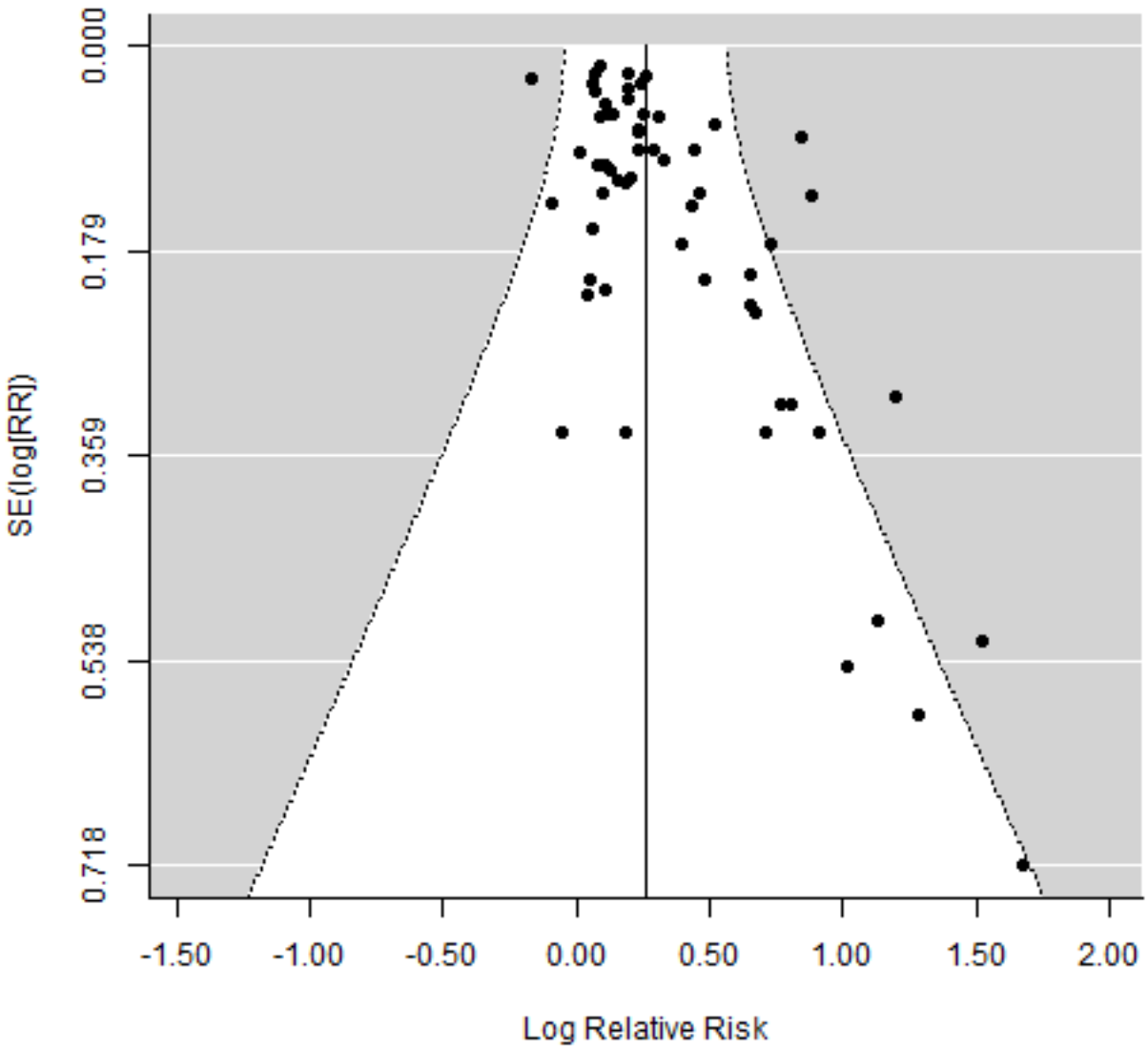
Twelve included studies evaluated the effect of patient reminder or recall interventions on receipt of immunizations among adolescents (Brigham 2012; Chao 2015; Marron 1998; O'Leary 2015; Rand 2015; Rand 2017; Staras 2015; Stockwell 2012a; Suh 2012; Szilagyi 2006; Szilagyi 2011; Szilagyi 2013). Of these, 10 (30,868 participants) are included in the patient reminder or recall subgroup meta-analysis (RR 1.29, 95% CI 1.17 to 1.42) (Analysis 1.1) (Brigham 2012; Chao 2015; Marron 1998; O'Leary 2015; Rand 2015; Rand 2017; Staras 2015; Stockwell 2012a; Suh 2012; Szilagyi 2006). We excluded two studies from the subgroup analysis because they allocated households or families (Szilagyi 2011; Szilagyi 2013). All 12 studies of adolescents reported higher percentage point changes in receipt of immunizations among intervention groups compared with control groups; these differences ranged from 0.6 to 18 percentage points.

Patient reminder or recall interventions improve receipt of adolescent vaccinations based on high certainty evidence (Summary of findings 2).

Assessment of reporting biases

There is no evidence of reporting bias, as suggested in the funnel plot (Figure 3), based on the inclusion of approximately 95% of the studies within the 95% confidence region (Sterne 2004).

Figure 3. Funnel plot of comparison: Patient reminder or recall summary measure versus control



Sensitivity analysis

Both sensitivity analyses tend to support the robustness of our primary analyses. In our first sensitivity analysis, we examined the effect of excluding studies from our patient reminder recall summary measure analysis with a high risk of bias rating for random sequence generation, allocation concealment, and/or incomplete outcome data. We removed eight studies (Buchner 1987; Hogg 1998; Lieu 1998; Oeffinger 1992; Sansom 2003; Soljak 1987; Stockwell 2012a; Tollestrup 1991), recalculated the pooled random-effects RRs, and compared these results with the RRs calculated prior to deleting the eight studies. The RRs were nearly identical for the overall summary measure, childhood, adult, adult influenza subgroup, and adolescent subgroups; and were identical for the childhood influenza subgroup (Table 1). The overall patient reminder recall RR was 1.28 (95% CI 1.23 to 1.3) when including all studies, versus 1.29 (95% CI 1.23 to 1.36) after excluding studies with a high risk of bias rating for random sequence generation, allocation concealment, and/or incomplete outcome data.

In our second sensitivity analysis, we examined the effect of our decision to define our primary outcome as receipt of needed immunizations, whether one or multiple. We computed RRs and CIs after removing nine studies from the patient reminder or recall summary measure that defined the primary outcome as 'up-to-date' with all needed immunizations (CDC 2012; Daley 2004b; Hambidge 2009; Irigoyen 2006; Kempe 2001; LeBaron 2004; Szilagyi 2006; Vivier 2000; Wood 1998). When comparing RRs for the full set of included studies ('before') with the subset after deleting

nine studies from the meta-analyses ('after'), the before and after RRs were very similar for the overall measure, and childhood immunizations and adolescent immunization subgroups. The other subgroups were unchanged. The overall patient reminder recall RR was 1.28 (95% CI 1.23 to 1.35) when including the full set of articles, versus 1.32 (95% CI 1.25 to 1.39) after excluding studies with primary outcomes measured as receiving all needed immunizations.

DISCUSSION

Summary of main results

We found that reminder and recall systems were effective for children, adolescents, and adults, in all types of medical or health settings, including private practices, academic medical centers, and public health department clinics, and for universally recommended vaccinations such as routine childhood vaccinations, as well as targeted vaccinations, such as influenza vaccine. In addition, all types of patient reminder and recall were found to be effective, with increases in immunization rates tending to range from 5 to 20 percentage points higher in the intervention groups compared with controls. Telephone reminders were the most effective single intervention type, followed by letter reminders, which were somewhat more effective than text message, postcard, and autodialer interventions. In general, combinations of patient reminder or recall interventions, including patient reminder or recall combined with outreach or some type of mailing combined with telephone calls, were not observed to be as effective as the telephone or letter intervention studies included in the meta-analyses. However, some single type reminder or recall interventions used repeated contacts, which may have provided them the same expected advantages as combination interventions. Patient reminder or recall combined with provider reminder systems were the most effective intervention category in this review; however, the number of studies was small.

Overall completeness and applicability of evidence

Our systematic review is comprehensive in terms of including all known types of patient reminder or recall interventions and all routine immunization types. We focused primarily on strategies to increase immunizations in non-institutional settings because provider-based interventions may be more applicable than patient reminder or recall interventions in hospitals and skilled nursing facilities.

This study has several potential limitations. First, the scope of the review was limited to studies published in English. The potential effect of limiting included studies to English language is mixed. At least one study has found that randomized trials published in English were more likely to have positive findings than studies published in German journals (Egger 1997). However, such language bias was not noted in another study (Heidenreich 1999). A study of meta-analyses, which included five or more trials with binary outcomes and used comprehensive literature searches, found English-language trials were more likely to have more study participants, be of higher quality methodologically, and be less likely to produce positive results (Juni 2002). The estimates of treatment effects were, on average, 16% more beneficial in non-English language trials compared with English language trials (Juni 2002). A second systematic review, focusing on systematic reviews of conventional medical care, found that none of the studies showed major differences in reported treatment effects when comparing those that included versus excluded non-English language studies (Morrison 2012).

Second, it is possible that the effect of some types of reminders might diminish in the current world in which phone calls, autodialer calls, and even email and text messages are widespread. Some of these interventions may be included as 'standard practice' in the control groups, leading to attenuated findings. Or, as use of technologies changes, it may alter the way in which people respond to different message delivery modes.

A third potential limitation is publication bias, because the majority of studies in this review were located from MEDLINE, EMBASE, *Cochrane Library*, CINAHL, other bibliographic databases, and references from other studies. Publication bias typically results in failure to publish studies with negative or null findings (Chalmers 1990; Dickerson 1992; Easterbrook 1991), therefore it is possible that our findings of positive outcomes in the majority of reviewed studies is partly affected by publication bias, and that the effect of reminder and recall is lower than noted in this review. We attempted to minimize publication bias by searching the files of the review authors and immunization experts, searching references of published reviews for abstracts, and reviewing abstracts or proceedings of major scientific meetings. In addition, funnel plot analyses did not detect publication bias, thereby increasing the plausibility of our positive findings. We conducted searches of grey literature and a clinical trials register to try to identify unpublished studies.

A fourth limitation resulted from omitting studies from the meta-analyses that allocated families, households, clinicians, practices, or communities. Fifteen generally well-designed studies, included in the initial review and meta-analyses, were omitted from the current analyses because they randomized families, households, providers, practices, or communities and analyzed patient-level data. While studies of health practice interventions, such as reminder or recall, can minimize contamination by randomizing at the practice level rather than the individual level, and many of these studies did that, reminder or recall of vaccines cannot avoid the effect on household members who may undergo vaccination as a result. That behavior may affect the measured outcomes of the study, but our meta-analysis could not control or adjust for this effect on household members.

Most of the studies in this review were performed in health systems of developed countries in settings in which the potential recipients generally have primary care providers who they see on a regular or as-needed basis and are followed over time. The providers could be public or private, physicians, nurse practitioners, or other health services experts, generalists, or more specialized providers, such as pediatricians in the US. The cornerstone is that there is a population of potential recipients who would need annual influenza vaccinations, or periodic vaccinations on some schedule, in the case of children. In many developing countries or regions, such a situation does not exist and although health services providers do serve patients, there is little ability to determine the population of eligible vaccine recipients. Thus reminder or recall interventions are found primarily in higher-income countries (WHO Working Group 2014). However, a few studies have been done which, while not eligible for inclusion in our systematic review, show promising results in terms of acceptability, including Guatemala (Domek 2016), and Nigeria (Brown 2015). Furthermore,

a few studies, while of low quality, have been conducted in low-income countries and found an overall positive, albeit relatively low, effect of reminders or recalls on immunizations (Muehleisen 2007; Usman 2009; Usman 2011; WHO Working Group 2014). More recently, a randomized trial in Zimbabwe found positive effects of reminders or recalls on immunization (Bangure 2015). However, in virtually all settings in which patient reminder and recall interventions were rigorously evaluated, and these settings were generally those in which patients were connected with a health system, the reminder and recall systems were found to be effective in improving immunization rates.

Our review does not include cost data to address questions of cost-effectiveness. The costs of patient reminder or recall interventions were reported in 16 studies, including eight pediatric studies (Campbell 1994; Lieu 1997; Lieu 1998; Linkins 1994; Rodewald 1999; Stehr-Green 1993; Wood 1998; Young 1980), and six studies of adults (Baker 1998; Buchner 1987; Hull 2002; McDowell 1986; Nexoe 1997; Rosser 1992). Eight studies estimated the cost-effectiveness of reminder and recall systems (LeBaron 2004; Lieu 1997; Lieu 1998; McDowell 1986; Rodewald 1999; Rosser 1992; Young 1980). Costs varied widely across studies, due to variability in methods of calculating costs and items included in analyses, such as existing staff or computer programming; different types of reminders used; different levels of intensity of interventions, from single postcard reminders to repeated reminders plus home visits; and different study time periods. As a result of the limited cost data reported and variations in the methods, the cost information is of limited use and is not reported. We did not track studies reporting cost data in the current review.

Finally, it is important to note that even relatively small effect sizes for interventions aimed at increasing immunizations are clinically meaningful because vaccinations are recommended for virtually every individual at some point. Therefore, even a small effect of a patient reminder or recall intervention, if scaled to a population level, might have a large beneficial effect on public health.

Certainty of the evidence

We assessed the certainty of the evidence in the estimate for each outcome and intervention type in our review using GRADE (Appendix 2). The GRADE assessment for our overall patient reminder recall summary measure was moderate (3; Appendix 2) rather than high because of some inconsistencies in the findings, with a few effect size outliers in each direction, and variation in the type of reminder or recall delivery mechanisms and messages, and because of some imprecision for several included study arms (Appendix 2). However, we consider the results to be of moderate certainty because of consistency of the estimates of effect for this outcome from our previous reviews, and the positive findings for all patient reminder or recall intervention types individually.

We rated the certainty of the evidence as high in four intervention subgroups (postcard; text message; autodialer; combination patient reminder or recall with outreach) and moderate for four subgroups (telephone; letter; combination of mail and phone; combination patient reminder or recall and provider reminder). We rated the certainty of the evidence as high in the childhood and adolescent vaccination subgroup analyses, moderate in the childhood and adult influenza vaccination sub-analyses, and low in the other adult vaccination sub-analysis. We downgraded the certainty of the evidence for other adult vaccinations because only four studies were included in this subgroup, risk ratios ranged from 1.08 to 3.61, and some imprecision was observed in two studies. In general, the risk of bias was not serious for the majority of our 75 included studies, with one of eight risk of bias criteria rated as high in 11 studies, two criteria rated as high in nine studies, and three criteria rated as high in three studies. Fifty-two included studies had ratings of low or unclear risk of bias for all nine criteria.

Potential biases in the review process

Our review process has potential limitations with respect to our method of pooling data, particularly in light of heterogeneity of some of the data, which is often present in meta-analyses (Gottlieb 1982; Thompson 1991). These reminder or recall studies were performed in a variety of populations, using different interventions, in multiple settings, targeting different types and numbers of immunizations, and across five decades; therefore it is not surprising that there is between-study heterogeneity in the results. Indeed, we found heterogeneity in study components. Populations ranged from infants due for their well-child visit vaccinations, to adolescents past due for the human papillomavirus vaccine, to older adults due for influenza or pneumococcal vaccines, and adults who had not received the influenza vaccination during the prior year. Some study populations represented the general public, while others targeted those at high risk for vaccine-preventable diseases. Some populations represented practice panels, whereas others a specific geographical region. The interventions varied by mode, including telephone, letter, postcard, text message, and autodialer, and intensity, in terms of number as well as perhaps tone, and complexity, from single to step-wise interventions. Text messages, as a medium, introduce another source for heterogeneity across studies - that is, self-selection - because these studies required patients or their parents to provide their cell phone numbers and specifically approve text messaging for this intervention.

By necessity, our investigation could not separate high-intensity interventions from low-intensity interventions. Studies that employed more than one study arm, where one arm used a high-intensity intervention and a second used a low-intensity intervention, contributed to the meta-analysis with the average of their effect. Similarly, the control groups differed somewhat in terms of the types of other practice, media, and community-based interventions that may have influenced immunizations. In general, we excluded studies that implemented interventions in the control groups that were expected to have a substantial influence on immunization rates. However, we chose to include a few studies with lower-intensity interventions in the control group if they were standard practice, thereby potentially diminishing the observed effect (Carter 1986; Ferson 1995; LeBaron 2004). Some concerns with control group exposure are not very amenable to change, such as external media campaigns, however, some of these factors may have exerted similar influences on intervention and control participants.

Our outcomes also varied in terms of the number of immunizations needed per participant and types of immunizations. We defined our primary outcome as receipt of any needed immunizations. In some studies, participants were targeted to receive only one immunization, such as one dose of the influenza vaccine. In some studies participants were targeted to receive a series of the same vaccine, such as human papillomavirus (HPV). In others, especially for children, participants were targeted to receive a series of

immunizations. We addressed this, in part, by conducting sub-analyses by participant and immunization type, such as adult influenza, child influenza, and other child vaccinations, which tended to group similar types of outcomes. In addition, we conducted sensitivity analysis to assess whether omitting studies that defined outcomes as up-to-date for immunizations changed our findings; however, our results were very similar after removing studies with outcomes defined as up-to-date.

Agreements and disagreements with other studies or reviews

The findings of our systematic review are similar to other published reviews of patient and parent-focused interventions aimed at increasing receipt of immunizations (Groom 2015; Harvey 2015; Niccolai 2015; Odone 2015; Thomas 2014; Watterson 2015; Williams 2011). Groom 2015 examined the effectiveness of immunization information systems in supporting interventions aimed at increasing immunization rates. Of the 240 included studies, 30 focused on client reminder and recall systems. All but one of these were US studies. Thirteen studies measured the effect of intervention on immunization rates; the median absolute percentage point improvement in immunization among these studies was 6 percentage points. Harvey 2015 assessed the effect of parental reminder and recall and education interventions on early childhood immunizations. All intervention types were found to be effective, with mailed and telephone reminders being the most effective, with a risk difference of 0.11 (95% confidence interval 0.03 to 0.19). Niccolai 2015 specifically focused on HPV vaccination among adolescents. Of the 14 included studies, seven examined the effect of reminder and recall systems, four using randomized designs. Interventions included letters, telephone calls, text messages, and outreach visits. Each of the seven studies reported increases in at least one HPV vaccination outcome attributable to the intervention. Odone 2015 focused on the effect of 'new media' interventions, such as text messaging, smart-phone applications, YouTube videos, Facebook, targeted websites and portals, software for health professionals, and emails, on vaccination coverage. Most of the 19 included studies were conducted in the US; both text messaging and patient-held web-based portals were found to be somewhat effective in increasing immunization rates. Oyo-Ita 2016 examined the effect of several intervention types on improving immunization coverage among children in low- and middle-income countries. Of the six included studies, one examined the effect of patient immunization cards on immunization rates. This intervention type is not considered to be patient reminder or recall in our review because of the passive nature of the card. Thomas 2014 assessed the effect of patient-focused and other interventions on older adult influenza immunization rates. Of the 57 included randomized trials, four examined the effect of letters, postcards, or telephone calls in immunizations. Odds ratios for patient reminder or recall studies were positive; however, the comparison groups tended to include similar interventions. Last, Williams 2011 studied the effect of interventions aimed at improving immunizations among children in developed countries. Fourteen of 41 intervention arms among 22 studies of parental reminders and recalls showed positive outcomes. The overall median change in immunizations was 11 percentage points, with a range of −11 to 19 percentage points. Positive results were reported for telephone only and combined telephone and mailed interventions (Williams 2011).

These reviews are briefly outlined in Appendix 3. It is important to note that some of the systematic reviews had considerable overlap with our review in terms of included studies (Williams 2011). Some of these reviews focused on multiple interventions and did not exclude studies with interventions received by control group participants. Our systematic review was the most comprehensive of those examining patient reminder and recall interventions.

AUTHORS' CONCLUSIONS

Implications for practice

The findings from this updated systematic review continue to show that implementing patient reminder and recall systems improve immunization coverage levels in primary care. Evidence from our review is supportive of recommendations from a number of bodies (AdHoc Working Group; Shefer 1999; Task Force 1999; Udovic 1998). In all settings that were evaluated, patient reminder and recall systems appear to be effective for improving immunization rates. As such, methods to incorporate reminder and recall systems into practices should have a positive effect on vaccine-preventable diseases. Different types of reminder and recall systems can be tailored to suit specific provider or practice needs. While person-to-person telephone reminders are most effective, they may also be more costly than other methods, and have not been studied extensively in children, except for the use of autodialers, which were found to have smaller but positive effects. However, for this update we identified five new studies that assessed the effect of letter reminder or recall interventions on immunization rates, and one new study focused on childhood influenza vaccination. Practical issues relevant to choices of reminder and recall systems include: characteristics of current computer systems, staffing, perceived accuracy of patient telephone numbers or addresses, availability of computer programmers, and estimated patient responsiveness to different types of reminders. These factors vary widely across nations or geographic regions; therefore immunization leaders will want to interpret the findings in this review with respect to their own setting. For example, settings with widely used computerized immunization registries could adopt postcard reminders sent by the registries. Practitioners today can tailor their own billing systems to function as reminder and recall systems for simple procedures, such as selecting all patients over 65 years of age for reminders about influenza or pneumococcal vaccination. Many billing systems have recently incorporated separate modules that can track immunization status.

A critical issue involves the complexity of 'rules' required for a reminder or recall system. The simplest scenario involves older adults, because no special immunization algorithm is needed, and eligible patients can be selected by birth dates. A slightly more complex scenario involves 'flagging' adult patients with problems such as end-stage renal disease, including those receiving hemodialysis, with HIV infection, or with chronic liver disease that may require hepatitis B vaccinations. More sophisticated algorithms are required to track prior immunization status, particularly for the complicated pediatric immunization schedule. A very promising approach involves vaccine providers recording the administered vaccines in computerized immunization registries shared across the region. These have been developed in many European countries (Johansen 2012), as well as Australia (Chin 2012), Canada (Canadian 1998), New Zealand (Wansbrough 2009), and the United States (CDC 1998c; NVAC 1999; USDHHS 2000), and are being developed in various forms in developing nations (Bosch-

Capblanch 2009). These registries already contain the necessary algorithms to assess the up-to-date status of children, and could be modified to deliver patient reminders. Finally, databases of managed care organizations and accountable care organizations can be modified to become reminder and recall systems. For practitioners, the usefulness of such databases depends on the proportion of a practice's patients covered by the managed care plan and the accuracy of the database information.

Overall, the technology exists, in the developed world, to incorporate patient reminder and recall into routine primary care practice. There are additional benefits to the patient and practice, beyond improving immunization rates. Studies have shown that patients behind with immunizations are also behind in other measures of preventive care (Fairbrother 1996; Rodewald 1995), and that reminder or recall systems targeting immunizations can also have "spillover effects" to improve other aspects of preventive care (Rodewald 1999), if they are used within primary care practices.

The use of patient reminder and recall systems provides the primary care practitioner with real-life experience at practicing population-based care, by improving the care for the entire population served by the practice (Halpern 2000). Although medicine is traditionally taught and practiced one patient at a time, and preventive services such as immunizations are delivered to individual patients, the measures of success, such as immunization rates, are population-based. Such population-based primary care, while not easy to do in a busy practice, has the potential to improve the quality of care and performance of primary care providers (Halpern 2000; OConnor 1998; Rivo 1998).

Implications for research

This study also has implications for research. Again, this updated systematic review includes 28 new studies and addresses two new technologies not addressed previously. They include electronic simple-message system text messages and electronic medical record messages in secured patient portals. As these technologies mature, researchers should consider how they can enhance reminder and recall interventions and what improvements in their effect can be achieved. We suspect that additional new technologies will also debut and researchers should test those platforms as well. Indeed, the Ericsson Mobility Report, published in 2015, reported 7.1 billion mobile phone subscriptions worldwide in 2014 (Ericsson 2015). That number included 2.6 billion smartphones, telephones with data plans that perform many of the functions of a computer, typically having Internet access and capable of running downloaded applications or apps. Ericsson predicts that in 2020 these numbers will increase to 9.2 and 7.7 billion respectively. That means that in 2020 Ericsson predicts that 70 per cent of the world's population will have a smartphone. Much of the growth will occur in the Middle East and Africa and parts of the Asia Pacific region. Thus the growth of smartphone availability, even in the next five years, promises new opportunities for reminder and recall innovation.

With the plethora of studies showing that patient reminder and recall systems improve immunization rates in all types of settings, future researchers should consider not simply repeating prior studies but rather building on them and addressing gaps. For example, only six included studies focused on text message interventions (Bangure 2015; Moniz 2013; O'Leary 2015; Rand 2015; Rand 2017; Stockwell 2012a). Four of these studies examined text message reminders and the effect on adolescent immunizations (O'Leary 2015; Rand 2015; Rand 2017; Stockwell 2012a), one focused on pregnant women and influenza vaccinations (Moniz 2013), and one focused on childhood immunizations (Bangure 2015). None of these included studies examined the effect of text messages on childhood influenza or other adult vaccinations. The effect sizes were generally positive, with only two demonstrating a relatively strong effect size (Rand 2017; Stockwell 2012a). There is a need to explore the characteristics and intensity of the interventions, target populations, and target immunizations to identify the most effective use of text message reminder and recall interventions. This need to learn more about characteristics of the most effective text message interventions was also a conclusion in a review of systematic reviews (Hall 2015), which found text messages to be generally effective in improving several types of health behaviors, such as diabetes, weight loss, physical activity, and smoking cessation.

Much of the focus, so far, with reminder and recall interventions is the evaluation of the effect on vaccines received. Reminders, rather than recalls, also have the theoretical ability to maintain a patient with on-time vaccinations, i.e. receipt of vaccinations by the recommended age or time, as opposed to up-to-date, i.e. the number or proportion of the population who have received the vaccine at a certain point in time, whether or not they received the vaccine by the recommended age or time. Researchers should consider testing the effect of patient reminders on on-time vaccination as a particular outcome.

Only five included studies examined the effect of reminder and recall interventions on childhood influenza vaccinations (Daley 2004a; Dombkowski 2012; Kempe 2005; Kemper 1993; Szilagyi 1992); four of five studies used letter reminders and one used a combination of letter and postcard (Daley 2004a). No included studies examined the use of telephone calls, autodialer, text messages, or other combination interventions on influenza vaccination among children. With approximately 40 percent of children, ages six months to 17 years, not having received the influenza vaccination during the 2014 to 2015 influenza season (CDC 2016b), it is important to better understand how to improve these rates.

Previously we had identified a single study that reviewed adolescent immunization delivery in an urban setting (Szilagyi 2006). This study did not demonstrate significant improvement with use of autodialer reminders. However, we have now identified 11 additional studies that examined the effect of reminder and recall interventions on immunization rates among adolescents. These studies examined the effect of letters (Chao 2015; Marron 1998; Szilagyi 2013), telephone (Brigham 2012), autodialer (Rand 2017; Szilagyi 2006; Szilagyi 2013), text messages (O'Leary 2015; Rand 2015; Stockwell 2012a); postcard (Staras 2015); combination of letter and autodialer (Suh 2012), and a tiered reminder or recall with outreach (Szilagyi 2011) on immunization outcomes. With the rising importance of adolescent immunizations and the multiple settings in which adolescents receive care, additional studies of adolescents would be useful for determining which strategies may be most effective.

The rapid implementation of computerized immunization registries presents opportunities for research in implementing, on a community-wide basis, reminder and recall interventions

that appear to be effective in single practice settings. In addition, managed care plans have databases that could be used as the backbone of reminder and recall interventions; studies incorporating such linkages would be helpful. The relatively recent implementation of patient portal systems and secure messaging with patients within these systems is another area to be further explored. None of the patient portal studies we reviewed met the inclusion criteria for this review. Patient portals linking the electronic health record systems, for example, could support reminders and recalls for additional vaccinations based on high-risk indications. Studies about 'fine-tuning' patient reminder and recall interventions would be helpful, such as investigations of the degree to which different combinations improve outcomes, or the degree to which combinations of patient reminder and recall and other types of interventions improve outcomes. Finally, because the majority of reviewed studies of patient reminder and recall interventions found positive effects, any studies that do not find improved immunization uptake should carefully investigate the reasons for lack of improvement. Such detailed investigations may uncover important barriers to care delivery that are likely to be useful in better understanding how to improve services for patients.

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CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Alto 1994

Methods	Study design: randomized trial; allocated children without grouping children in same family Study duration: 6 months; 1 January 1991 to 30 June 1991 Study aim: evaluate effectiveness of mail and telephone interventions in increasing immunization rates among children less than 7 years of age in family practice residency clinic
Participants	Inclusion: children actively enrolled in family practice residency clinic; not up-to-date with immunizations Age: older than 2 months of age as of 1 January 1991 and less than 7 years as of 30 June 1991 Setting: family practice residency clinic (USA) n = 464 randomized, 446 analyzed
Interventions	Intervention: sent postcard reminder to parents, indicating types of immunizations needed by child, and urging parents to make appointment; made telephone calls to parents of unimmunized children, 6 weeks after postcard intervention; written in English; n = 213 Control: no intervention; no special contact; n = 233
Outcomes	Number and percent of children immunized: intervention 8.8 percentage point increase over controls Number and percent of children receiving all needed immunizations: intervention 8.7 percentage point increase over controls
Notes	13% of postcards sent were returned as undeliverable Approximately 1% of families in practice Spanish-speaking; postcards may not have been understood; 17.8% of telephones were disconnected 41 of 177 intervention families not reached by telephone Results seem to be inconsistently reported for children brought up-to-date with immunizations; reversed in study abstract compared with results in Table 3

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"immunization records of the 519 children were entered into a minicomputer" Probably randomized within computer even though method not explicitly specified

Alto 1994 *(Continued)*

Allocation concealment (selection bias)	Unclear risk	Charts of infants were reviewed for immunizations received; supplemented these data with immunizations recorded in health department registry; entered immunization records into minicomputer prior to randomizing children; procedures not explicitly described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No information provided
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified for review of practice billing codes and charts
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Number of reviewed records not specified; asked parents by telephone about immunizations received Immunization status confirmed by reviewing practice billing codes and charts and county health department's records Did not confirm or record immunizations received at other sites
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Randomized patients within residency clinic; authors noted there may have been some contamination of control group because children with different surnames living in same household could have been assigned to different study groups
Baseline measurement	Low risk	"Immunization records of the county health department were reviewed." At baseline, reviewed charts of all infants actively enrolled in practice and older than 2 months and less than 7 years of age; supplemented information from health department immunization registry; selected participants behind on immunizations

Baker 1998

Methods	Study design: randomized trial Study duration: perhaps 1 influenza season; mailed reminders during third week of September 1995 Study aim: evaluate effect of 3 types of computer-generated mailed reminders on influenza immunization rates
Participants	Inclusion: adult patients aligned with primary care physician within health system and at high risk for influenza complications based on age 65 years or older, or diagnosis of asthma, diabetes, end stage renal disease, sickle cell disease, ischemic cardiomyopathy, or nephrotic syndrome Age: adults; mean age = 67.2 years Setting: multispecialty group practice that serves patients in health system's affiliated nonprofit, mixed-model health maintenance organization and patients in other fee-for-service health financing programs; southeastern Michigan (USA) n = 24,743 randomized
Interventions	Intervention group 1: generic postcard to patient, standard message; n = 6169 Intervention group 2: personalized postcard from patient's primary care physician; n = 6252

Baker 1998 *(Continued)*

	Intervention group 3: personalized letter from the patient's primary care physician, addressed to specific patient; message tailored to specific health risk of patient; n = 6151 Control: no reminder, but comprehensive immunization program for all 4 groups; n = 6171 Comprehensive program included: walk-in influenza vaccination clinics during October at all health system outpatient clinic locations, display of posters and take-home postcards in clinic entrances and waiting areas, toll-free information telephone line, developed program logo and theme used in all print media, and standard message in printed materials was based on Health Belief Model
Outcomes	Number and percent receiving influenza vaccination Group 1: 2.9 percentage point increase over control group Group 2: 4.1 percentage point increase over control group Group 3: 4.6 percentage point increase over control group
Notes	Patient reminders were one component of comprehensive influenza immunization program. Used billing data to calculate rate of immunizations in study groups; some vaccinations may have been received at unaffiliated clinics, some of which provided vaccinations free of charge Authors identified possible threshold effect

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Patients were identified as being eligible for study using computerized appointment scheduling system and demographic data and computerized billing data; patients were randomized to 4 groups; method is not described
Allocation concealment (selection bias)	Unclear risk	Randomized patients into one of 4 groups; method not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No information provided
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Measured outcomes using billing data; blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Used billing data to obtain immunization rates Authors note possibility that some participants may have received immunizations at non-study clinics, some of which offered free vaccinations
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes to answer study questions
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Identified eligible patients using computerized billing data Obtained data on date of birth, sex, race, and marital status Demographic characteristics similar between study groups

Bangure 2015

Methods	Study design: randomized trial Study duration: participants followed for 14 weeks; recruitment began 1 January 2013; study follow-up ended 31 August 2013 Study aim: determine effectiveness of short message service reminders on immunization receipt
Participants	Inclusion: women or caregivers were recruited into study soon after delivery or during third and seventh day visits after delivery of baby; must have cell phone and resident of Kadoma city Age: mothers of infants Exclusion: no cell phone Setting: clinics in Zimbabwe n = 304
Interventions	Intervention group: short message service reminders indicating next appointment date and health education; 7, 3, and 1 day before immunization due date; repeated for 6-, 10-, and 14-week appointments; message indicated immunization protects your child against deadly diseases, and reminder of vaccination appointment; n = 152 Control group: informed mothers or caregivers about next scheduled immunization visit and provided routine health education; n = 152
Outcomes	Receipt of scheduled vaccines at 6, 10, and 14 weeks 6 weeks OPV1, Penta1 and PCV: 97% versus 82%; 15 percentage point difference 10 weeks OPV2, Penta2 and PCV2: 96% versus 80%; 16 percentage point difference 14 weeks OPV3, Penta3 and PCV3: 95% versus 75%; 20 percentage point difference
Notes	Immunizations may have been measured at the date due or day after

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were assigned by computer-generated random numbers to intervention and control groups
Allocation concealment (selection bias)	Low risk	Participants were assigned by computer-generated random numbers to intervention and control groups
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding of outcome assessment not specified Entered and analyzed data in Epi Info 7
Incomplete outcome data (attrition bias) All outcomes	Low risk	152 participants randomized and analyzed in each group; obtained outcomes by telephone follow-up and clinic immunization registry; compared data sources
Selective reporting (reporting bias)	Low risk	Reported pre-specified outcomes of interest

Bangure 2015 *(Continued)*

Other bias	Low risk	Did not identify other sources of bias
Baseline measurement	Low risk	Reported characteristics of mothers; similar for marital status, place of residence, educational levels, employment status, religion, and median age

Becker 1989

Methods	Study design: randomized trial Study duration: 8 months; enrolled patients in study between August 1986 and April 1987; reviewed charts from April through August 1987 Study aim: evaluated effect of patient and provider reminders on immunization rates and other preventive services
Participants	Inclusion: patients with recorded telephone number, at least 1 clinic visit within 18 months of study, 40 to 60 years of age, and house officer or general medicine fellow assigned as primary physician Exclusion: residence in nursing home or long-term care psychiatric facility Age: 40 to 60 years Setting: University of Virginia internal medicine clinic (USA) n = 1050; 350 patients in each study arm; 1055 patients eligible
Interventions	Intervention group 1: mailed memo to patient, and physician reminder clipped to chart; individualized patient reminder, specified which preventive services were needed and when they should be obtained Preventive services included: blood pressure check, dental exam, ocular pressure measurement, stool exam for occult blood, influenza, pneumococcal and tetanus vaccinations, mammogram, and Papanicolaou smears; n = 350 Intervention group 2: physician reminder clipped to chart; ineligible intervention; n = 350 Control: no reminder; no intervention; n = 350
Outcomes	Immunization rates for Intervention group 1: Pneumococcal: 0.8 percentage point increase over control group Tetanus: 8.2 percentage point increase over control group Influenza: 16 percentage point increase over control group
Notes	Multiple interventions, including patient and provider reminders "Limited and variable follow-up times" for outcome measures because intent was to complete study within a 12-month period with same group of house staff Number of patients not meeting inclusion criteria was higher than expected; this limited power to detect differences in outcomes between study groups

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Used computerized clinic database to select eligible patients; "they were randomly assigned to three study groups"; specific method not described
Allocation concealment (selection bias)	Unclear risk	Specific allocation procedure not specified; participants potentially meeting eligibility were selected using computerized clinic database

Becker 1989 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Study hypothesis "was not revealed" to physicians; physicians received reminders in groups 1 and 2; blinding not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified Reviewed outpatient medical records Re-interviewed 20% random sample of each study group to identify whether preventive services were obtained at non-affiliated clinics, specifically for dental and ophthalmologic services
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Obtained outcome data by reviewing full outpatient medical records at least 4 months after telephone interview to assess whether services were obtained within medical clinic, other clinics, or emergency department
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included outcomes for all 8 preventive services, including 3 immunization types
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Used patient telephone interviews and clinic chart reviews to develop individualized schedule of preventive care services for each participant; if patient's belief about whether a service had been received differed from chart, based recommended need for service on patient's recall Obtained demographic data for all eligible patients, including age, sex, race, and distance from medical center Study groups similar in need for preventive services and demographic characteristics

Brigham 2012

Methods	Study design: randomized trial Study duration: interventions conducted between 12 May 2010 and 19 July 2010; assessed receipt of vaccinations at 4 weeks and 1 year after randomization Study aim: evaluate whether adolescent immunization rates can be increased by calling parents or guardians, or parents or guardians and adolescents
Participants	Inclusion: billing codes for physical exam at adolescent practice within 3 years prior to 13 May 2010; not received MCV4; not received Tdap in past 5 years; or received only 1 VAR, but did not have documented history of chickenpox Age: 13 to 17 year olds Exclusion: in custody of Department of Children and Families or Department of Youth Services; having sibling enrolled in study; or having no record of any immunizations or only influenza vaccinations Setting: Adolescent Medicine Practice at Boston Children's Hospital, Boston, Massachusetts (USA) n = 424 allocated; 142 to control; 141 to parent reminder only; and 141 to parent and adolescent reminder; 1099 assessed for eligibility; excluded 675
Interventions	Intervention group 1: telephone calls to parent or guardian only, indicating adolescent was overdue for immunizations; study investigator made calls and used telephone script to briefly describe

Brigham 2012 *(Continued)*

	vaccine-preventable illnesses, inquire about immunizations received in other locations, and offer to schedule vaccination appointment Up to 4 call attempts were made in 1 week until content was delivered or parent asked not to be contacted; did not leave voicemail messages Made telephone calls between 9 am and 7 pm on weekdays only Medical interpreters were used, when necessary; n = 141 Intervention group 2: telephone calls to parent or guardian and adolescent, indicating adolescent was overdue for immunizations; similar script; parents were asked permission to contact adolescent; n = 141 Control: no specific outreach regarding immunizations; usual care; n = 142
Outcomes	Used intention-to-treat analysis Primary outcome: new record of 1 or more of the 3 vaccines of interest, Tdap, MCV4 or VAR within 4 weeks after the first phone call attempt Secondary outcomes: receipt of 1 or more of 3 vaccines within 1 year after the intervention; receipt of any other vaccines by 4 weeks or 1 year after the Group 1 intervention: 7.4 percentage point increase over control group, for 1 or more of 3 vaccines within 4 weeks; 14.4% versus 7.0% Group 2 intervention: 7.5 percentage point increase over control group, for 1 or more of 3 vaccines within 4 weeks; 14.5% versus 7.0%
Notes	Only reached 30 adolescents by telephone in Group 2 intervention Power calculations: a priori power calculations indicated 174 participants were required in each group to detect "15%" difference between groups with 80% power; study group sizes did not meet this estimate; post-hoc power calculations indicated that actual participant numbers and data provided enough power to detect "12%" difference between outcomes for intervention and control groups

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomization software was used to develop randomization assignment lists; "assignments were designated in randomly permuted blocks of 6 or 9"
Allocation concealment (selection bias)	Low risk	Randomized adolescents using randomization software
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	"trial was not blinded to investigators"; however, it is not clear whether the outcome could be influenced by lack of blinding
Blinding of outcome assessment (detection bias) All outcomes	Low risk	"Immunization status was assessed by using … electronic medical record"; outcome measurement is not expected to be influenced by lack of blinding by investigators
Incomplete outcome data (attrition bias) All outcomes	Low risk	Assessed immunization status using hospital's electronic medical record Reviewed immunization records at 4 weeks and 1 year after intervention to determine vaccination status During telephone calls, asked parents whether immunizations were received at different location; if so, asked parents to have records mailed or faxed to practice

Brigham 2012 *(Continued)*

		Changed script during study to ask all parents to have records of immunizations received in other locations mailed or faxed to practice Did not reach 269 of 424 participants at 4 weeks and 270 of 424 participants at 1 year (Figure 1)
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included outcomes for all 3 immunization types
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Reviewed hospital billing and immunization databases to identify adolescents with physical exam billing code at adolescent practice within 3 years before 13 May 2010, and met eligibility criteria Study groups were similar with respect to age, sex, race and ethnicity, insurance type, and vaccines needed

Brimberry 1988

Methods	Study design: randomized trial Study duration: 3 months; 1984 to 1985 influenza season Study aim: evaluate and compare effectiveness of telephone and letter reminders at improving influenza vaccination rates
Participants	Inclusion: listed in active patient computer files of family medical center; high risk for influenza and complications; not yet received influenza vaccination in current season Age: not clear Setting: Family Medical Center, University of Arkansas (USA) n = 787 patients
Interventions	Intervention group 1: mailed form letter using first class mail; letter emphasized influenza could pose serious threat because of certain health conditions, and patient's physician recommended influenza vaccination; signed by influenza vaccination director; n = 267 No appointment was needed; patients were informed of cost Intervention group 2: personal telephone reminder with same information as letter; added reference to each patient's diagnosis and physician; made up to 2 telephone call attempts, 1 during daytime hours and 1 in evening; used standard script to provide uniform information; n = 258 Control: no intervention; no effort to contact patients; n = 262
Outcomes	Number and percent receiving influenza vaccination Group 1: 5.9 percentage point increase over control group Group 2: 5.5 percentage point increase over control group
Notes	Authors indicated outside efforts to encourage vaccination, such as local media promotions, may have influenced vaccination rates

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Eligible patients "were randomly assigned by computer to one of three groups"

Brimberry 1988 *(Continued)*

Allocation concealment (selection bias)	Low risk	Identified patients from active computer files; randomly allocated participants to study groups by computer
Blinding of participants and personnel (performance bias) All outcomes	Low risk	"To avoid bias, physicians at the Family Medical Center were not informed of the purpose or nature of the study."
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified; "clinic nurses used a standard form to keep a record of all patients who received their vaccination during the study period."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Clinic nurses collected immunization data for all patients during study period, using standard form
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included immunization outcomes for all 3 study arms
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Influenza immunization data not available prior to 1984; determined influenza immunization status at baseline for persons considered at high risk for influenza and related complications prior to randomization

Brown 2016

Methods	Study design: group randomized trial Study duration: followed each infant for 9 to 12 months until 12 months of age; recruited from August to November 2012; cell phone reminder and recall occurred for 14 months, 2012 August through 2013 September Study aim: evaluated the effect of reminder-recall intervention and primary care immunization provider training on routine immunization completion among infants
Participants	Inclusion: age 0 to 12 weeks at first immunization visits; parents living in study communities Age: up to 12 months; 0 to 12 weeks of age at recruitment Exclusion: no cell phone; infant died; left service area Setting: immunization clinics in Ibadan, Southwest Nigeria n = 605
Interventions	Intervention group 1: 2 cell reminder phone calls to child's parent or other contact person; made 2 and 1 day before immunization appointment; recall for missed appointments; n = 148 Intervention group 2: Primary Health Care Immunization Providers' Training (PHCIPT); 2 days refresher training on theory and practice of immunization conducted for nurses, midwives, community health officers, and community health extension workers; 4 modules adapted from World Health Organization immunization training manual; not our intervention; n = 150 Intervention group 3: telephone reminder and recall with provider training; n = 147 Control group: usual care; no intervention; n = 150
Outcomes	Receipt of routine immunizations at 12 months of age

Brown 2016 *(Continued)*

	Intervention group 1: 98.6% versus 57.3%; 41.3 percentage point difference
Notes	Data not included in meta-analyses

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomly selected 2 local government areas from urban and 2 from suburban area; used ballot system to allocate areas into 3 intervention and 1 control group; randomly selected 1 ward from each area and purposively selected 1 primary health services facility from each ward
Allocation concealment (selection bias)	Unclear risk	As above
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel was not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding was not specified Researchers and research assistants used paper-based immunization data system; integrated data collection into health facility activities; collected data using immunization records and cards, and qualitative feedback from mothers in reminder-recall group
Incomplete outcome data (attrition bias) All outcomes	Low risk	10 of 605 participants were lost to follow-up
Selective reporting (reporting bias)	Low risk	Outcomes reported for study questions
Other bias	Low risk	Did not identify other sources of bias
Baseline measurement	High risk	Groups were similar with respect to mother's age Groups differed for children's mean age at first immunization visit, children's sex, family type, birth order, family's religion, maternal education, and place of delivery

Buchner 1987

Methods	Study design: randomized trial Study duration: possibly 1 influenza season; vaccination cue sent in October 1984, about a month after influenza vaccinations became available Study aim: evaluate effectiveness of simple vaccination reminder at increasing influenza vaccination
Participants	Inclusion: active patients Exclusion: nursing home resident, allergy to influenza vaccine or eggs Age: at least 65 years

Buchner 1987 *(Continued)*

	Setting: private practices of 3 board-certified internists near Seattle, Washington; sites differed in patient demographic mix; 1 site generally served lower middle class population in rural area; 2 sites generally served suburban, middle and upper middle class populations (USA) n = 655 patients randomized; 540 analyzed
Interventions	Intervention: postcard reminder; short message on 3-inch by 5-inch card, mailed in business envelope with physician's return address; message indicated flu season was coming, some people are at greater risk for influenza and complications, flu shots can decrease risks with minimal side effects, and it is needed each year; also provided instructions for where to obtain flu shots; n = 262 analyzed Control: no intervention; n = 278 analyzed
Outcomes	Percent of participants receiving influenza vaccination Intervention group: 1.0 percentage point increase over control group
Notes	Eligibility criteria specify 65 years of age or older; however, introduction specified over 65 years of age 1 site had used mailed reminders in past Power calculations: number of patients was sufficient to detect vaccination increase from baseline of 30% to at least 45%, with 90% power

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Study personnel assisted each site with providing a roster of active patients for the study; eligible patients were randomly assigned to study groups by unspecified method
Allocation concealment (selection bias)	Unclear risk	Randomly assigned patients to study or control groups Allocation method not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Obtained outcome data from clinic records; process not described; questionnaires were mailed to patients to estimate compliance; blinding not specified
Incomplete outcome data (attrition bias) All outcomes	High risk	Mailed follow-up questionnaires to randomized patients to estimate compliance because many patients obtain influenza vaccinations outside study clinics; 77.1% of participants responded to vaccination status questionnaire
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; influenza vaccination rates are reported for intervention and control groups
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Unclear risk	Prior year vaccination rates obtained by questionnaire

Buffington 1991

Methods	Study design: randomized trial Study duration: 3 months; 23 September 1989 to 30 December 1989

Buffington 1991 *(Continued)*

	Identified target populations by late September 1989 in 2 intervention groups, and in December 1989 for control group physicians Study aim: evaluate effect of population-based tracking system, postcard reminder, and immunization tracking chart on increasing influenza vaccinations
Participants	Inclusion: patients active in private physician office setting affiliated with 1 teaching hospital; cared for at least once in physician's office within 2 years of study start Age: 65 years or older, as of 1 January 1990 Setting: private physician office settings; 13 private practice groups, Rochester, New York (USA) n = 45 of 56 active physician practitioners agreed to participate; 8376 patients in 2 arms included in our review; 2149 included in poster only group, and ineligible intervention
Interventions	Intervention: postcard reminder and provider poster or chart; n = 3,604 Poster included 11-inch by 17-inch chart, displaying target population for each physician, the patient denominator; used chart to track percent of target patients immunized each week, over time Control: no intervention; no new immunization initiatives; n = 4772
Outcomes	Percent of patients receiving influenza vaccination Intervention group: 17 percentage point increase over control group Odds ratio 2.0, CI 0.67 to 5.93, adjusted for intra-practice variation
Notes	Randomized at practice or provider level, analyzed at patient level Data not entered in RevMan Potential for under-reporting of vaccinations obtained at county health department because incomplete linkage of patients with primary care providers and inaccuracies in spelling of primary care clinicians' names in health department records Reported intervention costs

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Stratified 13 private practice groups based on estimated numbers of patients > 65 years in physicians' practices; randomized practices based on stratification; method not described
Allocation concealment (selection bias)	Unclear risk	Allocated 13 private practice groups to 3 study groups: 17 physicians to control group, 13 physicians to clinician poster group, and 15 physicians to postcard and clinician poster group; method not specified
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified; tracked immunization rates on physician-specific posters in intervention and control practices; insufficient information to assess whether high risk or low risk
Incomplete outcome data (attrition bias) All outcomes	Low risk	Outcome data collection procedures were extensive; specific number and pe cent of participants with outcome data not specified Tracked influenza vaccinations using computer-generated billing codes in 4 provider groups

Buffington 1991 *(Continued)*

		Asked physicians and clinic staff to record all influenza immunizations given to persons 65 years and older and graph percent of target population on poster Study coordinators visited office personnel in intervention clinics approximately every 2 weeks during study period to verify that charts were updated All participating practices billed USD 8.00 administrative fee for influenza vaccination; used data to help determine number of vaccinations given Obtained immunization data from county health department at study end Did not record verbal reports of vaccinations received outside physicians' offices
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; influenza vaccination rates are reported for 2 intervention and 1 control group, stratified by type of practice
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Unclear risk	Baseline measurement not described Used computer-generated patient lists to identify target population in some practices Used billing records and treatment files to identify patients not computerized

Campbell 1994

Methods	Study design: randomized trial Study duration: 7 to 13 months Study aim: assess and compare effect of patient-specific letters and appointment postcards on well-child appointment show rates and immunizations
Participants	Inclusion: newborn infants enrolled at clinic, but not those receiving well care from first author of paper Age: infants from birth to 7 months Setting: pediatric continuity clinic in teaching hospital in Rochester, New York; almost all clinic providers were pediatric residents; clinic served approximately 7300 children from predominantly poor backgrounds in urban areas; 71% of visits made by Medicaid beneficiaries (USA) n = 288 patients enrolled and analyzed
Interventions	Intervention group 1: sent letter to parents 1 week before scheduled well-care appointment patient-specific and visit-specific reminder letters designed using Health Belief Model; specified appointment date and time, and age-specific interventions to be received by patients; n = 87 Intervention group 2: sent postcard reminder to parents 1 week before each scheduled well-care appointment; only specified appointment date and time; n = 96 Control: no reminder letter or postcard; n = 105
Outcomes	Number and percent receiving 3 DTP by 7 months of age Group 1 (letter): 5.9 percentage point increase over control group Group 2 (postcard): 2.5 percentage point increase over control group
Notes	Letters reminded patients of appointments and discussed several topics Postcards reminded patients of clinic appointment date and time only, but not specific immunizations needed
Risk of bias	

Campbell 1994 *(Continued)*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Methods to randomize patients not specified
Allocation concealment (selection bias)	Unclear risk	Random allocation of patients; process not described
Blinding of participants and personnel (performance bias) All outcomes	Low risk	"Medical group providers were blinded to study group assignment"
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified for chart auditing process
Incomplete outcome data (attrition bias) All outcomes	Low risk	Charts were audited after patients completed study to determine "date of DTP immunizations received"
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Enrolled infants; interviewed mothers to obtain demographic and socioeconomic data Compared demographic data between study groups, differences not identified

Carter 1986

Methods	Study design: randomized trial, stratified by age and diagnosis Study duration: 2-week influenza shot clinic in October of study year Study aim: evaluate and compare effectiveness of letters and informational brochure on increasing influenza vaccination among persons who had not received vaccine in prior year and at high risk of getting influenza or complications
Participants	Inclusion: patients cared for in general medical clinic of 1 hospital; at high risk for influenza complications Exclusion: received influenza vaccination in previous year; living in nursing home; severe disabling mental, visual, or hearing impairment Defined high risk as: 65 years and older, or diagnosed with diabetes, chronic lung disorders, or chronic heart disorders Age: adults Setting: Veterans Administration Medical Center, general medical clinic, Seattle, Washington (USA) n = 284 patients of 1093 eligible
Interventions	Intervention group 1: standard letter and informational brochure; developed using multi-attribute utility-based messages; sent to patients approximately 10 days before 2-week special flu shot clinic in October; n = 66

Carter 1986 *(Continued)*

	Intervention group 2: augmented letter; added statement to standard letter that 70% of veterans from medical center were vaccinated last year; n = 57 Intervention group 3: augmented letter and informational brochure; n = 55 Control: standard letter; considered standard practice because it was in use prior to study; mentioned that flu season is approaching, potential risk for getting flu complication because at high risk, safety and effectiveness of flu vaccine, recommendation by doctor to receive flu shot each year, and time and location of flu shot clinic; signed by clinic chief; n = 57
Outcomes	Number and percent receiving influenza immunization Group 1: 13 percentage point increase over standard letter control group Group 2: 7 percentage point increase over standard letter control group Group 3: 23 percentage point increase over standard letter control group
Notes	Control group includes patient reminder (standard letter), so no true control group Study participants had not received influenza vaccination in previous year, not general population Active influenza vaccination program had been operational in study setting since 1978; included sending mailed letters to patients at high risk of influenza, inviting them to receive vaccine

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Patients identified as high risk were stratified into risk groups and randomly assigned to one of 4 groups; allocation method not described
Allocation concealment (selection bias)	Unclear risk	Stratified high risk patients without history of influenza vaccination at the start of year 2 of larger study into those 65 years and older and less than 65 years, then randomly assigned to 1 of 4 groups; allocation process not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified Mailed vaccination status questionnaire to each participant to obtain outcome data; conducted second mailing and telephone follow-up, if needed; also used clinic vaccination records
Incomplete outcome data (attrition bias) All outcomes	Low risk	83% of participants remained in study at end of intervention Compared self-report of immunization with clinic records; 94% agreement between data sources
Selective reporting (reporting bias)	Unclear risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	High risk	Control group includes patient reminder (standard letter), so no true control group Study participants had not received influenza vaccination in previous year, so not general population
Baseline measurement	Low risk	All eligible patients had not received an influenza vaccination in the prior year

CDC 2012

Methods	Study design: randomized trial Study duration: 3- to 4-month follow-up period; extracted baseline data from Medicaid billing files on 28 December 2010; during June 2011, reassessed vaccination status with claims files, including vaccinations administered through 30 April 30 2011 Study aim: evaluate effectiveness of recall letter, sent to parents of Medicaid beneficiaries, in improving immunization series completion among young children
Participants	Inclusion: parents of children enrolled in Montana Medicaid; known not to have completed some vaccinations with routinely recommended series; birth dates from 2 December 2008 through 1 May 2009 Age: 19 to 23 months of age Exclusion: children known to have completed vaccination series; or home address outside Montana Setting: Montana Medicaid program and Montana Department of Public Health and Human Services; state-wide (USA) n = 878 eligible for study participation; recall letter sent to 438 parents of eligible children
Interventions	Intervention: sent 1 state-generated recall letter to parents, reminding them to take their children to health services providers to receive missed vaccinations; did not list specific missing vaccinations; n = 438 Control: no letter sent from state; n = 440
Outcomes	Received all needed childhood vaccinations Intervention group: 4 percentage points over control group; not statistically significant
Notes	1865 children enrolled in Montana Medicaid were 19 to 23 months of age at the time of the study; of these 47% were not up-to-date with immunizations Individual practices may have delivered reminder-recall interventions; 21% of respondents to survey of Montana Medicaid health services providers indicated use of immunization reminder or recall strategies Power calculations: if 250 participated in each study group, study had 99.9% likelihood of detecting statistically significant difference with 15 percentage point difference, or 72% likelihood with 6 percentage point difference

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"Using the Comprehensive Clinic Assessment Software Application random generator tool, … randomly assigned."
Allocation concealment (selection bias)	Low risk	Centrally allocated children enrolled in Montana Medicaid using random number generator tool
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Blinding of participants or personnel not specified; however, health services providers that administered vaccinations and submitted Medicaid claims were not involved with intervention or data collection
Blinding of outcome assessment (detection bias)	Low risk	Blinding not specified; used Medicaid billing records to determine vaccination receipt

CDC 2012 *(Continued)*

All outcomes		
Incomplete outcome data (attrition bias) All outcomes	Low risk	Reassessed vaccination status 3 months after recall letter was sent using Medicaid claims and immunization registry data; health services "providers have up to 1 year to bill Medicaid for vaccines administered, so delays in billing for some vaccines might hide some differences in vaccination coverage between intervention and control cohorts." Missing outcome data are not expected to differ between groups
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes for each immunization type
Other bias	Unclear risk	Individual practices may have delivered reminder-recall interventions; 21% of respondents to survey of Montana Medicaid health services providers indicated use of immunization reminder or recall strategies
Baseline measurement	Low risk	Extracted data from Medicaid billing records and web-based immunization registry to determine whether children received all immunizations in vaccination series Study groups did not differ for age, sex, American Indian-Alaskan Native classification, population density within county of residence, and number of missing vaccinations

Chao 2015

Methods	Study design: randomized intervention study Study duration: assessed HPV vaccination status 3 months after mailing; 12-month evaluation period; 13 February 2013 to 12 February 2014 Study aim: evaluated effectiveness of reminder letter on HPV vaccine 3-dose series completion
Participants	Inclusion: female members of health system for at least 1 year prior to study; received at least 1 dose of HPV4 during 3-month period before 13 February 2013; valid address in membership file Age: 9 to 26 years when received first HPV4 dose Exclusion: more than 2 doses of HPV4; unresolved pregnancy; had not met the minimum HPV vaccine dosing intervals specified by ACIP; terminated health plan membership during evaluation period Setting: Kaiser Permanente Southern California Health Plan n = 12,205
Interventions	Customized reminder letter; 9th or 10th grade reading level; English and Spanish; indicating HPV4 immunization schedule, date of first dose and telephone numbers; encouraging follow-up vaccination visits; sent to patients if 12 to 26 years and to parents if 9 to 11 years; 4 waves of mailings were scheduled quarterly; therefore, letters did not reach participants when a dose was due; n = 9760 Control group: usual care; author does not have information about reminder or recall systems used in individual clinical practices; n = 2445 System-wide provider reminders in electronic medical records for intervention and control group
Outcomes	HPV vaccine 3-dose series completion Intervention group: 56.4% versus 46.6%; 9.8 percentage point difference

Chao 2015 *(Continued)*

Notes	Inconsistency in study method descriptions

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomization process not described; inconsistent description of allocation process; either 80% of eligible persons were randomly selected for intervention group and 20% for control group; or patients were randomized
Allocation concealment (selection bias)	Unclear risk	Randomization process not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants or personnel not described
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding of outcome assessment and outcomes data source(s) not described
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Data source(s) and follow-up not described Not all reminder letters were successfully delivered; some were returned as undeliverable (n = 388; 4%); intention-to-treat analysis
Selective reporting (reporting bias)	Low risk	Reported results for all study questions
Other bias	Unclear risk	Methods are not fully described
Baseline measurement	Low risk	HPV4 vaccination history, including 1 or 2 doses, and age, race and ethnicity, Medicaid insurance, and length of managed care membership were reported and similar across study groups

Daley 2002

Methods	Study design: randomized trial Study duration: October to December 2010 Study aim: evaluate efficacy of registry-based letter and telephone recall intervention on rates of pneumococcal conjugate vaccine (PCV7)
Participants	Inclusion: all children included in immunization registry Age: 6 weeks to 22 months Exclusion: siblings of included participants; registry documentation of having received PCV7; duplicate registry record; moved; died Setting: primary care clinic of The Children's Hospital, Denver, Colorado; teaching clinic predominantly serving Medicaid beneficiaries and uninsured patients (USA) n = 1234; 610 intervention and 624 control participants

Daley 2002 *(Continued)*

Interventions	Intervention: letter and telephone call from vaccination registry; English-Spanish letter; indicated new vaccine protected against some types of specified infections; recommended in children less than 2 years of age; letter signed by 11 attending physicians; instructed all clinic trainees about dosing schedule and indications for PCV7; research nurse made up to 6 telephone calls per participant, beginning 10 days after letter was sent; during daytime, weekend, and evening hours; asked parents questions about recall letter and gave information about PCV7; encouraged parents to make vaccination appointments for children; n = 610 Control: no intervention; clinic did not routinely contact patients by telephone or letter to remind them of appointment reminders or interventions; n = 624
Outcomes	Receipt of one or more doses of pneumococcal (PCV7) vaccine during 2-month study period Intervention: 2.8 percentage points above control group; 23% versus 20.2% Intervention group, received reminder letter and call: 9.4 percentage points above control group; 29.6% versus 20.2% Used intention-to-treat analysis
Notes	All attending physicians of the clinic agreed to immunize all children less than 24 months of age with PCV7, a new vaccine at time of study Abundant supply of PCV7 vaccine during study period Immunization registry in operation since May 1998 Power calculations: with estimated sample size of 1410, study would have 80% power to detect 5 percentage point difference in immunization rates between intervention and control groups with 5% significance level Difficult to contact intervention group

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"All children aged 6 weeks to 22 months were selected from an immunization registry database." Used Microsoft Excel 96 "to randomly assign subjects to study arms."
Allocation concealment (selection bias)	Low risk	Randomized children using Microsoft Excel 97; one child was randomly selected if eligible siblings
Blinding of participants and personnel (performance bias) All outcomes	Low risk	"Attending physicians, trainees, nurses, and control subjects were blinded to subject group assignment." Blinded intervention participants to study objectives
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Blinded care providers to study group assignments Outcomes were obtained from documentation in the immunization registry, maintained by the clinic; data are entered in the registry daily
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Entered vaccinations in registry each day Registry error rate of 8% when reviewing small sample

Daley 2002 *(Continued)*

		"There may have been underascertainment of immunization status because of underrecording in the registry or because patients obtained vaccinations at a site that was not captured by the registry."
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias Checked 40 charts to assess reliability of immunization registry data; 8% error rate with missing vaccination in registry; < 1% duplicate records
Baseline measurement	Low risk	Assessed PCV7 vaccination status at baseline Study groups similar for age, sex, insurance status, and immunization rates for the primary vaccination series

Daley 2004a

Methods	Study design: randomized trial Study duration: 11 months; July 2002 through May 2003 Study aim: evaluate effectiveness of letter reminder and postcard recall intervention on influenza immunization rates among children with high risk conditions
Participants	Inclusion: pediatric patients with high-risk conditions, record in registry and billing database, and clinic visit to participating practices within 18 months When 2 or more siblings with high-risk conditions in same household, randomly selected 1 child to participate Providers: pediatricians and advanced practice registered nurses or physician assistants Age: 6 to 72 months Setting: 4 private pediatric practices in metropolitan Denver, Colorado (USA) n = 1851
Interventions	Intervention: staged reminder letter and postcard recall; letter strongly encouraged parents to have their children vaccinated for influenza; provided telephone number to schedule appointment; sent second reminder 4 weeks later to those not yet vaccinated, emphasizing that child may have a condition that increases risk for influenza infection; sent postcard to those not immunized 4 weeks after second letter, stating there was still time to vaccinate child; mailings used practice letterhead and were addressed to parents of participants; n = 920 Control: standard practice; may have included some personal reminders; n = 931
Outcomes	Number and percent receiving influenza vaccination Intervention group: 17 percentage point increase over control group
Notes	Authors mentioned that reminder-recall intervention may have increased clinician awareness about influenza immunization; this may have increased vaccinations in control group

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Allocated patients within each study practice; used SAS software
Allocation concealment (selection bias)	Low risk	Participating practices used a common billing system and registry

Daley 2004a *(Continued)*

		Participants were "assigned to intervention versus control groups by simple random allocation using SAS software"
Blinding of participants and personnel (performance bias) All outcomes	Low risk	"We did not inform providers about which of their patients had been identified or recalled."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Blinding not specified; however, providers were not informed about patient study group assignment, and outcome data were obtained using immunization registry and billing data
Incomplete outcome data (attrition bias) All outcomes	Low risk	Obtained immunization data for each study participant using immunization registry and billing data, during March 2003 Telephoned randomly selected group of those not immunized to ask about influenza vaccinations at other locations, during April to May 2003
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	Authors mentioned that reminder-recall intervention may have increased clinician awareness about influenza immunization; this may have increased vaccinations in control group During November and December 2002, before study began, comparison of medical record data and registry immunization data revealed 14% of vaccines not entered or incorrectly entered in immunization registry
Baseline measurement	Low risk	In year prior to study, entered data about all children less than 72 months of age in study practices into regional immunization registry Compared demographic characteristics of intervention and control group participants; found to be similar for age category, insurance status, and percent up-to-date with immunizations by 24 months of age

Daley 2004b

Methods	Study design: randomized trial Study duration: 2 months, June 2000 to July 2000 Study aim: evaluate effectiveness of patient postcard reminders and telephone recall interventions on increasing immunizations among young children
Participants	Inclusion: children with record in immunization registry and not up-to-date with immunizations Age: 5 to 17 months Setting: pediatric primary care clinic of inner-city teaching hospital, Denver, Colorado; 51% of patients served by clinic were enrolled in Medicaid or other public insurance, 20% had private health insurance, and 29% uninsured; clinic staffed by pediatric attending physicians who supervise care provided by medical students, residents, and physical assistant interns (USA) n = 420
Interventions	Intervention: sent postcard reminder to parents, indicating child needed immunizations and parents should call clinic to schedule nurse-only or physicians visit; re-mailed postcards returned with forwarding address; called parents to obtain forwarding address if card returned without it; conducted telephone recall 1 month after postcard mailing if patient not seen or scheduled to be seen; made up to 4 telephone call attempts; n = 205

Daley 2004b *(Continued)*

	Control: standard practice, including quality improvement initiative, chart prompts, and provider reminders; n = 215
Outcomes	Number and percent up-to-date with immunizations; point estimates Intervention group: 1 percentage point increase over control group
Notes	Follow-up study to previous randomized trial that evaluated immunization reminder and recall; focused on addressing barriers identified in earlier study; no overlap in study participants between 2 trials Quality improvement initiative did not improve accuracy of parent contact information Other socio-economic status barriers may have contributed to results Clinic had computerized database of immunization records, since May 1998, for all patients seen

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"subjects were randomized by simple random allocation"
Allocation concealment (selection bias)	Unclear risk	Participants randomized by "simple random allocation" to intervention and control groups Specific process not described
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Blinded staff and providers to study group assignment
Blinding of outcome assessment (detection bias) All outcomes	Low risk	"Clinic staff and providers were blinded to study group assignment, and group allocation was not identified in the registry." Front office staff access the immunization registry; however, it is not clear who enters immunizations
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Extent of follow-up not explicitly specified Obtained immunization status at baseline for all participants by immunization registry and medical record review Asked parents about immunizations received outside of clinic to update records; then obtained medical record releases, faxed to outside clinics, and tracked Unable to reach 90 of 205 families by mail and telephone when conducting assessment of missed immunization opportunities Majority of immunization providers in area were not participating in registry at time of study
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	Immunization registry data found to have 8% error rate and duplicate record rate of less than 1%

Daley 2004b *(Continued)*

		Brief study period of 2 months to get children up-to-date with immunizations may have been insufficient to achieve desired goals
Baseline measurement	Low risk	Obtained baseline data by immunization registry and medical record review for all participants Intervention and control groups were similar for age, sex, and prior clinic utilization

Dini 2000

Methods	Study design: randomized trial Study duration: enrollment occurred over a 15-month period until the sample size was reached; 22-month follow-up period; 1993 through 1996 Study aim: assess sustained effect of computer-generated telephone and letter reminders on immunization coverage during first 2 years of life
Participants	Inclusion: children who received first dose of diphtheria-tetanus-pertussis (DTP) or poliovirus (PV) vaccines; telephone numbers listed in computerized health department database Age: 60 through 90 days Setting: 4 public health clinics in Denver metropolitan area; tri-county health jurisdiction; Denver, Colorado (USA) n = 1227 enrolled; 861 reached 24-month follow-up point at study end; 735 received full intervention during 22-month follow-up period
Interventions	Intervention group 1: computerized telephone messages (autodialer) followed by letters; 1 autodialer reminder message prior to scheduled immunization date and up to 4 recall messages, 1 per week, over 4-week period after due date; if no response, 1 letter was sent a week after fifth autodialer contact; sent second letter 1 week later, if needed Intervention group 2: computerized telephone messages (autodialer) only; 1 autodialer reminder message prior to scheduled immunization date and up to 4 recall messages, 1 per week, over 4-week period after due date; made up to 9 attempts for each autodialer call, from 6 pm to 9 pm on weekdays, and noon to 8 pm on Saturdays Intervention group 3: letters only; up to 4 computer-generated letters; sent first letter 2 days after scheduled immunization was missed; follow-up letters were sent at 1-week intervals Conducted all interventions from main office according to schedule Letter and autodialer messages were simple, indicating children were due for immunizations, immunizations are important, they prevent children from getting diseases that can make them very sick, and parents should make appointments or keep existing ones Delivered messages in English and Spanish according to specified preferred language Control: no notification
Outcomes	Received all immunization in series at 24 months of age Group 1 - autodialer and letter: 9.3 percentage points over control group Group 2 - autodialer only: 8.4 percentage points over control group Group 3 - recall letter only: 7.3 percentage points over control group

Dini 2000 *(Continued)*

	Analysis based on families reached
Notes	Data not entered in RevMan data tables

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Identified participants through the computerized health department database; randomization procedure not described
Allocation concealment (selection bias)	Unclear risk	4 public health clinics in 3 counties had computerized databases that were linked to the main office; interventions were conducted from the main office; Randomized children within households; allocation method not explicitly described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified; clinic staff entered immunization due dates into computerized immunization records
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified; "Data were abstracted from the same computerized databases that were used to make decisions about scheduling of both immunization visits and the interventions associated with those visits."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	At the end of clinic visits, entered immunization due dates in computerized immunization database; abstracted immunization data from database Of 1227 randomized children, 861 were 24 months of age by study end; followed 735 of 1227; "Study completion rates, however, did not differ by group or by demographic characteristics." Investigators did not attempt to obtain vaccination data at other sites
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes, including intention-to-treat and receipt analyses
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Study groups were similar for number of children in household, sex, and Medicaid insurance status Differences between study groups observed for ethnicity and language preference

Dombkowski 2012

Methods	Study design: randomized trial Study duration: November 2008 to February 2009 Study aim: assess effectiveness of statewide immunization information system and letter reminders to increase influenza vaccination among children with chronic conditions
Participants	Inclusion: children with high-risk chronic conditions living in 3 county local health department jurisdictions; currently or previously enrolled in Medicaid Age: 24 to 60 months

Dombkowski 2012 *(Continued)*

	Exclusion: children had already received influenza vaccination during fall 2008; ineligible for reminder-recall notices through Michigan Care Improvement Registry because they opted out, moved, or died Setting: local health departments; 3 Michigan counties (USA) n = 3618 potentially eligible children were identified; after excluding ineligible children, 1372 were mailed reminder letters; 1358 were allocated to control group; total study sample = 2730; 2001 children with valid addresses were included in effectiveness analyses
Interventions	Intervention: letter reminder; generated notices using Michigan Care Improvement Registry, statewide immunization information system with data on at least 95% of children up to 6 years; generated English-language reminders during first week of November 2008; letters noted importance of annual influenza vaccination, especially for persons with chronic conditions, and encouraged parents to contact local health department or child's clinician; sent letters using first class mail with "return service requested" to help track undeliverable letters; n = 1372 Control: no reminder; n = 1358
Outcomes	Entered 1 or more seasonal influenza vaccination doses into Michigan Care Improvement Registry during follow-up period, from November 2008 to February 2009 Intervention: 6.5 percentage point increase over control group Only included participants with valid addressed in analyses
Notes	"The degree to which [children] received reminders from health plans or other providers during the study period is unknown."

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Sorted eligible children by random number within each of 3 local health department jurisdictions; allocated half to reminder and half to control group
Allocation concealment (selection bias)	Low risk	Identified children through Michigan Care Improvement Registry, a statewide immunization information system; sorted children by random number; immunization reminders were generated using the registry
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Randomized 3618 potentially eligible children; 2730 (75%) were included in study after excluding ineligible children; after randomization, 687 were excluded because they already received vaccination; 201 were excluded for other reasons, such as opted out of registry or were deceased; included 2001 children with valid addresses in effectiveness analyses, 55% of children randomized; 73% of included children; attrition is balanced between intervention and control groups for each reason
Selective reporting (reporting bias)	Unclear risk	Only children with valid addresses were included in the immunization reminder effectiveness analysis

Dombkowski 2012 *(Continued)*

Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Identified participants using Michigan Care Improvement Registry; registry data were used to compare study groups for demographic characteristics and vaccination history, including receipt of any influenza vaccination dose during previous season No differences were reported in demographic characteristics between intervention and control groups

Dombkowski 2014

Methods	Study design: randomized trial Study duration: June 2008 to June 2009 Study aim: evaluate effectiveness of reminder-recall strategies in increasing vaccination rates among children living in urban area
Participants	Inclusion: not up-to-date for at least 1 vaccination for 7- or 19-month recall study arms; turning 12 months of age during August 2008, regardless of vaccination status Age: 7 to 19 months Setting: local health departments in greater Detroit area, including city and surrounding area in Wayne County, Michigan (USA) n = 12,762 eligible; 10,175 analyzed; 2072 in 7-month recall; 3502 in 12-month reminder; and 4601 in 19-month recall
Interventions	Intervention group 1: letter intervention; recall of children not up-to-date at 7 months, indicating specific doses needed; n = 2072 Intervention group 2: letter reminder of all children aged 12 months, regardless of vaccination status; noted vaccinations due after first birthday; n = 3502 Intervention group 3: letter intervention; recall of children not up-to-date at age 19 months; n = 4601 All letters centralized using the Michigan Care Improvement Registry, a statewide immunization information system Control: no reminder letters; n = 3887, including 1014 for 7-month recall, 1761 for 12-month reminder, and 1112 for 19-month recall
Outcomes	Immunization activity: new dose administered within 60 days of any reminder-recall cycle Group 1, 7-month recall: 2 percentage points over control group; 35% versus 33% Group 2, 12-month reminder: 1 percentage point over control group; 50% versus 49% Group 3, 19-month recall: 3 percentage points over control group; 18% versus 15%
Notes	—

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Dombkowski 2014 *(Continued)*

Random sequence generation (selection bias)	Low risk	Allocated children using "automated group assignment process"
Allocation concealment (selection bias)	Low risk	Michigan Care Improvement Registry, a statewide immunization information system, was used to identify eligible children and send reminder and recall interventions; allocated children using "automated group assignment process"
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified; staff at the health departments mailed the reminder-recall letters
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified; registry was source of intervention delivery and outcome data
Incomplete outcome data (attrition bias) All outcomes	Low risk	State of Michigan law requires that all immunizations administered to persons younger than 20 years be entered in Michigan Care Improvement Registry Reported outcomes for 79.7% of randomized patients
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	"Unknown whether pediatric offices or other local providers independently sent reminder/recall notifications concurrently with this study"
Baseline measurement	Low risk	Used registry to identify eligible children Compared demographic characteristics between study groups, stratified by children's age at time of notifications Characteristics of children in 3 study groups similar for local health department jurisdiction and location of prior immunizations; observed differences in Medicaid enrollment between intervention and control group for 7-month recall groups only

Ferson 1995

Methods	Study design: randomized trial Study duration: approximately 3 to 5 months Study aim: evaluate and compare 2 interventions used by school nurses to increase immunizations among children entering school
Participants	Inclusion: children enrolled in schools that were located where child health screening was to be conducted during 1991 Age: 5 to 6 years, in kindergarten Setting: 28 primary schools in Eastern Sydney (Australia) n = 239 children
Interventions	Intervention: "active intervention"; telephone call, letter and brochure to parents; school nurses sent letter and brochure to parents of children with missed immunizations, informing parents that children needed immunizations; 1 to 2 months later, school nurse called parents to inquire about vaccination status and encourage parents to have children immunized if not completed; n = 120

Ferson 1995 *(Continued)*

	Control: "passive intervention"; school health nurses sent letters and health department brochure on immunization to parents of children with missed immunizations; letter encouraged parents to get children immunized; n = 119 Materials generally sent in English; also available in 15 other languages
Outcomes	Number and percent immunized for measles, mumps and DTP Intervention group: 34 percentage point increase over control group
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"For each school, the cards for children who appeared to have missed either the measles or before-school boosters were randomized into two groups, the passive and active intervention groups."
Allocation concealment (selection bias)	Unclear risk	Randomized children to 2 groups; allocation procedure not described; school nurses sent passive and active intervention materials to parents and conducted telephone follow-up; a research office from the Public Health Unit ascertained immunization status
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	School nurses delivered the interventions; insufficient information to classify as low risk or high risk
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified; research officers obtained outcomes verbally from parents
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	34% (41) were lost to follow-up in passive intervention group, and 24 were initially misclassified at baseline and had actually been immunized; 25.8% (3) were lost to follow-up in active intervention group, and 40 had been fully immunized at baseline but were misclassified Contacted parents by telephone to determine whether children had received immunizations Insufficient information to permit judgment of low risk or high risk
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	High risk	Not a true control group; control participants received all components of intervention except telephone call
Baseline measurement	High risk	Baseline immunization status was obtained by questionnaire for children in kindergarten; misclassification of immunization status was a problem for 24 in passive intervention group and 40 in intervention group

Frame 1994

Methods	Study design: randomized trial; stratified using 4 criteria, including clinical office, whether woman older than 50 years of age was in household, whether all family members were active in practice, and whether family had health insurance Study duration: 2-year study; 1-year follow-up per intervention Study aim: evaluate and compare manual health maintenance tracking system with computerized tracking system that generated patient reminders for all patients
Participants	Inclusion: families active in practice, defined as seen in clinic within past 2 years Exclusion: patients living in group homes and those living outside practice area; families that could not be reached by telephone or did not return mailed questionnaire to obtain demographic data for all adult family members; transferred care to another practice; or charts could not be located Age: 21 years of age or older Setting: rural, nonprofit, fee-for-service, family practice center that cares for patients in 5 offices; 4 of 5 offices participated; Dansville, New York (USA) n = 1008 families; 1665 adult family members
Interventions	Intervention: telephone reminders to patients, computer-generated health maintenance status report on chart and 2-hour provider instruction session; n = 829 Control: manual flowchart-based health maintenance tracking system; n = 836
Outcomes	Provider compliance with 11 health maintenance procedures within protocol, including per cent of participants immunized for tetanus diphtheria Considered providers compliant if: procedure was documented as done, not indicated, offered but patient refused, or it was provided somewhere else Intervention group: 20 percentage point increase over control group
Notes	Randomized families; data not entered in RevMan Study focused on 11 health maintenance procedures, with only one immunization measure: tetanus-diphtheria immunization Other non-immunization outcomes studied: tobacco use, blood pressure, weight, serum cholesterol, fecal occult blood test, physician breast exam, mammography, Papanicolaou test, teaching self-examination, and teaching women to report post-menopausal bleeding Control families received telephone reminders for health maintenance if requested by provider

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"Randomly assigned" families to intervention or control group within each of 32 strata based on 4 criteria; randomization procedure not described
Allocation concealment (selection bias)	Unclear risk	Randomized families to study groups; allocation procedure not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified; however, the statement "the system must allow providers to specify or cancel sending patient reminders as well as specify the month in which reminders will be sent" implies that providers were not blinded; information is not sufficient to assess whether low risk or high risk
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified for conducting chart audits

Frame 1994 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	High risk	Final chart audit was conducted at end of intervention Outcomes were defined as provider compliance with Td vaccination, as defined above; immunization rates were not reported
Selective reporting (reporting bias)	Low risk	Outcome data were presented for all 11 health maintenance procedures
Other bias	Unclear risk	Control families received telephone reminders for health maintenance if requested by provider Generated a list of guarantor numbers for each participating practice, randomly; investigators attempted to contact families by telephone or mailed questionnaire to obtain demographic data; families were not included if demographic data not obtained
Baseline measurement	Low risk	Manually audited intervention and control charts at baseline Baseline characteristics of intervention and control groups were compared; small differences were observed in health insurance coverage for office visits; other characteristics were similar at baseline

Haji 2016

Methods	Study design: randomized trial; randomized 9 practices in 3 districts Sequentially enrolled children in each practice until met sample sizes Study duration: not clear; measured vaccination of infants at 10 and 14 weeks; enrolled between February and October 2014 Study aim: evaluate the effect of text message and sticker reminders on vaccination of children
Participants	Inclusion: Kenyan districts with pentavalent 3 vaccine drop outs rates exceeding 10%; brought to selected health facilities in 3 districts for first dose of pentavalent vaccine; enrolled until sample sizes were reached Age: less than 12 months of age; media age 45 days; range of 31 to 99 days Exclusion: districts with high pentavalent vaccine coverage rates, geographically hard to reach, or security concerns; mothers did not have telephone number Setting: 9 practices providing vaccination in 3 districts; Kenya n: 1126 children assessed; 10 excluded; enrolled 1116
Interventions	Intervention group 1: short text messages reminding caretakers to return children for second and third doses of pentavalent vaccine 2 reminders from automated web-based system 2 days before and on the day of second and third scheduled pentavalent vaccination due dates; Kiswahili and English; routine health education and advice on vaccinations; n = 372 Intervention group 2: stickers reminding caretakers to return children for second and third doses of pentavalent vaccine; not eligible intervention; n = 372 Control group: "no extra reminder messages"; next appointment date in a well-child booklet; routine health education and advice on vaccinations; investigator contacted caretaker 2 weeks or more after immunization due date to determine reason for missed vaccinations; n = 372

Haji 2016 *(Continued)*

Outcomes	Received scheduled pentavalent vaccines at 10 and 14 weeks Intervention group 1, 10 weeks: 98% versus 91% received pentavalent vaccine dose 2; 7 percentage point difference Intervention group 1, 14 weeks: 96% versus 83%; 13 percentage point difference
Notes	Not sure vaccines were only counted vaccines if given on the exact due date

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Random sequence generation not specified
Allocation concealment (selection bias)	Unclear risk	Randomization process not specified
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding not specified; randomized practices
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Data collection process not clearly described; data possibly obtained by caretaker questionnaire or clinic records; data not obtained if immunizations obtained at other facilities
Selective reporting (reporting bias)	Low risk	Outcomes reported for study questions
Other bias	Unclear risk	Not able to determine if other sources of bias because methods not fully described
Baseline measurement	Low risk	Study groups were similar for demographic characteristics of caregivers and children

Hambidge 2009

Methods	Study design: randomized trial Study duration: 1 February 2004 through 31 May 2006; children monitored through 15 months of age Study aim: evaluate multi-step reminder-recall and case management intervention on childhood immunization rates
Participants	Inclusion: newborn infant in which family was planning to receive care at one of 3 participating clinics; infant birth weight greater than 1500 grams Age: infants from birth to 15 months of age

Hambidge 2009 *(Continued)*

	Setting: Denver Health Medical Center and 3 of its affiliated community health centers predominantly serving socioeconomically disadvantaged populations, many of which are Hispanic; Denver Health is a vertically integrated community health center system (USA) In 2005, 90% of patients less than 15 months of age and served by these 3 clinics were eligible for Medicaid n = 811 infants; 409 intervention; 402 control
Interventions	Intervention: stepped intervention of case management or patient navigators, telephone reminders, telephone and postcard recall, and home visitation; initially case managers or patient navigators contacted mothers using scripts, in hospital, by phone, or home visit, to identify barriers to care and risks for under-immunization; mothers were provided with refrigerator magnet with care manager contact information, an immunization schedule, and bag of educational materials; intervention progressed in steps, depending on response from families; n = 409 Step 1: language-appropriate reminder postcards sent 10 days before each well-child visit Step 2: mothers received telephone reminder 10 days before each well-child visit and postcard and telephone recall intervention for each missed well-child visit or immunization 10 and 21 days after overdue Step 3: infants missing well-child visits or behind on immunizations received intensive outreach and home visits 30 days after overdue; calls and home visits were made by Master's prepared patient navigators; conducted outreach conduct on evenings, weekdays, and weekends Control: not specified; n = 402
Outcomes	Outcome 1: primary, continuous number of days under-immunized in first 15 months of life; ineligible outcome Outcome 2: received all needed childhood immunizations at 15 months of age: 2 pneumococcal; 4 DPT; 3 poliovirus; 1 MMR; 3 H. flu; 3 hepatitis B; 1 varicella; Outcome 3: influenza immunization rates: before and after without comparison group; ineligible study arm Results: Intervention - Outcome 2: 11 percentage points above control group; 44% versus 33% Used intention-to-treat analyses
Notes	Intervention intensity similar among 3 study clinics

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Allocated infants to groups using random blocks of 2, 4, or 6 infants, using numbered non-translucent envelopes Randomization sequence generated and maintained by study personnel
Allocation concealment (selection bias)	Low risk	Used newborn nursery log to identify eligible infants; "Research assistants who were responsible for opening the envelopes and assigning the treatment arm were blinded to the randomization sequence"; "randomization sequence was generated by an analyst who was not otherwise involved in the study and it was maintained by the principle investigator, who was not involved in the actual random assignment of patients"

Hambidge 2009 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants or clinicians not specified
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Blinding not specified; however, outcome data obtained from the Denver Health electronic immunization registry, a "system-wide legal repository for pediatric immunizations"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Used Denver Health electronic immunization registry to obtain immunization outcome data; registry records pediatric immunizations throughout health system and captures an estimated > 97% of immunizations given in health system Only 1 of 409 intervention infants and 3 of 402 control infants excluded from analyses All children monitored through 15 months of age Patients not tracked after leaving Denver Health system
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Unclear risk	Used newborn nursery log to identify potentially eligible infants Obtained demographic and other data from medical chart review; downloaded billing and diagnosis data from Denver Health computer system Study participants were primarily covered by public insurance or uninsured, Hispanic, Spanish-speaking, and urban families Intervention group had higher proportions of women with maternal alcohol use and tobacco use than women in control group; trends toward more illicit drug use and fewer Hispanic mothers in intervention group

Hogg 1998

Methods	Study design: randomized trial Study duration: 1 year; 1990 to 1991 Study aim: evaluate effectiveness of customized family reminder letters on improving preventive services, including immunizations
Participants	Inclusion: patients registered with medical practice for at least 1 year and had made at least 1 visit to the clinic in previous 2 years Age: mean = 37.1 to 41.6 years Setting: community-based care; rural family medicine center, western Quebec, 40 kilometers north of Ottawa (Canada) n = 1998 patients; 719 families
Interventions	Letters sent between September 1990 and March 1991 Intervention group 1: computer-generated customized letters, reminding patients of needed preventive services using plain language in standardized format; mailed packet had cover letter and one page for each family member, describing preventive services that participants were eligible to receive; dates

Hogg 1998 *(Continued)*

	of previously obtained preventive services were listed on individualized letters; n = 613 patients within 204 families Intervention group 2: form letter to patients, which described all recommended preventive procedures for all ages and both sexes; dates of previously received services not included; n = 676 patients within 252 families Control: no letters, but physician reminder system existed for all patients; n = 682 patients within 263 families
Outcomes	Number and percent of overdue vaccines received: adult tetanus, influenza, MMR, Hib, DPT and TOPV; procedures, including immunizations, considered completed if documented as ordered by clinician; influenza vaccination stratified by age over 65 years and persons with chronic disease Outcome range for intervention groups compared with control group: 5.9 percentage point decrease to 2.6 percentage point increase for different immunization types and interventions
Notes	Medical center computerized since 1984

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Randomly selected patients to participate using computerized patient registration numbers; after individual patients were selected, families of patients were randomized to study arms
Allocation concealment (selection bias)	Unclear risk	After individual patients were selected, families of patients were randomized to study arms; specific method not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	"not blinded in that physicians could be aware that a patient was a member of a family in the study if the patient mentioned that the family had received a letter"
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Collected outcome data from patient charts and encounter forms; blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Data available for 1971 of 1988 patients Data collected at 2, 4 and 6 months after letters were mailed by reviewing patients' charts and encounter forms Compared patient charts with encounter forms to assess accuracy of physician documentation of preventive services; error rates were measured; in a 5% sample, 3.7% of electronic patient records were missing documentation of 6 preventive services Outcomes were defined based on whether or not service was ordered; unclear whether ordered procedures were completed
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	Physicians could refuse to have letters sent to individuals Procedure was considered done when it was ordered
Baseline measurement	High risk	Collected data at baseline; differences in baseline measures were observed between study groups for proportion of procedures up-to-date, number of family members, and mean family age

Hull 2002

Methods	Study design: randomized trial Study duration: 2 months; September 2000 to October 2000 Study aim: assess whether telephone calls made by receptionists at a clinic increase influenza immunization uptake
Participants	Inclusion: registered patients without chronic disease Unit of allocation: household Exclusion: patients with chronic disease, including asthma, diabetes, chronic obstructive pulmonary disease, ischemic heart disease, and renal disease Age: 65 to 74 years Setting: 3 general practices in east London and Essex areas that serve multi-ethnic, mobile, inner-city populations (UK) n = 1261 patients
Interventions	Intervention: telephone call to patient during a 2- week period between 25 September 2000 and 6 October 2000; receptionist made up to 2 telephone calls at different times of day to patients; receptionists were provided with information sheets and suggested invitation language; however, they were not trained on how to deliver the intervention; n = 660 individuals within 605 households Control: untargeted activity; city sent letter and brochure; 658 individuals within 601 households
Outcomes	Receive of influenza immunization Intervention group: 5.9 percentage point increase over control group Immunization uptake varied by practice
Notes	Reported differences as "percent" changes rather than percentage point changes; this may be a reporting error Allocated households; adjusted OR reported in paper showed minimal effect of this allocation approach Included data in RevMan data tables Only 60% of intervention households were reached by telephone A national television campaign occurred during September 2000 to promote influenza vaccination Participating practices had conducted influenza immunization recall in past Practices use EMIS computer system for clinical and administrative documentation Measured and reported some costs of intervention

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Used STATA to allocate list of households to study groups within in each practice
Allocation concealment (selection bias)	Low risk	Each practice identified registered patients, ages 65 to 74 years; study coordinator used STATA to allocate list of households to study groups within in each practice

Hull 2002 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Low risk	Nurses who worked in immunization clinics were "unaware of the household allocation to control or intervention group"; "immunization is almost exclusively done by appointment at clinics run by practice nurses" Receptions, who made the telephone reminder calls, were not blinded
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Practice nurses recorded immunizations in practice computer system; nurses were unaware of household allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Obtained immunization outcome data for all 1261 participants
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Process of obtaining baseline characteristics was not reported; baseline patient characteristics were similar between study groups, and patient characteristics were included in statistical modeling, including age, sex, household size, and practice

Humiston 2011

Methods	Study design: randomized trial Study duration: 2003 to 2004 Practices were recruited during summer 2002; intervention began on different dates starting between 29 September 2003 and 13 October 2003 Intervention ended 22 January 2004 Study aim: evaluate effect of practice-based interventions on influenza immunization among older adults
Participants	Inclusion: all active patients of participating primary care centers; residents of New York; "active" was defined differently for different practices, but included at least 1 visit to practice in past 2 to 5 years Age: 65 years and older Exclusion: patients who had received influenza vaccination before intervention began Setting: 6 of 7 large urban primary care practices that serve large proportion of Rochester, New York's African American and Hispanic older adults agreed to participate (USA) Practices included 2 internal medicine neighborhood health centers, 2 family medicine neighborhood health centers, 1 internal medicine hospital clinic, and 1 internal medicine - pediatric practice n = 3752 patients were randomized; 1748 intervention and 2004 controls
Interventions	Intervention: combination of patient tracking and reminder-recall, outreach, and provider reminders; n = 1748 Step-wise practice-based intervention; patient tracking; provider reminders using bright-colored sheet with reminder stating "REMEMBER, This patient needs influenza vaccine"; patient recall using letter or card; outreach to patients by telephone; transportation assistance was offered; 1 patient was vaccinated by a home visit

Humiston 2011 *(Continued)*

	Control: standard of care was based on each office routine; 1 practice reported sending some form of notification regarding the influenza vaccination to patients; n = 2004 All: community-based campaign; enhanced vaccine delivery through non-traditional venues
Outcomes	Number and percent receiving influenza vaccination during study period Intervention: 42 percentage points over control group
Notes	Sample size calculations were conducted; at least 170 patients per study group were needed to demonstrate at least "15%" difference in vaccination rates with control rates of 50%; enrollment exceeded these requirements 7 control participants (0.35%) were contacted by telephone or mail by mistake

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Randomized patients using last digit of social security number; odd numbers were allocated to intervention group; even numbers were allocated to control group
Allocation concealment (selection bias)	High risk	Downloaded patient names and demographic data from individual primary care centers' patient information systems into study site-specific database; randomized patients using last digit of social security number; odd numbers were allocated to intervention group; even numbers were allocated to control group
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	"Use of patient reminders/recall precluded blinding of either patients or outreach workers, and use of provider prompts precluded blinding PCC staff"; however, health services "providers tended to be unaware of group assignment for an individual patient except during health-care visits if the patient chart included a provider prompt"
Blinding of outcome assessment (detection bias) All outcomes	High risk	Outreach workers conducted intervention and reviewed medical records for influenza immunization status
Incomplete outcome data (attrition bias) All outcomes	Low risk	Assessed all participants for vaccination status; none lost to follow-up Reviewed charts 2 months after study end Performed quality assessment checks with "extremely high accuracy"
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Collected patient demographic data according to processes approved by each primary care center's institutional review board Intervention group had higher proportion covered by Medicare and higher proportion of males than control group Groups similar for race and ethnicity

Irigoyen 2006

Methods	Study design: randomized trial Study duration: 6.5 months; 11 September 2001 to 31 March 2002 After randomization, children remained in the study for 6 months Study aim: evaluate effectiveness of registry-generated patient reminder and recall postcards on childhood immunization rates
Participants	Inclusion: made at least 1 visit to inner city practice network and due or late for DTaP Age: 6 weeks to 15 months Setting: 5 community-based pediatric practices, New York city (USA) Payer mix: approximately 85% of visits covered by Medicaid n = 1662 of 13,886 eligible children
Interventions	Postcards were registry-generated with photograph of a baby; each postcard had a standard bilingual English or Spanish message indicating need for immunizations and encouraging parents to call the clinic to make an appointment Intervention group 1: continuous reminders; weekly postcards; n = 549 Intervention group 2: limited reminders; up to 3 postcards; n = 552 Control: no intervention; n = 561
Outcomes	Up-to-date with DTaP; analysis based on intention-to-treat Intervention group: 4.3 percentage point increase over control group
Notes	Network of practices did not previously have reminder systems in place Postcards were returned for 13.6% children 25.6% of children were misclassified as due or late for a DTaP dose and were sent reminders that were not needed One in 6 children not reached because of incorrect addresses One in 6 children not vaccinated because of missed opportunities

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Programmed EzVAC, a provider-based registry, to identify eligible children every week based on need for DTaP vaccine, randomly sample 12% of those eligible, and then randomly assign those to 1 of 3 study groups
Allocation concealment (selection bias)	Low risk	Randomly selected and randomly assigned children to study groups within EzVAC, a computerized system
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Immunizations are entered in EzVAC, a provider-based registry, at the point of service Blinding was not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Used EzVAC registry every week to identify if participants needed repeated reminder Outcomes were measured at 3 and 6 months after randomization

Irigoyen 2006 *(Continued)*

		Tracked immunizations in EzVAC; for children who were not up-to-date in EzVAC, NY Citywide Immunization Registry was checked for out-of-network received immunizations (16%)
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	29 children were recorded as not having received the vaccine because of a vaccine shortage; for these children, investigators simulated the vaccine as being given on date ordered Misclassification rate for DTaP dose was 30%
Baseline measurement	Unclear risk	Checked data in EzVAC registry to determine immunization needs at baseline; 25.6% were sent false reminders because they were misclassified as being due or late for a DTaP dose; misclassified children were distributed evenly across study groups

Kempe 2001

Methods	Study design: randomized trial Study duration: 6 to 7 months; January to July 1999 Study aim: evaluate effectiveness of immunization recall for young children served by an urban teaching clinic
Participants	Inclusion: seen for well-child care or acute illness in clinic Age: 5 to 17 months Setting: urban children's hospital-based teaching clinic that serves primarily low-income families; clinic has section for acute illness visits and a second section for training residents in a continuity clinic that does the majority of well-child care, Denver, Colorado (USA) Clinic population: 63% covered by Medicaid or a state-subsidized insurance program; 21% commercial insurance; 16% uninsured; highly transient with at least 50% of families changing addresses or telephone numbers each year n = 603 were randomized
Interventions	Intervention: postcard and attempts to call; provider prompts with child's immunization record attached to front of child's chart Postcard indicated that children needed immunizations and asked parents to call to schedule a visit; provided telephone number; postcards remailed if returned with updated address; up to 4 call attempts were made 2 weeks after postcards were mailed; n = 294 Control: provider prompts with child's immunization record attached to front of chart; n = 309
Outcomes	Received all needed immunizations at 7, 12, and 19 months of follow-up Intervention group: 4 percentage point decrease to 12 percentage point increase compared with control group, with the largest positive effect being observed at 12 months follow-up
Notes	Used computerized database for immunization records

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomization process not described

Kempe 2001 *(Continued)*

Allocation concealment (selection bias)	Unclear risk	Used computerized immunization database to identify eligible children; randomly assigned children who were not up-to-date with immunizations; allocation procedures were not explicitly described
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Blinded clinic providers to study group assignment
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Per clinic policy, nurses enter immunization data directly into the computerized database at the time of administration or shortly after; this process also occurs for historical records received by the clinic; providers were blinded to children's study group assignment
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Charts for 2 children in intervention group and 5 in control group were not available for outcome review Authors report incomplete immunization records Unable to contact 28.1% of intervention group participants Inadequate immunization records were reported for approximately 18% of participants
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	At baseline, determined immunization status for 742 children using clinic database and medical records; children who were up-to-date with immunizations were excluded

Kempe 2005

Methods	Study design: randomized trial Study duration: 6 months; 1 September 2003 to 29 February 2004 Study aim: achieve universal immunization of 6- to 21-month old children against influenza during the 2003 to 2004 influenza season; evaluate effect of reminder or recall letters on immunization receipt
Participants	Inclusion: children visiting practices during the previous 18 months and had a record in regional immunization registry Age: 6 to 21 months Exclusion: children with chronic medical condition, died, or there was documentation that family moved to non-participating practice Setting: 5 pediatric practices in metropolitan Denver, Colorado (USA) n = 5193
Interventions	Intervention group: up to 3 reminder or recall letters were generated by immunization registry; first reminder letter was sent in October 2003 to all intervention participants; second recall letter was sent during November 2003 to those not vaccinated; letters indicated that providers were recommending annual influenza vaccinations for all children 6 to 23 months of age and for children of parents receiving letters; letters also noted how to schedule an appointment; letters for some practices provided information about special walk-in or influenza vaccination clinics; n = 2595 2 of 5 practices sent third recall letter in December 2003

Kempe 2005 *(Continued)*

	Control: standard practice; n = 2598
Outcomes	Receipt of one or more influenza immunizations during the 2003 - 2004 season Intervention group: 4.4 percentage point increase over the control group
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"Used random allocation of subjects stratified according to practice site" to distribute participants equally to intervention and control groups for each practice; randomization method not described
Allocation concealment (selection bias)	Unclear risk	Randomly allocated participants, stratified by practice site, to include equal numbers of control and intervention participants at each site; method of randomization not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participating practices used the regional immunization registry and shared a common computerized billing system Both administrative and registry data were used to assess whether an influenza vaccination had been given Staff members are expected to enter immunizations given into registry within 24 hours after administration Quality assessment of 30 charts per practice, comparing registry data to medical record data, showed 97.4% completeness of children in practice that were in the registry Reported error rate of 7.2% in the immunization registry
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	High risk	3 of 5 practices were experiencing an influenza vaccination shortage in their offices, so did not send third letter to intervention participants Conducted telephone survey August to October 2003 to describe characteristics of study practice populations and assess parents' attitudes and intentions for influenza immunization; contamination may have attenuated observed effect A pandemic was occurring with extensive media coverage
Baseline measurement	Low risk	Infants were enrolled, so prior influenza vaccination histories were not generally applicable

Kempe 2005 *(Continued)*

	Intervention and control group participants were similar for age, sex, and insurance coverage

Kemper 1993

Methods	Study design: randomized trial Study duration: 1 influenza season; fall 1991 Study aim: assess whether computer-generated reminder letters improve influenza immunization receipt among children seen at urban teaching clinic
Participants	Inclusion: received primary care at 1 children's clinic; had 2 or more emergency or clinic visits in past year for asthma Age: children at least 6 months old Setting: primary clinic serving poor, urban children in Seattle, Washington (USA) n = 96 randomized
Interventions	Intervention: 1 computer-generated letter to parent and standing order for influenza immunization; n = 43 Letter included: child's name and address; reason for immunization; need for 2 shots for children younger than 9 years of age, at least 1 month apart; request to bring letter to clinic so immunization could be given without an appointment or without seeing physician; signed by clinic's medical director Control: standard practice, memo to providers on recommendations; n = 53
Outcomes	Number and percent of children immunized with influenza vaccine Intervention group: 26 percentage point increase over control group
Notes	During October 1991, memo sent to care providers, reminding them about influenza vaccination recommendations Nurses could give influenza immunizations without individual physician order Relatively small sample size; power calculations not reported During fall 1991, local media launched campaign to inform public about dangers of influenza and need for vaccination

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Used computer system to randomly assign patients to intervention and control groups
Allocation concealment (selection bias)	Low risk	Clinic-based computer system generated list of eligible patients, randomly assigned them to intervention or control groups, and generated personalized reminder letters for intervention group participants
Blinding of participants and personnel (performance bias) All outcomes	High risk	"Parents were asked to bring the letter to clinic so the immunization could be given without an appointment and without having to see a physician"; this implies lack of blinding of participants and personnel
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Research assistant, blinded to study group assignment, reviewed medical records for influenza immunization status

Kemper 1993 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	Research assistant reviewed medical records for each participant to obtain number of influenza vaccinations received for each child
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Generated list of eligible patients from clinic-based computer system Intervention and control groups similar for sex, age, and number of visits because of asthma in year prior to study Baseline data not reported for prior year influenza vaccination status or overall immunization status

Larson 1982

Methods	Study design: randomized trial Study duration: 1 influenza season; 1978 to 1979 influenza season Study aim: evaluate and compare effectiveness of postcard reminders with different messages on improving influenza vaccination rates
Participants	Inclusion: patients at high risk for serious complications from influenza infection based on age over 65 years or diagnosis of chronic heart disease, bronchopulmonary disease, renal disease, or diabetes mellitus Age: mean = 66.7 years Setting: University of Washington Family Medical Center (USA) n = 395 were identified and randomized to study groups Data were collected on 283 participants
Interventions	Intervention group 1: neutral postcard mentioned influenza vaccine now available; listed telephone number for nurse appointments; addressed to "Dear Patient"; n = 68 Intervention group 2: health belief model postcard, emphasizing severity of influenza, susceptibility of at risk persons to influenza, and benefits of vaccination; addressed to "Dear Patient"; n = 70 Intervention group 3: personal postcard; addressed to patient's name and signed by clinician; postcard mentioned that influenza season is approaching and recommended the patient come in for flu shot; it listed telephone number to call and make appointment with nurse; n = 61 Control: no intervention; n = 84
Outcomes	Percent vaccinated for influenza Group 1: 4.8 percentage point increase over control group Group 2: 31.2 percentage point increase over control group Group 3: 20.8 percentage point increase over control group
Notes	Study timeframes unclear

Risk of bias

Bias	Authors' judgement	Support for judgement

Larson 1982 *(Continued)*

Random sequence generation (selection bias)	Unclear risk	Randomization process not described
Allocation concealment (selection bias)	Unclear risk	Eligible participants were identified based on diagnostic codes stored in the family medical center's computer; randomly assigned patients to one of 4 groups; allocation process not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding of outcome assessment not specified; data collection "occurred either when study patients came to the FMC for vaccination or ….when they were called and interviewed by phone."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Data collection occurred when intervention patients came to clinic during study period In mid-December patients were called and interviewed by telephone; control participants were asked if they had received influenza vaccination Obtained vaccination status by self-report for large proportion of participants because nearly two-thirds of clinic patients are vaccinated at other varied sites Completed follow-up on 71.6% of persons initially selected and randomized, and on 92% of persons remaining in study
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	High risk	Baseline demographic data obtained when patients were assigned to study groups Health Belief Model and Personal postcard groups had more patients that had received influenza vaccinations in past year or anytime in past 5 years than control group or neutral postcard group Treatment groups similar for age, sex, prior history of influenza, adverse reaction to vaccine, diagnostic classification, and clinic utilization rates

LeBaron 1998

Methods	Study design: controlled before and after Study duration: 1 year; 1 September 1992 to 31 August 1993 Study aim: assess the effect of interventions delivered by community-based organization on immunization rates
Participants	Inclusion: children in Fulton County; patients of 4 public clinics or residents of one of 9 lower socioeconomic communities Age: 3 to 59 months Setting: community based organization in operation since 1984, serving disadvantaged populations in Fulton county, Georgia (USA) n = 4 public clinics and 9 inner city communities; 2093 housing units within the 9 study communities; 755 parents of children were surveys in the housing units

LeBaron 1998 *(Continued)*

	2 clinics served predominantly African American populations, and 2 served predominantly Hispanic populations Allocated clinics to 1 intervention and 1 control clinic for each ethnic-race category Communities consisted of 6 public housing communities with primarily African American populations, and 3 private housing communities Allocated public housing communities to 3 intervention and 3 control groups Allocated private housing communities to 2 intervention and 1 control group
Interventions	Intervention group 1: "clinic" group; telephone, mail or home visit with family Usually contacts with families were made by telephone or mail, but home visits were made when necessary; n = 2 clinics Intervention group 2: "community"; door-to-door campaign to identify under-vaccinated children, provide immunization education, provide culturally sensitive promotional materials, and introduce them to services; these interventions were followed by a weekly mobile vaccination van or temporary on-site vaccination stations, free child care, and incentives of food and baby products; ineligible intervention Interventions were applied for 1 year; n = 3 public housing communities and 2 private housing communities Control: no intervention; n = 2 clinics, 3 public housing communities, and 1 private housing community
Outcomes	Age-appropriate vaccination rates and series completion rates Intervention groups: immunizations increased by 15 percentage points Controls: no change in immunization rates
Notes	Data not entered in RevMan data tables Selection of intervention sites was based on the community-based organization's ties and perceptions of intervention feasibility Organization participated in selection of control sites

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Allocation process was not random
Allocation concealment (selection bias)	High risk	Allocation occurred by community and practice; intervention clinics not located in control community; control clinics not located in intervention communities; allocation process was not randomized
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants and personnel not blinded
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Georgia Department of Public Health district immunization officer visited each county clinic and reviewed health records of all children seen in clinic and who were 21 to 23 months of age at time of officer's visit

LeBaron 1998 *(Continued)*

		In 2 intervention clinics, vaccination records were reviewed monthly
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	Selection of intervention sites was based on the community-based organization's ties and perceptions of intervention feasibility Organization participated in selection of control sites
Baseline measurement	Low risk	Reported baseline measures; in 1992, age-appropriate immunization rate for children 3 to 59 months was 44% overall, and for intervention and control arm participants General characteristics of populations served by clinics and communities were similar between intervention and control groups

LeBaron 2004

Methods	Study design: randomized trial Study duration: 2 years; September 1996 to August 1998 Study aim: evaluate effect of large-scale, registry-based reminder and recall intervention on childhood immunization rates in inner city population with history of low vaccination rates
Participants	Inclusion: children residing in Fulton County; had received care through Fulton County health department clinics or public hospital health system; and born between 1 July 1995 and 6 August 1996 Children were identified in MATCH immunization registry Providers: city-wide hospital, clinic, health department Age: 1 to 14 months Setting: Atlanta, Georgia (USA) n = 3050
Interventions	Intervention group 1: autodialer and postcard; autodialer reminder 7 days before dose was due from health department; repeated every 30 to 60 minutes if no answer or a busy signal; if contacts not successful, postcard was sent at least 5 days before vaccination due date; autodialer recall 6 days after due date if needed dose not in registry; autodialer was repeated on days 11, 17, and 23, if needed, followed by postcard on day 28; Spanish-language option was available; n = 763 Intervention group 2: outreach; within 7 days after an immunization due date, an outreach worker attempted to reach the family by telephone; sent a postcard if no working telephone; a postcard was sent 7 days later, followed by a home visit 30 days later if a dose was missing; efforts continued monthly until contact was made with the family; n = 760 Intervention group 3: autodialer and outreach; see descriptions for each intervention above; n = 764 Control: standard practice; in some cases this included non-automated recall postcards; n = 763
Outcomes	Age-appropriate vaccination rates Group 1, autodialer and postcard: 6 percentage point increase over control group Group 2, outreach: 3 percentage point increase over control group Group 3, autodialer and outreach: 4 percentage point increase over control group
Notes	Power calculations: a sample size of 3050 was reported to provide 80% power to detect 5% differences in immunization rates between study groups Study sample had relatively high vaccination coverage at the start, with most children only needing 1 or 2 visits to complete vaccination series

LeBaron 2004 *(Continued)*

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Allocated participants using computer-generated random numbers
Allocation concealment (selection bias)	Low risk	Allocated participants using computer-generated random numbers
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	"We did not attempt blinding"; reminders and recall interventions encouraged participants to obtain immunizations from health provider; personnel conducting outreach were not health care providers
Blinding of outcome assessment (detection bias) All outcomes	High risk	Blinding not attempted; "all intervention contact attempts and outcomes were recorded in a study database"
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Entered vaccination data each day, in any Fulton County clinic, into electronic vaccination record; downloaded data weekly to MATCH immunization registry, which has vaccination records from the largest vaccination providers in Atlanta metropolitan area; Authors mention the possibility of registry inaccuracies Did not include non-registry immunization records
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	Non-automated recall postcards were sent to some participants in the control group
Baseline measurement	Low risk	At baseline, the intervention and control groups were "essentially identical" for demographic and vaccination characteristics

Lemstra 2011

Methods	Study design: controlled before and after, with historical comparison and contemporaneous geographic comparison Study duration: 1-year follow-up for telephone reminders Study aim: determine causes of the low MMR immunization coverage rates in young children and evaluate effectiveness of telephone reminders and telephone reminders combined with home visits on improving childhood MMR immunization rates
Participants	Inclusion: parents of children behind with MMR immunizations, defined as not receiving 2 MMRs by 2 years of age as of October 2007 to September 2008; born between October 2005 and September 2006 Age: children greater than 2 years of age Setting: Saskatoon Health Region, Saskatchewan; comparison in Regina Qu'Appelle Health Region, Saskatchewan (Canada) n = 911 were behind on at least 1 immunization
Interventions	Intervention group 1: telephone reminder; n = 115 in one subgroup analysis

Lemstra 2011 *(Continued)*

	Intervention group 2: telephone reminder and offer to have a public health nurse give vaccinations during a home visit; n = 142 in one subgroup analysis Control for group 1: no telephone reminder; "without enhanced intervention" Control for group 2: telephone reminder
Outcomes	Number and percent received MMR immunization by 24 months of age Group 1: pre-intervention to post-intervention increase by 6.6 percentage points in intervention group and 2.7 percentage points in comparison region
Notes	Data not entered in RevMan data tables In Saskatchewan, children are recommended to receive 2 MMR vaccinations by 18 months of age; incomplete coverage is defined as fewer than 2 MMR immunizations by 24 months of age Intervention 1 compared with control group Intervention 2 compared with intervention 1 Historical comparison: used 5-year average

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Regions were not randomized for eligible intervention; "block randomization through using computer allocation was used to divide the six neighborhoods into two blocks" for ineligible intervention
Allocation concealment (selection bias)	High risk	Intervention group was compared with a control health region
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified; this study was conducted in a health region; it is not clear whether clinicians were involved with or aware of the study
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Survey: of 911 children who were behind on at least 1 immunization; 787 (86%) of parents or guardians could not be contacted by telephone; however, 629 of 787 agreed to participate in the survey (69%) Extent of outcome data not clear for telephone reminder
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Saskatchewan Immunization Management System combines vital statistics and health insurance information to identify children that have not received recommended vaccinations for their respective age

Lieu 1997

Methods	Study design: randomized trial Study duration: 4 months per subject Study aim: evaluate effectiveness of computer-generated recall letters and immunization tracking system on childhood immunization rates
Participants	Inclusion: enrolled children at 2 medical centers, Santa Clara and Santa Theresa medical centers Age: reached 20 months of age between January 1994 and November 1994 Exclusion: patients with gap in health plan membership between 12 and 19 months of age Setting: Kaiser Permanente, a group model health maintenance organization (HMO), northern California (USA) n = 321 patients randomized
Interventions	Intervention: personalized letter and brochure; in English and Spanish; letter indicated that Kaiser's record showed that the child was overdue for an immunization, and parent should call clinic to make appointment for preventive visit; printed on stationery of local medical center; generated and mailed by regional Division of Research to parents; brochure listed recommended immunizations; n = 172 randomized and 153 analyzed Control: no letter; n = 149 randomized and 136 analyzed
Outcomes	Number and percent of MMR vaccinations recorded in the Kaiser immunization tracking system, or parental report of MMR received outside the system, between 20 and 24 months of age Intervention group: 19 percentage point increase over control group
Notes	No copayments within HMO for immunizations, although there were copayments for office visits for some HMO participants, up to USD 15 High literacy level in study population, based on a previous study in this population

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomized patients using a random number generator
Allocation concealment (selection bias)	Low risk	Eligible children were identified each month through a regional computerized immunization tracking system; randomized patients using a random number generator; recall letters were computer-generated
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified; intervention letters were mailed by the regional Division of Research using letterhead from the individual clinics; the mailing included a "slip" that a parent could take to the injection clinic to obtain immunizations without an appointment
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified; immunization data were obtained from the Kaiser immunization tracking system
Incomplete outcome data (attrition bias) All outcomes	Low risk	Primary analysis included immunizations recorded in Kaiser immunization tracking system Secondary analysis included immunizations recorded in tracking system and immunizations reported by parents in follow-up survey; 22 families of 160 families whose children had not received MMR vaccine by 24 months of age were not interviewed

Lieu 1997 *(Continued)*

		Kaiser immunization tracking system allows data entry of immunizations received outside of Kaiser Permanente; it is possible that these immunizations are not entered Study results similar between primary analysis with Kaiser immunization tracking system data only and secondary analysis, where parental report data were also included with Kaiser tracking system data
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Children were identified as not having received MMR by 20 months of age in regional computerized immunization tracking system 5 of 321 children were excluded after randomization because they had already received MMR vaccine based on parent report and chart review

Lieu 1998

Methods	Study design: randomized trial; controlled before and after Intervention participants were randomized to 4 groups; controls were not randomized Study duration: September 1996 to January 1997 Study aim: assess effectiveness of sending letters to families, delivering automated telephone messages to families, or both, in improving immunization adherence among under-immunized 20-month old children in health maintenance organization (HMO) setting
Participants	Inclusion and age: underimmunized 20-month olds identified by HMO; lived in residence areas of 10 northern California medical centers of Kaiser Permanents Medical Care Program of Northern California Setting: non-profit group model HMO, Northern California (USA) n = 867 included in analysis, including 648 randomized to intervention groups and 219 non-randomized controls; initially 752 were selected and randomized to 4 intervention groups; 67 were excluded because of gap in health insurance coverage
Interventions	Intervention group 1: automated telephone message followed by a letter 1 week later; n = 167 Intervention group 2: automated telephone message; 1-minute prerecorded message stating that child was overdue for immunizations; it provided telephone numbers for advice or appointment lines at nearest Kaiser clinics; message was personalized with child's first name; system prompted listener to select language for message, either English, Spanish, or Cantonese; n = 165 Intervention group 3: letter; n = 162 Intervention group 4: letter followed by an automated telephone message 1 week later; n = 154 Control: no systematic intervention; n = 219
Outcomes	Primary outcome: receipt of any needed immunization by the 24-month birthday Odds ratios for combined interventions = 2.1 and 2.5 Group 1: 17.7 percentage point increase over control group Group 2: 8.2 percentage point increase over control group Group 3: 8.6 percentage point increase over control group Group 4: 22.2 percentage point increase over control group

Lieu 1998 *(Continued)*

Notes	Power: sample size was expected to have 80% power to detect a "16%" difference in immunization outcomes Reported intervention costs

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Randomized patients to 4 intervention groups; selected comparison group of "similar patients"
Allocation concealment (selection bias)	Unclear risk	Eligible participants were identified by a computerized immunization tracking system; Randomized patients to 4 intervention groups but not a comparison group because their previous study found letters to be an effective intervention; investigators added "a comparison group of similar patients who turned 20 months old during January 1996"; selection of comparisons not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Interventions were sent from the health maintenance organization's regional office; blinding of participants and personnel not described
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Computerized immunization tracking system may not have complete vaccine information for children enrolled in the health maintenance organization after 42 days of age Tracking system does not consistently include data about immunizations that are given after child leaves health plan 67 of 752 patients were excluded because their follow-up data may have been incomplete
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Unclear risk	Children were identified using regional immunization tracking system Selected only underimmunized children Characteristics of participants were not described and contrasted between study groups

Linkins 1994

Methods	Study design: randomized trial Study duration: 4-month enrollment period; 30-day follow-up period per study participant Study aim: assess effectiveness of computer-generated telephone reminder and recall messages in increasing immunization visits

Linkins 1994 *(Continued)*

Participants	Inclusion: preschool children; if computerized immunization record included telephone number; and if children were due or overdue for immunizations at any time during enrollment Age: less than 2 years Exclusion: more than 1 child in household younger than 2 years, to avoid randomizing multiple children from same household Setting: 14 counties and county health departments in urban and rural Georgia (USA) n = 8002 patients Grouped children into 6 immunization categories, A through F, based on immunizations due (Groups A, C and E) or overdue (Groups B, D and F)
Interventions	Intervention: autodialer; computer-generated phone reminders; general versus specific reminders; n = 4636 Placed automated calls twice a day for 7 days until made contact Delivered second call during week following first successful contact if an immunization visit was not made Control: no intervention; n = 3366
Outcomes	Rates of immunization visits for childhood vaccines Intervention: 7.9 percentage point increase over control group; 36.3% versus 28.4% Immunization rates were higher for children due for immunization than those overdue
Notes	Telephone numbers listed in computerized immunization database for 94% of children in largest county Contacted 70.3% of intervention households using computer-generated telephone reminder system It is possible that automated phone messages were received by household members other than parents, such as siblings Measured immunization visits rather than immunizations administered Percentage of intervention households successfully contacted varied by county of residence and ethnicity, with Hispanic and "other" ethnic children having highest percentages of unsuccessful contacts

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Sorted computerized files of eligible children into 6 immunization categories Within each of 4 categories, telephone numbers were sorted and assigned identification numbers sequentially; allocated children with odd identification numbers to intervention group; assigned all other children to non-intervention group Within 2 remaining categories, telephone numbers were sequentially assigned values of 1, 2, or 3; children in group 1 were allocated to receive a general message, group 2 were to receive a specific message, and group 3 were assigned to the non-intervention group
Allocation concealment (selection bias)	Low risk	Used computerized files of eligible children from 14 county health departments to randomize children to study groups
Blinding of participants and personnel (performance bias)	Unclear risk	Blinding of participants and personnel not specified; immunization visits were recorded in each health department's immunization database; following each

Linkins 1994 *(Continued)*

All outcomes		autodialer call session, "this information was uploaded and merged with the study file"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Outcome assessment blinding not specified; outcomes assessed using computerized immunization records
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Immediately recorded immunization visits in each health department's immunization database when children arrived to receive immunizations Followed study participants for 30 days, beginning on start date of follow-up or date an immunization was due; for children late for immunizations, start date was first date of successful contact
Selective reporting (reporting bias)	Low risk	Reported immunization status for all 6 immunization categories, as described in the methods
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Created county-specific computerized study files of all eligible children Allocated children after immunization status was determined Measured and compared characteristics of children; groups similar for county and type of residence, ethnicity, sex, and age

Lukasik 1987

Methods	Study design: randomized trial Study duration: 3 months; mid-September 1985 to December 1985 Study aim: evaluate effectiveness of simple office interventions in increasing influenza vaccination rates
Participants	Inclusion and age: all active registered patients in practice, 65 years and older Exclusion: patients chronically hospitalized or in nursing homes; persons unable to communicate by telephone or house-bound Setting: single family practice center; teaching practice affiliated with University of Western Ontario; London, Ontario (Canada) n = 243
Interventions	Intervention: telephone call to patient and bright-colored reminder sticker on clinic chart to remind health services team to promote influenza vaccination; n = 120 Telephone calls were made by staff physician, registered nurse, and registered nursing assistant, in approximately equal numbers During calls, informed patients that influenza vaccine was available and they could schedule a regular or nurse visit Made maximum of 3 telephone call attempts to each household Telephone calls were not made if patients made clinic visit before the call was planned Control: notification at clinic visit and reminder sticker on clinic chart; n = 123
Outcomes	Number and percent receiving influenza vaccine; intention-to-treat analysis Intervention group: 24 percentage point increase over control group

Lukasik 1987 *(Continued)*

Notes	An 8" by 11" advertisement was displayed in the waiting room, saying "Be Keen about Flu Vaccine" Data not entered in RevMan data tables; allocated households No outreach interventions during prior years to promote influenza vaccination

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	"After a random start, patients were alternately assigned to each group"
Allocation concealment (selection bias)	High risk	Alternate assignment to groups within one family medicine center; allocated households; related persons in same household were assigned to same group
Blinding of participants and personnel (performance bias) All outcomes	High risk	"Brightly coloured sticker was applied to the charts of the entire study population as a reminder to the health-care team that the study was under way and that they were expected to promote the flu vaccine"; staff physician, registered nurse, and nursing assistant made telephone calls; callers were provided a call sheet with 5 names each week
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified; "following the immunization period, collaborators reviewed all charts"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Collaborators reviewed all charts following immunization period
Selective reporting (reporting bias)	Low risk	Reported influenza immunization outcomes, as described in the methods
Other bias	Low risk	Study appears to be free of other sources of bias
Baseline measurement	Low risk	Presented influenza immunization rates for participants for 2 years preceding the study; significant differences not observed during 1983 or 1984 Study groups did not vary for sex, mean age, marital status, household composition, number of clinic visits, adverse reactions to medication, and presence of chronic illnesses

Margolis 1992

Methods	Study design: controlled before and after with concurrent control groups Study duration: approximately 7 months; August 1989 to March 1990 Study aim: assess effect of multifaceted influenza vaccination program, in a community setting, that was previously effective in an academic medical center
Participants	Inclusion: patients enrolled in 1 of 4 clinics Age: 65 years and older Setting: 4 clinics in staff model, closed-panel, non-profit health maintenance organization (HMO), Minneapolis, Minnesota (USA) 2 intervention clinics, 1 suburban and 1 urban, each with an estimated 2800 and 1600 older adults, respectively

Margolis 1992 *(Continued)*

	2 control clinics selected based on similar locations and comparable numbers of older adults n = 600
Interventions	Intervention: letter to patients, standing order for nurses, and reminder sticker on appointment roster; n = 300 Standing order allowed nurses to vaccinate patients without signed physician order Reminder sticker placed on appointment rosters each day for eligible persons; Convenient walk-in vaccination times made available and publicized in informational mailing Held inservice education session for nurses Described program to physicians at 1-hour lunch meeting Control: no intervention; n = 300
Outcomes	Number and percent of patients receiving influenza vaccination Intervention clinic 1: 5 percentage point decrease in influenza vaccination rate compared to baseline Intervention clinic 2: 16 percentage point increase in influenza vaccination rate compared to baseline Control clinic 1: 3 percentage point increase in influenza vaccination compared to baseline Control clinic 2: 4 percentage point decrease in influenza vaccination compared to baseline Pre-intervention to post-intervention odds ratio: 1.32
Notes	HMO patients cared for in 19 primary care clinics No special influenza immunization programs in place at clinics prior to study Data not entered in RevMan data tables One intervention clinic, with baseline vaccination rate of 75%, may have experienced a ceiling effect

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Included 2 intervention and 2 control clinics of 19 primary care clinics serving older adults of a health maintenance organization; control clinics were selected based on location and similar numbers of older adults served
Allocation concealment (selection bias)	High risk	Allocated clinics to study groups
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Sent postcard survey to randomly selected participants from each of 4 clinics to assess immunization status Pre-intervention survey response rates were 73% to 89% Post-intervention survey response rates were 86% to 93%

Margolis 1992 *(Continued)*

		Did not report use of health records or administrative databases to verify immunization outcome data
Selective reporting (reporting bias)	Unclear risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	One intervention clinic, with baseline vaccination rate of 75%, may have experienced a ceiling effect
Baseline measurement	Unclear risk	Obtained baseline immunization rates; clinic-specific rates ranged from 51% to 75% Participants in 4 clinics were similar for age and risk-factors, based on patient survey responses

Marron 1998

Methods	Study design: randomized trial Study duration: 6-week intervention phase from 5 October 1994 to 18 November 1994; follow-up period from 22 November 1994 to 3 April 1995 Study aim: evaluate effectiveness of mailed informational letter in increasing hepatitis B vaccination among college students
Participants	Inclusion: freshman university students; not received hepatitis B vaccine; US citizens Age: less than 20 years Exclusion: international students, because of short study timeframe and time it would take for the letter to reach other countries Setting: University of Rochester, a private university n = 732
Interventions	Intervention: mailed informational letter was sent to college students and their parents; provided information about hepatitis B vaccine and recommended vaccination; enclosed reminder card with hepatitis B logo and appointment telephone number; n = 366 Control: no informational letter; n = 366
Outcomes	Number and percent receiving first and second hepatitis B vaccinations Intervention, first hepatitis B: 8.1 percentage points over control group; 11.7% versus 3.6% Intervention, second hepatitis B: 10.1 percentage points over control group; 12% versus 1.9%
Notes	Vaccine charge: USD 66 per series or USD 22 per dose Power and sample size calculations: 365 students per study group were needed, assuming an 18% immunization rate in control group and 28% in intervention group; alpha = 0.05; beta = 0.10

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	50% of freshman students and their parents received the intervention letter; "prospective randomized study"; details of randomization not provided

Marron 1998 *(Continued)*

Allocation concealment (selection bias)	Unclear risk	Allocation procedure not specified
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Used university health database; no other sources of vaccination data; documentation process not described
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	During September 1994, an intensive campus-wide educational campaign was conducted to inform students about hepatitis B virus infection and vaccine availability; campaign used articles and announcements in school newspaper, notices on bulletin boards, brochures, and peer-led education
Baseline measurement	Low risk	Used university records to identify students who had not received hepatitis B vaccination; Used health history forms to compare baseline characteristics; study groups did not differ with respect to receipt of care for chronic condition, or history of pelvic infection or viral hepatitis Intervention participants more likely to report exercising than controls; no other differences observed

Mason 2000

Methods	Study design: randomized trial Study duration: September 1998 to April 1999 Recruited participants monthly from September 1998 to January 1999 Obtained immunization status at end of study, during April 1999 Study aim: evaluate effect of letter and leaflet on uptake of MMR vaccine
Participants	Inclusion: not received MMR vaccine by 21 months; residents of 1 health authority Age: 21 months; born between November 1 1996 and April 31 1997 Setting: 1 health authority, Iechyd Morgannwg Health (United Kingdom) n = 511 children; 255 intervention group; 256 control group Identified children every month during study
Interventions	Intervention: personal reminder letter and "posting leaflet" regarding MMR vaccine; letter was copied to child's general practitioner and health visitor; n = 255 Control: usual practice; no action; n = 256

Mason 2000 *(Continued)*

Outcomes	Number and percent of participants receiving MMR vaccine between 21 and 24 months of age Intervention: 1.3 percentage points over control group; 7.1% versus 5.8%
Notes	Uptake of first MMR vaccine dose had fallen dramatically after adverse publicity about vaccine Power calculations estimated that 219 participants were needed in intervention and control groups to detect a "10%" difference in proportions immunized, using a 5% significance level, and assuming an intention-to-treat analysis

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomized parents of children using computer-generated random numbers
Allocation concealment (selection bias)	Low risk	Each month a list of children was obtained from the computerized child health record system; parents were randomized using computer-generated random numbers
Blinding of participants and personnel (performance bias) All outcomes	Low risk	"Parents and health professionals were not informed of the trial"; personal reminder letters were "copied to the child's general practitioner and health visitor."
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Immunization status was obtained from the child health record and system; blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Obtained immunization status of 493 children at study end from child health records and system (96.5%)
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Unclear risk	Enrolled children who had not received MMR vaccine Obtained list of eligible children monthly from computerized child health record system Did not report characteristics of participants and prior vaccination status, by study group

McCaul 2002

Methods	Study design: randomized trial Study duration: not specified Study aim: evaluate effectiveness of different types of messages on influenza vaccination
Participants	Inclusion: Medicare beneficiaries without influenza vaccine the previous year based on Medicare reimbursement requests

McCaul 2002 *(Continued)*

	Age: not clear Setting: 49 counties in North Dakota; estimated 89% of counties; generally rural (USA) n = 23,733; 15,837 intervention and 7896 controls 29 intervention counties and 20 control counties
Interventions	Intervention group 1: reminder letter from peer review organization (PRO); addressed to individuals; on PRO letterhead: allocated into 3 different message groups; message indicated that influenza shot should be received every year; Medicare will pay for vaccination; shot is safe; and shot should be obtained soon Intervention group 1a: reminder letter with gain-framed insert; letter stated patient was at risk for getting serious case of influenza; insert included picture of woman with positive testimonial; n = 3260 Intervention group 1b: reminder letter with loss-framed insert; letter stated patient was at risk for getting serious case of influenza; insert included picture of woman with negative testimonial, indicating she had not received flu shot and spent several days in bed, sick with the flu; n = 3262 Intervention group 1c: brief reminder from North Dakota peer review organization; n = 3258 Intervention group 2: action letter; county health officers sent one-page letters with explicit action instructions; n = 6057 Control; group 3: no letters; n = 20 counties; 7896 participants
Outcomes	Number and percent receiving influenza vaccination Group 1a, reminder letter only: 4.9 percentage point increase over control group Group 1b, reminder letter with gain-framed insert: 3.9 percentage point increase over control group Group 1c, reminder letter with loss-framed insert: 4.9 percentage point increase over control group Group 2, action letter: 8.6 percentage point increase over control group
Notes	All interventions were letter reminders, therefore they were grouped for analysis

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomized 29 counties to the intervention group and 20 counties to the control group; the randomization process was not described
Allocation concealment (selection bias)	Unclear risk	Randomized counties to 3 groups Randomized patients within reminder letter group to 3 subgroups
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	County health officers were asked to mail a single letter from their own offices
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Blinding not specified; however, used claims to determine immunization status
Incomplete outcome data (attrition bias) All outcomes	Low risk	Determined vaccination rates by analyzing Medicare claims for 6 months following intervention In 20 control counties, tracked randomly selected participants for behavior; did not include returned letters in numbers

McCaul 2002 *(Continued)*

		Participant loss was estimated at 6%
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Selected participants that had not received influenza vaccination during previous year, based on Medicare claims files

McDowell 1986

Methods	Study design: randomized trial Study duration: 2 months; 23 October 1984 to 31 December 1984 Study aim: compared 3 ways to remind patients about influenza vaccination
Participants	Inclusion: patients registered in 4 practices Age: at least 65 years, for influenza vaccination study arm Exclusion: patients in an institution Setting: University of Ottawa Family Medicine Center, Civic Hospital (Canada) n = 1420 patients in 6 practices included in influenza vaccination trial; 939 patients in 4 of 6 practices elected to participate and were allocated to study groups
Interventions	Intervention group 1: patient reminder in person by physician; not an eligible intervention Intervention group 2: patient reminder by telephone; called by their nurse within 10 days after the start of the study; made up to 5 attempts to contact each family Intervention group 3: patient reminder letter; single letter sent on October 23, encouraging patients to receive vaccination; printed and addressed by computer; signed by patient's physician and practice nurse; letter recommended influenza vaccination, mentioned availability, and encouraged patient to call clinic and schedule vaccination appointment Control group 1: no intervention control group Control group 2: non-participating controls; 2 practices that opted not to join the study
Outcomes	Number and percent receiving influenza vaccination Intervention group 1: 13.1 percentage point increase over control group Intervention group 2: 27.2 percentage point increase over control group Intervention group 3: 25.3 percentage point increase over control group Patients in 2 non-participating practices had lowest vaccination percentages
Notes	All patients attending medical center had been registered on computerized record system since 1976; updated system data to prepare for the study Data not included in RevMan data tables Only 2 of 239 letters were returned as undeliverable

Risk of bias

Bias	Authors' judgement	Support for judgement

McDowell 1986 *(Continued)*

Random sequence generation (selection bias)	Unclear risk	Randomization process not described
Allocation concealment (selection bias)	Unclear risk	Allocated families; grouped family members at same address Patient information included in computerized record system Allocation procedure not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Letters were printed and addressed by the computer; blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding not specified; vaccinations given at the family medicine center were recorded in the computer and used for analysis in the database
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Recorded vaccinations given at family medical center in computer database Difficult to assess follow-up of patients who did not come to clinic; investigators called random samples of patients from each study group to estimate underreporting of vaccination, 8 weeks after study ended; 97 were contacted
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	"Because the physicians in the randomized trial would be asked to remind some but not all of their patients, they might tend to remind every patient they saw and thereby inflate the rates of vaccination…"; authors analyzed vaccination data for 2 additional non-randomized controls to attempt to assess the extent of possible bias Of 97 patients contacted by phone, 15 indicated they received vaccine, including 8 at the center; 7 of 8 (87.5%) were confirmed as having received the vaccine by reviewing physician consultation notes
Baseline measurement	Low risk	Determined vaccination status prior to study Prior year immunization data not reported Compared groups for family size, age, and sex; differences in characteristics were not detected

Moniz 2013

Methods	Study design: randomized trial Study duration: September 2010 to February 2012; 2 consecutive influenza seasons Study aim: evaluate effectiveness of text message reminders on increasing influenza vaccination among ambulatory pregnant women, especially those unsure about or unwilling to receive the vaccine
Participants	Inclusion: obstetrics patients less than 28 weeks of gestation; have cell phone with text messaging capabilities Age: 14 to 50 years

Moniz 2013 *(Continued)*

	Exclusion: received influenza vaccination that season, prior to the study; wanted to receive vaccination the day of potential study enrollment; contraindications, such as egg allergy or prior adverse reaction; or previously participated in study Setting: women recruited at routine obstetrics visits at Magee-Women's Hospital outpatient clinic; academic medical center (USA) n = 216 enrolled women; 158 included in pre-protocol analysis
Interventions	Intervention: 12 weekly text messages encouraging general pregnancy health plus influenza vaccination; texts mentioned benefits and safety of influenza vaccination during pregnancy; n = 104 Control: 12 weekly text messages encouraging general pregnancy health General texts covered topics such as prenatal vitamins, nutritional foods, and seat belt use during pregnancy; n = 100
Outcomes	Number and percent receiving influenza vaccination Intervention: 2 percentage points over control group; 33% versus 31%; not statistically significant
Notes	Offered influenza vaccine to patients at prenatal visits; offered at no cost to clinic patients Power calculations: sample size of 70 women per study group was estimated to have 80% power to detect vaccination rate change from 55% at baseline to at least 70%

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"The randomization sequence was generated and group assignments were placed in sequentially numbered, sealed, opaque envelopes by a researcher"
Allocation concealment (selection bias)	Low risk	Randomized participants "to two study arms with equal frequency using a permuted block design with random block sizes of two, four and six"; using sequentially numbered, sealed, opaque envelopes; the researcher managing the randomization was "uninvolved in participant recruitment or clinical care"
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Health services "providers were blind to the groups to which participants were randomized"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	"Record review was conducted after exit surveys were completed by a researcher (M.H.M.) unaware of participants' random allocation"
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Data were available for 140 of 216 enrolled women (64.8%); 18 women in the control and 28 in the intervention were "nonevaluable" because they did not receive text messages, pregnancy was terminated early, or they were lost to follow-up One researcher reviewed medical records to verify vaccine receipt after exit surveys were completed Electronic health record automatically updated vaccination date when administered, through unspecified mechanism
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes

Moniz 2013 *(Continued)*

Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Women were potentially eligible if they had not received influenza vaccination during current season, based on self-report and documentation in electronic health record Participants completed anonymous surveys before and after intervention to determine sociodemographic characteristics, beliefs about prevention, and attitudes about text messaging Groups similar at baseline for age, race, education, marital status, household income category, and insurance status Pre-intervention surveys were self-administered at enrollment; post-intervention surveys were conducted by telephone approximately 12 weeks after enrollment by research staff

Moran 1992

Methods	Study design: randomized trial Study duration: possibly one influenza season Study aim: evaluate whether 1 or 2 sequentially mailed reminder letters would improve receipt of influenza immunization among high-risk patients
Participants	Inclusion: high risk patients seen between February and September 1990 Age: half less than 65 years, half at least 65 years Setting: urban community health center (USA) n = 409
Interventions	Intervention group 1: 1 reminder letter to patients; n = 135 Intervention group 2: 2 reminder letters to patients; n = 138 Reminder letters were written at fifth grade reading level; described need for influenza vaccination, mentioned vaccine does not cause influenza, possibility of minor side effects, and vaccine could be obtained free of charge without an appointment Control: no intervention; n = 136
Outcomes	Number and percent received influenza vaccination Group 1, 1 letter: 1.8 percentage point increase over control group Group 2, 2 letters: 8.5 percentage point decrease over control group
Notes	Immunizations obtained at scheduled appointments, annual health fair that promotes health for older adults, and on a walk-in basis at the clinic

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Randomization methods not described
Allocation concealment (selection bias)	Unclear risk	Eligible patients were identified by searching a computerized clinical tracking system using date of birth and diagnosis codes recorded by primary care providers; randomized patients to 1 of 3 groups; method not described

Moran 1992 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Low risk	Health center providers blinded to study group assignment
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Outcome assessment blinding not specified; however, only immunizations given at the health center were analyzed; and providers were blinded to study group assignment
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Immunization data only obtained from health center, not other sites
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Unclear risk	Baseline data not reported

Mullooly 1987

Methods	Study design: randomized trial Study duration: outcomes measured during 8-month period, from October 1984 through May 1985 Study aim: evaluate mailed cue that promotes influenza vaccination by emphasizing risk of influenza complications among older high-risk adults
Participants	Inclusion: high risk elderly members of health maintenance organization (HMO); discharged alive from hospital between October 1983 and September 1984 Discharge diagnoses: cardiovascular, pulmonary, renal, metabolic or nutritional, neurological, or malignant diseases Age: at least 65 years Setting: Kaiser Permanente HMO, Portland, Oregon and Vancouver, Washington metropolitan area (USA) n = 2217
Interventions	Intervention: personalized persuasive letter sent to patients; letter emphasized importance of influenza vaccination for older adults at high risk for influenza and complications, benefits of vaccination, and how and where to obtain the vaccine; n = 1105 Control: standard practice; members notified by newsletter about how to obtain vaccination; n = 1112
Outcomes	Percent of eligible persons receiving influenza vaccination Intervention: 8.8 percentage point increase over control group Pneumococcal vaccinations also measured; but not targeted by intervention
Notes	Immunizations covered by HMO health plan; can be obtained by members at affiliated immunization clinic without an appointment Power calculations not specified

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Mullooly 1987 *(Continued)*

Random sequence generation (selection bias)	Unclear risk	Randomized patients using "pseudo-random digit" of individual membership identification number
Allocation concealment (selection bias)	Unclear risk	Participants were identified by computerized inpatient records using age, discharge status, and discharge diagnoses; randomized patients using "pseudo-random digit" of individual membership identification number
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Obtained influenza vaccination data by retrospective review of medical records at end of study period; measured from October 1984 through May 1985 Did not specify proportion of outcomes obtained
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Unclear risk	Intervention and control groups similar for age and chronic condition distribution; intervention group has a somewhat higher proportion of males Baseline immunization rates for influenza or other vaccinations not specified

Nexoe 1997

Methods	Study design: randomized trial Study duration: 3 months; September 1995 to December 1995 Study aim: evaluate effect of postal reminder and vaccination fee on influenza vaccination rates
Participants	Patient inclusion: 45 patients, selected consecutively per practice; persons being treated for chronic conditions of pulmonary or cardiovascular systems, persons with acquired or congenital immunodeficiencies, other chronic diseases identified by physician as being high-risk, and residents of nursing homes Age: at least 65 years Practitioner inclusion: planned to select 15 practitioners; did not send mailed reminders in previous years; serving at least 45 elderly patients in specified risk group Setting: 13 general practitioners working in solo practices; 11 male and 2 females; practices ranged in size from 661 to 1754 patients on their lists, with a mean of 1300; counties of Funen and Vejle (Denmark) n = 585 patients, 234 males and 351 females
Interventions	Intervention group 1: postal invitation and free vaccine; invitation letter, personalized with patient's name and general practitioner's signature; n = 195 Intervention group 2: postal invitation and usual charge; n = 195 Letters personalized with patient's name and clinician's signature

Nexoe 1997 *(Continued)*

	Control: no intervention; n = 195
Outcomes	Number and percent receiving influenza vaccine Group 1: 47 percentage point increase over control group Group 2: 24 percentage point increase over control group Combined intervention more effective than postal letter alone
Notes	Only solo practitioners were invited to participate; characteristics of participating providers similar to other general practitioners in Denmark for age and number of patients; few female clinicians participated in study Among 51 general practitioners who did not want to participate, 1 used reminders in past, 1 considered randomization to be unethical, and 49 either considered study workload to be too heavy or did not provide a reason Financial incentives, such as providing vaccine free versus a charge, were not eligible interventions

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomization process not specified
Allocation concealment (selection bias)	Unclear risk	Selected 45 patients from each practice, consecutively with a random starting point; then randomized patients within each practice to 3 study groups; method of allocation not specified
Blinding of participants and personnel (performance bias) All outcomes	Low risk	"Randomization was blinded for the GPs"
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	General practitioners blinded to randomization; practitioners apparently knew which patients were randomized; the date of vaccination was "registered"; data collection process not described; outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	For all patients vaccinated, documentation included: indication for vaccination, date of birth, sex, vaccination date, and whether patient was vaccinated during previous year; Possible data misclassifications were checked with practitioners
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Unclear risk	Recorded vaccination status for previous year for all vaccinated patients; differences between groups not specified 83% of control group participants that received vaccinations during study period were vaccinated in prior year

O'Leary 2015

Methods	Study design: randomized trial Study duration: September 2012 to August 2013 Study aim: evaluate effectiveness of bi-directional text messages in increasing immunization rates among adolescents
Participants	Inclusion: adolescents needing recommended adolescent vaccination or well child check; seen at participating practice at least once in previous 2 years; parents had cell phone number Age: 11 to 17 years Exclusion: sibling participating in study Setting: 5 urban-suburban private pediatric and 2 safety-net practices in Colorado (USA) n = 4587; 2228 intervention and 2359 control
Interventions	Intervention: up to 3 (abstract) or 4 (page e1222) brief text messages with script, sent to parents, indicating that patient is due for either vaccination, checkup, or both; reply options: request to be called by clinic to schedule an appointment, plan to call the clinic, or stop texts; n = 2228 Control: usual care; no reminders; n = 2359 Practices did not use reminders during the study other than texts to intervention participants
Outcomes	Outcome 1: receipt of all needed vaccinations, including Tdap, MCV4 and HPV Outcome 2: receipt of any vaccination Intervention, outcome 1: 4.1 percentage points over control group; 15.0% versus 11.9% Intervention, outcome 2: 5.2 percentage points over control group; 15.0% versus 20.2% Intention-to-treat approach used for primary analysis
Notes	Intervention was developed with focus group input from adolescents, parents, and care providers, from 7 practices

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomized patients within each practice using random number generation with SAS 9.3
Allocation concealment (selection bias)	Low risk	Randomized patients within each practice using random number generation with SAS 9.3; providers were blinded to group allocation Selected practices purposefully to enroll a diverse cross section of patients
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Care providers blinded to group assignment Blinded intervention parents and adolescents to which sibling was enrolled in study when household had multiple potentially eligible adolescents; non-study siblings also received intervention, but were not included in analyses
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Outcome assessment blinding not specified; however, care providers were blinded, and investigators used administrative data from practices' electronic billing systems and the immunization information system

O'Leary 2015 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	Included practices participate in the Colorado Immunization Information System, which was used in most primary care practices, school-based health centers, public health departments, and some pharmacies All outcomes were assessed 6 months after last text message; no patients lost to follow-up 1877 of 2228 received the text messages in the intervention group
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias Data in Colorado Immunization Information System, for new interfaces, are reviewed for quality and validity
Baseline measurement	Low risk	Used practice administrative data to determine study eligibility; merged electronic billing systems data with Colorado Immunization Information System data Study groups similar for age, sex, immunization status, or other primary outcomes at baseline

Oeffinger 1992

Methods	Study design: randomized trial Study duration: 1 year Study aim: evaluate effect of brief educational session and letter reminder on receipt of childhood vaccinations
Participants	Inclusion: mothers and newborns delivered by Family Practice residents Age: enrolled as infants Exclusion: child with serious neonatal illness, such as extreme prematurity, that may require different immunization schedule; living outside county Setting: McLennan County Family Practice residency (USA) n = 238 infants and postpartum mothers
Interventions	Intervention: reminder letter to parents 2 months post delivery, 10- to 15-minute parent education session about immunizations on first day postpartum, delivered by nurse or physician, and one page handout summarizing key points from immunization discussion; n = 116 Control: no intervention; n = 122
Outcomes	Percent immunized for DTP and oral polio (OPV), first, second, and third doses 2- and 4-month vaccinations considered on time if occurred within 3 months and 5 months after delivery, respectively Intervention, at 3 months: 2 percentage point decrease compared with controls Intervention, at 5 months: 7 percentage point increase over controls Intervention, at 12 months: 4 percentage point increase over controls
Notes	Authors mentioned concerns about dual system for indigent care in the area and restricted hours of immunization clinic
Risk of bias	

Oeffinger 1992 *(Continued)*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	"postpartum mothers were assigned to either the intervention or the control group according to delivery date"; Intervention: Sunday, Tuesday, Thursday; Control: Saturday, Monday, Wednesday
Allocation concealment (selection bias)	High risk	Used date of birth of infant; infants and their mothers allocated to intervention or control group based on delivery date
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Followed children for 2- and 4-month DPT and OPV vaccinations; reviewed immunization records for completion of first 3 DPT and OPV immunizations at 1 year of age Contacted several physicians' offices to determine if vaccinations were obtained at private physicians' practices Immunizations are costly, so authors do not believe many immunizations are obtained from private practitioners; however, records of 1 clinician that administered vaccinations through the Medicaid Early and Periodic Screening, Diagnosis and Treatment (EPSDT) program were reviewed for study patients, and immunization data were included
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Study began at birth, so no prior immunization data Groups were similar for age, race, previous number of children, and prenatal care

Ornstein 1991

Methods	Study design: randomized trial Study duration: 1-year intervention program Study aim: compare effect of computer-generated reminders to patients, clinicians, or both on patient adherence to preventive services, including tetanus vaccination
Participants	Inclusion: active patients at family medicine center; at least 1 family member had clinic visit within previous 2 years Age: at least 18 years Setting: Family Medicine Center, Medical University of South Carolina (USA) n = 7397 patients
Interventions	Intervention group 1: 2 computer-generated personalized reminder letters to patients describing needed preventive services and requesting they make physician appointment to receive them; letters printed on letterhead stationery and signed by patient's primary physician

Ornstein 1991 *(Continued)*

	Sent first letter during August 1998; sent second letter in January or February 1989, unless first letter was returned without forwarding address; n = 1925 patients; 12 physicians Intervention group 2: computer-generated reminder letters to patients and computer-generated physician reminders; generated 1-page physician reminders the night before scheduled appointments; nursing staff attached them to medical record the morning of scheduled visit; form used by clinicians to check off actions taken for each preventive service; n = 1908 patients; 13 physicians Intervention group 3: computer-generated physician reminders only; this group is not an intervention in our review; n = 1988 patients; 14 physicians Control: educational sessions for residents, quarterly audits and flow sheet on chart; n = 1576 patients; 10 physicians All groups received educational and administrative interventions; resident physicians attended educational sessions about health promotion and targeted preventive services; performed quarterly audits to identify percentage of patients up-to-date with the 5 preventive services, per physician practice; health maintenance flow sheet was placed in medical record for all adult patients
Outcomes	Percent of persons receiving tetanus vaccine Group 1: 3.6 percentage point increase over control group Group 2: 13.4 percentage point increase over control group Other outcomes tracked: serum cholesterol measurement; fecal occult blood testing; mammography; Papanicolaou smears
Notes	Allocated providers; data not included in RevMan

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"Patients and their physicians were randomly assigned by practice group into one of 4 study groups"
Allocation concealment (selection bias)	Unclear risk	Conducted study at 1 family medicine center; used computerized database to identify patients; did not specify randomization process
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Research assistants collected physician reminder checklist forms each day; data on tetanus immunizations received outside the clinic could be entered in the computer by clinic nurses
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	Allowed physicians to withhold letters from individual patients Compared accuracy of computerized database with 500 patients' medical records; Kappa value for tetanus vaccines was 0.67

Ornstein 1991 *(Continued)*

Baseline measurement	High risk	Reviewed computerized medical records to assess whether patients were up to date with 5 preventive services, including tetanus vaccine At baseline, most patients had made at least 1 prior visit to the clinic Study groups differed for race distribution, insurance coverage, and visit frequency

Puech 1998

Methods	Study design: randomized trial Study duration: 4 months; 1 April 1996 to 31 July 1996 Study aim: assess effectiveness of postcard reminder on influenza vaccination
Participants	Inclusion: all nonresidential patients of the practice Age: at least 65 years Exclusion: received influenza vaccine by 1 April 1996, left the practice, allergic to egg protein, known by the practice to object to influenza vaccination, severe or terminal illness, dementia or unstable psychiatric conditions, or in nursing home; patients in nursing homes were not included in the registry from which patients were identified Setting: 3-partner urban general practice (Australia) n=325 patients, stratified by sex
Interventions	Intervention: single large postcard reminder with large print; sent on 1 April 1996 in a hand-addressed envelope, encouraging patients to visit the practice for influenza vaccination before month end; stressed seriousness of influenza and provided availability and cost information; had practice logo; Flesch readability score of 68, needing a minimum IQ of 90 to understand it; n = 154; 96 women and 58 men Control: standard care; n = 171; 104 women and 67 men Controls may have been exposed to mass media campaign
Outcomes	Number and percent receiving influenza vaccination Intervention group: 9.5 percentage point increase over control group Intervention more effective for men
Notes	Data not entered in RevMan

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Used computer-generated random number facility to allocate patients to study groups
Allocation concealment (selection bias)	Low risk	Identified participants from a computerized age, sex, and disease register at the practice Used computer-generated random number facility to allocate patients to study groups Allocated both members of married couples to same group

Puech 1998 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Low risk	General practitioners blind to randomization
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Record reviewer was blind to study group allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Medical records were reviewed for influenza vaccination 4 months after intervention postcard was sent Vaccination was considered not given if influenza vaccination prescription was given to patient but vaccination was not recorded in medical record
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Collected and analyzed baseline data; influenza vaccination rates similar between study groups during 1995

Rand 2015

Methods	Study design: randomized trial Study duration: July 2013 to March 2014 Study aim: evaluate effectiveness of centralized text message reminder on increasing receipt of first HPV vaccination dose among low-income adolescents
Participants	Inclusion: no prior HPV vaccinations; enrolled in Monroe Plan, a single health maintenance organization; patients having primary care provider at one of 39 primary care practices; phone number listed in the insurer's database; eligible as of 1 July 2013 Age: 11 to 16 years Exclusion: sibling of participating adolescent; transferred out of participating practice, or no longer insured by managed care organization during study period Setting: managed care organization; 39 primary care practices, 29 pediatric and 10 family medicine; each practice served more than 175 adolescents enrolled in the managed care organization (USA) n = 3812 publicly insured adolescents
Interventions	Intervention: sent up to 4 text message reminders to parents; generated by programmer at managed care organization, using third party vendor; initial text message allowed parents to opt out of text reminders; first reminder text indicated the adolescent was due for HPV vaccination, and were asked to call to schedule clinic appointment; n = 1893 Control: received initial message regarding health, with message that the parent could opt out; this was followed by different general adolescent health topic messages, such as eat breakfast, each time reminders were sent to intervention group parents; n = 1919
Outcomes	Primary outcome: received first HPV vaccine dose Secondary outcomes: received second and third HPV vaccine doses

Rand 2015 *(Continued)*

	Intervention group, first dose, persons with cell phone: 2.1 percentage points over control group; 14.4% versus 12.3% Intervention, second dose, persons with cell phone: 0.9 percentage point over control group; 6.1% versus 5.2% Intervention, third dose, persons with cell phone: 0.6 percentage point over control group; 2.0% versus 1.4%
Notes	We requested and obtained detailed numerator and denominator data from first author Almost half of parents did not have a working telephone number or a phone capable of receiving text messages, including 760 control and 730 intervention participants; 278 controls and 205 in intervention group opted out of text messages

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Stata was used to generate a randomization table
Allocation concealment (selection bias)	Low risk	Study was based centrally at a large not-for-profit managed care organization; randomized adolescents within each practice; used Stata to generate randomization table
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified; managed care organization programmer reviewed vaccination data to identify need for text messages using billing and registry data
Incomplete outcome data (attrition bias) All outcomes	Low risk	New York law requires documentation of immunizations in state immunization registry for persons less than 19 years Examined results for all participants
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Obtained baseline HPV vaccination status by reviewing billing data or New York state's immunization registry Managed care organization programmer reviewed immunization data Intervention and control participants were similar for age distribution, Medicaid and State Children's Health Insurance Program (SCHIP) coverage, practice specialty, and urban or suburban versus rural residence None had received HPV vaccination prior to enrollment

Rand 2017

Methods	Study design: randomized trial Study duration: patients recruited from April 2012 to December 2013; follow-up to April 2014 Study aim: assess effect of phone or text message reminders to parents of adolescents on receipt of human papillomavirus vaccinations
Participants	Inclusion: parents of adolescents who received HPV vaccine and filled out consent form at first or second dose Age: 11 to 17 years at enrollment Exclusion: completed HPV vaccine series or did not get first HPV vaccine dose; sibling of participant; incomplete forms; no longer interested; language barrier Setting: 3 urban primary care practices in Rochester, NY, USA n = 749 randomized
Interventions	Intervention group 1: autodialer; maximum of 3 successful reminders for each dose due; sent to parents 1 week apart using Televox communication system; up to 6 attempts; message indicates adolescent due for next HPV vaccination and to call to schedule appointment; n = 178 Intervention group 2: text messages; maximum of 3 successful reminders for each dose due; sent to parents 1 week apart using Televox communication system; shorter version than autodialer message; reminders continued through April 2014 if needed; n = 191 Control group 1, for autodialer: not described; n = 180 Control group 2, for text: not described; n = 200
Outcomes	Outcome 1 -- primary: time from enrollment to receipt of second and third doses of HPV vaccine; intent-to-treat analysis Outcome 2 -- secondary: HPV vaccination; doses 1, 2, and 3 Outcome 2, autodialer: 48% versus 40%; 8 percentage point difference Outcome 2, text message: 49% versus 31%; 18 percentage point difference
Notes	Sparse methodological details

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Participants consented to participate and selected preferred reminder method, and were randomized in a blocked format to reminder or usual care
Allocation concealment (selection bias)	Low risk	Analyst managing the randomization was blinded to individual group assignment
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Analyst was blinded; but blinding not described for clinical, participant or other study personnel
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding and data sources not described

Rand 2017 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Data collection procedures and follow-up were not described
Selective reporting (reporting bias)	Low risk	Reported outcomes for study questions
Other bias	Unclear risk	Insufficient information to assess other bias
Baseline measurement	Low risk	Phone and text groups similar for sex, practice, insurance, and ethnicity; adolescents in text arm slightly older than phone arm; whites more likely to choose text arm compared with blacks

Roca 2012

Methods	Study design: randomized trial Study duration: September 2009 to 30 April 2010 Study aim: assess efficacy of educational program and personalized letter on improving influenza vaccination rates among patients 60 years and older
Participants	Inclusion: patients of participating practices Age: at least 60 years on first day of 2009 influenza vaccination season Exclusion: patients with egg allergy or diagnosed with Guillain-Barre syndrome within 6 weeks of influenza vaccination in previous years Setting: practices of 13 family physicians; Centro de Slud Rafalafena, a health center in Castellon, Comunidad Valenciana (Spain) n = 2402 adults
Interventions	Intervention: Education Program Group (EPG); personalized letter was sent once to participants by surface mail during the first few days of September 2009, a few weeks before the official influenza vaccination campaign began; written in Spanish; included information about clinical manifestations of influenza and possible complications, vaccine efficacy, and recommendations from Centers for Disease Control and Prevention and local authorities of Comunidad Valenciana; addressed common vaccine concerns; written in plain language; n = 1201 Control: no program group; n = 1201
Outcomes	Number and percent of participants receiving influenza vaccination Intervention group: 5.4 percentage point increase over control group
Notes	No letters were returned as undeliverable No participants were excluded because of egg allergy or previous diagnosis of Guillain-Barre Syndrome Power calculations determined that 1187 participants were needed per study group to detect at least a "5%" difference in influenza vaccination rates, with significance level of 0.05 and power of 80%; sample size was achieved

Risk of bias

Bias	Authors' judgement	Support for judgement

Roca 2012 *(Continued)*

Random sequence generation (selection bias)	Low risk	Used computer random number generator to randomly assign participants
Allocation concealment (selection bias)	Low risk	Patients were included or excluded using Abucasis II, an Internet application used for clinical follow-up of all patients in the Agencia Valenciana de Salud Used computer random number generator to randomly assign participants
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Blinded health services workers
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Personal identification information was replaced with codes and use throughout all study phases Obtained vaccination data from Internet application, Abucasis II
Incomplete outcome data (attrition bias) All outcomes	Low risk	Collected data for all participants, including 2009 influenza vaccination coverage All data available for 2241 of 2402 patients (93%)
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Collected data for all participants: sex, age, nationality, race, labor status, primary care physician, district or town of residence, 2008 influenza vaccination status Groups were similar for sex, age, employment status, city of residence, and 2008 influenza vaccination rates

Rodewald 1999

Methods	Study design: randomized trial; 2 by 2 factorial design Study duration: interventions delivered over 18 months; March 1994 to August 1995 Study aim: measure effect of multi-modal tracking and outreach intervention on improving vaccination coverage among children
Participants	Inclusion: all children in 9 practices, born between 1 March 1993 and 28 February 1994 Age: 0 to 12 months Exclusion: children who changed to nonparticipating provider or moved from Monroe County, New York were excluded from analyses Setting: 9 primary care practices serving impoverished and middle class children; practices served more than half the city's preschool children, Rochester, New York (USA) Practices included: 2 pediatric urban group practices; 2 family medicine neighborhood health centers; 1 pediatric neighborhood health center; 1 hospital-based clinic; 3 rural health centers n = 3015 patients
Interventions	Intervention group 1: tracking with outreach; lay outreach workers, recruited from respective practice neighborhoods, were assigned to at least 1 practice; workers reviewed medical records to determine

Rodewald 1999 *(Continued)*

	immunization status, and worked with parents of underimmunized children by sending postcards and making telephone calls; they made home visits to non-responding parents; n = 630 Caseload: approximately 300 per outreach worker Intervention group 2: provider prompts; not an eligible intervention; n = 744 Intervention group 3: tracking, outreach, and provider prompts; received group 1 interventions, and distinct marker and "missed opportunity card" were placed on charts for children needing immunizations; n = 648 Control: no intervention; n = 719
Outcomes	Number and percent completing age-appropriate vaccination series, including DTP, OPV, MMR, and Hib Group 1: 21 percentage point increase over control group Group 3: 21 percentage point increase over control group
Notes	Used 1-month grace period to determine series completion outcomes Allocated patients; siblings not split between study groups; data not entered in RevMan Baseline immunization rates in area were relatively high, similar to national rates

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Allocated children to study groups using computer program
Allocation concealment (selection bias)	Low risk	Computer billing or encounter files were used to identify names and identifiers for participants Allocated children to study groups using computer program; outreach workers were provided with lists of intervention participants to conduct outreach and track
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified; outreach workers did not document their interventions in the medical charts
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Collected data by chart abstraction; chart reviewers were blind to study group assignment
Incomplete outcome data (attrition bias) All outcomes	Low risk	Independent research information group collected outcome data by conducting medical chart abstraction Study completion ranged from 88% to 94% within study groups Monroe County Health Department generally provided less than 1% of immunizations; health department provided written documentation to primary care providers or administered immunizations
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias Performed quality control checks with dual independent review of 10% of charts; only provider-validated immunization histories were accepted

Rodewald 1999 *(Continued)*

Baseline measurement	Low risk	Independent research group at the University of Rochester collected baseline data by medical chart abstraction; this group was not involved with conducting interventions Study groups were similar for age, sex, insurance type, and baseline immunization status; study groups differed for racial composition; race was not recorded in charts for almost half the participants

Rosser 1991

Methods	Study design: randomized trial Study duration: 4 months for influenza, October 1984 to January 1985; 1 year for tetanus, 1 April 1985 to 31 March 1986 Study aim: compare effectiveness of patient telephone or letter reminders and physician reminders in improving rates of preventive services, including influenza and tetanus vaccinations
Participants	Inclusion: patients active in practice, based on response to letters sent to patients in 1984 Exclusion: in hospital or institution Age: at least 15 years; 65 years and older for influenza vaccination; 18 years and older for tetanus toxoid Setting: Ottawa Civic Hospital Family Medicine Centre (Canada) Clinical practice was organized into 6 teams, each team served approximately 1200 patients and comprised 1 physician, 1 nurse, and 3 to 5 residents; patients visited their team during regular office appointments n = 5883 patients randomized
Interventions	Intervention group 1: telephone reminder to patient; practice nurse attempted to call family, trying up to 5 times; nurse informed patient about needed procedures and attempted to arrange to have them performed; n = 1104 families; 1468 people Intervention group 2: sent computer-generated reminder letter to patient and families; signed by physician and nurse; described needed procedures and importance of having them performed; sent second reminder to nonresponders after 21 days; 1168 families; 1541 people Intervention group 3: computer-generated physician reminder included on routinely printed encounter form before any office visit to inform physician of outstanding preventive services; ineligible intervention; 1122 families; 1471 people Control: no intervention; n = 1056 families; 1403 people
Outcomes	Percent of procedures performed Group 1, telephone, tetanus vaccination: 20.8 percentage point increase over control group Group 2, letter, tetanus vaccination: 27.4 percentage point increase over control group Group 1, telephone, influenza vaccination: 27.2 percentage point increase over control group Group 2, letter, influenza vaccination: 25.4 percentage point increase over control group
Notes	Allocated families; data not entered in RevMan 67 participants in the telephone group were not contacted because no phone, hearing impairment, or did not understand English or French; of remaining 1037 in phone group, 66% were contacted 164 letters were returned as undeliverable (14%)

Risk of bias

Rosser 1991 *(Continued)*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Used a standard randomization computer program to allocate families to study groups
Allocation concealment (selection bias)	Low risk	All patients of family medicine center registered in computer database since 1976; used a standard randomization computer program to allocate families to study groups For the active reminder groups, the computer printed a list of names and telephone numbers of persons needing the interventions each 2-week study period
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified; obtained outcome data from computer database and asked patients about immunizations and other procedures obtained at other sites
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Obtained outcome data from computer database for analysis Asked patients about procedures completed at other facilities and if they could be verified; procedures were recorded as completed if the patient said yes
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Unclear risk	Reviewed all patients' computerized records to identify whether procedures were completed prior to study period within appropriate timeframe Similar distribution of sex between study groups; not clear about other characteristics

Rosser 1992

Methods	Study design: randomized trial Study duration: 1 year; 1 April 1985 to 31 March 1986 Followed-up 1 year after reminder intervention; some patients had almost 2 years of follow-up Study aim: evaluate effect of 3 computerized reminders on tetanus immunization rates
Participants	Inclusion: clinic patients Exclusion: in hospital or institution Age: at least 20 years Setting: 4 of 6 practices with Ottawa Civic Hospital Family Medicine Centre (Canada) Each practice consists of a team of 1 staff physician, 1 nurse, and 3 or 4 residents n = 5589

Rosser 1992 *(Continued)*

Interventions	Intervention group 1: physician reminder and in-person patient reminder by physician; computer-generated reminder was printed on encounter form used for billing; to ask patient about tetanus vaccination; ineligible intervention n =1399 Intervention group 2: telephone patient reminder; practice nurse attempted to contact family by phone, making up to 5 calls per family during office hours; n = 1390 Intervention group 3: computer-generated patient reminder letter was sent to the family; signed by physician and nurse; inquired about tetanus vaccination and recommended booster every 10 years; enclosed prepaid envelope so patients could send a reply; n = 1471 Control group 1: no reminder; n = 1329 Control group 2: 2 non-participating practices; n = 2480
Outcomes	Percent of patients vaccinated during study period with tetanus booster or clear statement of receipt in past 10 years Group 1, physician reminder: 19.6 percentage point increase over control group 1; ineligible intervention Group 2, telephone: 20.8 percentage point increase over control group 1 Group 3, letter: 27.4 percentage point increase over control group 1 Analyses completed with 1 randomly selected person from each family; analyses repeated using data for all patients in sample
Notes	Data for 1 patient per family were entered in RevMan

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomized patients, as family groups, to study groups using standard randomization computer program
Allocation concealment (selection bias)	Low risk	Since 1976, all clinic patients have been registered in computer database; randomized families to study groups using standard randomization computer program; each family was given a unique identifier; each 2-week study period, the computer printed a list of patients and telephone numbers to receive telephone calls and letters
Blinding of participants and personnel (performance bias) All outcomes	High risk	"Each family member was given a unique identifier, and the group allocation was transcribed onto the file of each family member"
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Each patient was followed up for at least 1 year
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias

Rosser 1992 *(Continued)*

Baseline measurement	Unclear risk	At baseline, reviewed charts of 5589 patients; any tetanus vaccination information was added to computerized database Authors noted incomplete baseline records Patients in reminder groups were asked to provide year of last tetanus vaccination Study groups were similar for age, sex, and family size; family size was different between groups when data from non-participating practices were included

Sansom 2003

Methods	Study design: randomized trial, allocated participants by week Study duration: 11 months; enrollment from 19 January 1999 through 19 November 1999 Vaccine series completion was assessed through 16 June 2000 Study aim: evaluate effectiveness of telephone reminder-recall intervention on increasing rates of hepatitis B vaccinations
Participants	Inclusion: male patients who reported susceptibility to hepatitis A or B; had accepted first dose of hepatitis A or B vaccine before enrollment; provided telephone number for nurse to call and leave a message with reminders about due or overdue doses; only men who have sex with men were included in analyses Age: 18 years and older Setting: Los Angeles Gay and Lesbian Center's Sexual Health Program, California (USA) n = 524
Interventions	Intervention: telephone reminders; receive reminder 1 week before vaccination dose was due, and recalls at 2 and 6 weeks after dose was due; at least 1 other call attempt a different time of day, if patients not reached; n = 279 Control: no intervention; standard clinic follow-up with appointment card listing date for next scheduled vaccine appointment and telephone number to reschedule appointment; n = 245
Outcomes	Number and percent receiving second hepatitis B vaccine dose Intervention group: 6.3 percentage point increase over control group
Notes	Hepatitis A and B vaccines were provided free-of-charge to clinic 16.1% of intervention patients did not receive full intervention for second hepatitis B vaccine dose Vaccinations were free to patients

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Allocated participants by week enrolled
Allocation concealment (selection bias)	High risk	Allocated participants by week enrolled
Blinding of participants and personnel (performance bias)	Unclear risk	Blinding of participants and personnel not specified; "Vaccine-eligible clients were asked their willingness to be enrolled in an evaluation of a strategy to enhance completion of the vaccination series."

Sansom 2003 *(Continued)*
All outcomes

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Clinic employees recorded vaccination-related information on vaccination record forms, including dates vaccinations were received at clinic, serious vaccine-related adverse reactions, and reasons for dropping out of vaccine program 524 of 541 patients who accepted first vaccine dose included in evaluation
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	To be eligible for the study, "clients had to accept a first dose of at least one of the vaccines…" Written information about hepatitis A and B infections, and availability, safety, and efficacy of the vaccines was available in clinic waiting room At the beginning of clinic visits, patients were informed by the interviewer about the availability of free hepatitis A and B vaccines Clinicians were asked to discuss availability of and recommend hepatitis vaccines to eligible patients Nurses explained to patients about vaccinations number and schedule
Baseline measurement	Unclear risk	Collected demographic data from each patient at each clinic visit: age, race, ethnicity, highest level of educational attainment; data were displayed for all clients, vaccine-eligible clients, and clients who accepted the vaccine, but not stratified by study group Vaccine eligibility was based on self-report of previous hepatitis B infection or vaccination

Satterthwaite 1997

Methods	Study design: randomized trial Study duration: not clear Study aim: assess effects of 2 interventions, including reminder letters, on influenza vaccination rates
Participants	Inclusion of patients: patients of 16 general practitioners Age: over 65 years Inclusion of practitioners: capacity to generate list of names and addresses of all patients over 65 years; normally provide influenza vaccination to patients; work at least 80% full time equivalent; do not currently have postal influenza vaccination reminder in place Setting: general practitioners in the Auckland region (New Zealand) Patient n = 2791 Clinician n = 16 participated of 31 contacted; 8 not eligible; 7 eligible but not interested in participating
Interventions	Intervention group 1: personalized letter to patients, recommending visit to general practitioner to receive influenza vaccination; n = 931

Satterthwaite 1997 *(Continued)*

	Intervention group 2: personalized letter to patients, recommending visit to general practitioner to receive the influenza vaccination at no charge; letters signed by principal investigator; n = 930 Control: no intervention; n = 930
Outcomes	Number and percent receiving influenza vaccination Group 1, letter: 10 percentage point increase over control group Group 2, letter and free vaccination: 28 percentage point increase over control group
Notes	Vaccination sales in New Zealand suggested that no more than 20% of older adults were vaccinated for influenza each year; Typical cost of influenza vaccination was NZD 20

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Random sequence generation not specified
Allocation concealment (selection bias)	Unclear risk	General practitioners were randomly selected from a list of those currently active in the region Each practitioner generated a list of up to 210 patients over 65 years; randomized patients; process not specified
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	List of patients was used to document receipt of influenza vaccination, number of influenza vaccines given in each group and each general practitioner Full results were available for 15 of 16 participating general practitioners; data not available for control group and letter and free vaccine group for one practitioner; "the major potential source of bias in this study is incomplete recording of the administration of vaccine to people enrolled"; "Because people receiving free vaccine were required to hand in their individually signed letter, all of which were returned to the principle investigator, administration of flu vaccine to group 3 was readily verified."
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Unclear risk	Baseline measurement and data not reported

Siebers 1985

Methods	Study design: randomized trial Study duration: 1 year

Siebers 1985 *(Continued)*

	Study aim: evaluate effect of reminders on pneumococcal vaccination rates
Participants	Inclusion: continuing care patients of the General Internal Medicine Clinic, listed in computer file Age: at least 65 years Setting: General Internal Medicine Clinic, University of Wisconsin, Madison (USA) n = 243 patients
Interventions	Intervention: patient reminder letter and seminar on pneumococcal vaccination to clinic staff; letters sent in October 1982, encouraging patients to receive pneumococcal vaccination or update clinic records; n = 163 Control: seminar to staff on pneumococcal vaccination; n = 80
Outcomes	Intervention group, pneumococcal vaccine: 20 percentage point increase over control group Intervention group, influenza vaccine: 22 percentage point increase over control group
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomization process not described
Allocation concealment (selection bias)	Unclear risk	Used computer file to generate list of patients; randomized them to intervention and control group; process not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Charts were examined for changes in vaccination status; outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	In October 1983, reviewed charts of intervention and control patients for changes in vaccination status Data reported for 80 of 92 (87%) randomized control group and 163 of 173 (94.2%) intervention group patients
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Reviewed all charts of study group patients for vaccination status between July and September 1982 Study groups similar for age, sex, provider, prior year influenza vaccination status, and number of patients dropped from study

Soljak 1987

Methods	Study design: randomized trial nested within a larger study Study duration: 5 months

Soljak 1987 *(Continued)*

	Study aim: evaluate effect of centralized computerized immunization register and reminder postcards on childhood immunization rates
Participants	Inclusion: infants entered in health department's computer system; intervention group participants were all infants born between 20 April 1985 and 31 December 1985; control group participants were all infants born between 1 January 1985 and 20 April 1985 Age: infants Setting: Northland area (New Zealand) n = 2088 patients
Interventions	Intervention: reminder card sent to parent early during any month in which vaccinations were due; monthly printout was sent to general practitioner with names of children due for immunizations; n = 709 Control: standard practice; infants' names were listed on printout if they needed vaccinations; n = 766 Non-randomized controls: 613
Outcomes	Receipt of childhood immunizations: percent immunized at 6 weeks: 18.2% point increase, and at 3 and 5 months
Notes	Established centralized computerized immunization registry in New Zealand to address concerns about immunization data, such as using payment records that are grouped and not linked to patient-level information, and overestimated vaccination levels using parent questionnaires, administered by public health nurses, which monitor children's immunization at the time of school entry

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Allocated patients by even and odd dates of birth
Allocation concealment (selection bias)	High risk	Allocated patients to larger study based on date of birth, then further allocated into patient reminder study by even and odd dates of birth
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Practitioners received a monthly printout of names of all infants in the study with infants' dates of birth; blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Completed printouts, listing patients needing vaccinations, by placing check mark in appropriate immunization column for each infant; wrote in unlisted infants that received vaccinations; lists were submitted monthly as claims; payments were made, and infants' computer files were updated with immunizations given Immunizations among infants who moved in and out of the area after birth were not recorded
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias

Soljak 1987 *(Continued)*

Baseline measurement	Low risk	Infants were registered in a computer database as soon as possible after birth, with infant's date of birth, mother's name and address, and general practitioner's name

Spaulding 1991

Methods	Study design: randomized trial Study duration: 6 months Study aim: determine baseline rate of influenza immunization among military beneficiaries with high-risk conditions, and evaluate effectiveness of postcard reminder on influenza immunization rates
Participants	Inclusion: high risk patients Age: all ages Exclusion: patients 65 years and older without other risk factors Setting: Department of Family Practice, Madigan Army Medical Center, Fort Lewis, Washington (USA) n = 1068 patients
Interventions	Intervention: reminder postcard sent during 2 weeks before influenza vaccine was available, indicating that physician had determined they were at high risk for flu complications, and strongly urging them to come to clinic for immunization; n = 519 Control: no intervention; routine care; n = 549
Outcomes	Percent of persons receiving influenza vaccine Intervention: 16.1 percentage point increase over control group Postcard was observed to be effective for sex and rank subcategories, and most age subcategories, except those less than 21 years and 21 to 40 years of age
Notes	Allocated families, patients analyzed; data not entered in RevMan Registered information about all practice patients in computer: name, demographic data, and diagnoses Influenza vaccines were available to all eligible patients on walk-in basis, without an appointment, and free of charge

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Allocated families to study groups using table of random numbers
Allocation concealment (selection bias)	Low risk	Last 2 digits of military sponsor's social security number were used for all members of a family to group them in allocation process; then families were allocated using table of random numbers
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Physicians in the department "were aware that a study was in progress and that some of their patients might receive postcards about influenza immunization" Offered vaccination to all eligible patients on a walk-in basis, without appointment, and free of charge

Spaulding 1991 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	"The physician or a nurse completed the standard department computer form for each patient receiving influenza immunization"; outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Physician or nurse completed standard computer form for each patient that received an influenza vaccination
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Unclear risk	Collected data on all identified patients at high risk for influenza complications: age, sex, rank of sponsor, and whether the patient received the influenza vaccine during the 6-month study period Study groups similar for age distribution; intervention group had more female participants and officers than control group

Staras 2015

Methods	Study design: randomized trial; study subset randomized to intervention and control groups Study duration: 8-month study; drew sample 1 August 2013 through 15 November 2013; study began 19 August 2013; claims reported by 1 April 2014 Study aim: evaluate feasibility of implementing multi-level intervention to increase HPV vaccination among adolescents
Participants	Inclusion: enrolled in Medicaid or CHIP in June 2013; no HPV vaccine claims; residential zip code in North Central Florida; Gainesville, FL or surrounding primary care service area; at least 1 regular office visit between 1 July 2011 and 1 August 2013 Age: 11 to 17 years; mean = 13.7 years Exclusion: previously received HPV vaccine based on Medicaid or CHIP claims data Setting: clinics in Gainesville, Florida and surrounding service areas (USA) n: 5663 in non-health information technology (HIT) groups
Interventions	Intervention group 1: 2 postcards sent to parents, one at study start and one 2 months later; sex-specific; used learner verification framework; behavioral experts developed and refined postcards using iterative approach with focus groups of parents of Florida Medicaid and CHIP-enrolled adolescents; 6- by 8-inch full color postcards with images of adolescents and parents; English and Spanish; described vaccine benefits, costs, side effects, and safety; urged parents to discuss vaccination with the adolescent's health services provider; n = 2839 Intervention group 2: HIT system; not eligible intervention; n = 1774 Control, non-HIT: no patient reminder or recall; n = 2824
Outcomes	Initiation of human papillomavirus vaccine series Intervention group 1: 5.6% versus 4.6%; 1 percentage point higher

Staras 2015 *(Continued)*

Notes	Randomly selected 200 parents of girls and 200 parents of boys to receive 3-page survey to assess the acceptability of postcards; enclosed USD 5 cash and hand-stamped return envelope; survey sent on 1 November 2013; follow-up survey sent 28 January 2014 to non-respondents

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomly assigned half of the boys and half of the girls in the HIT and comparison arms to receive postcard intervention; method of randomization not described
Allocation concealment (selection bias)	Unclear risk	As above
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not described
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Used Medicaid and Children's Health Insurance Program (CHIP) claims and patient surveys to assess vaccinations; blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Obtained immunization data from Medicaid and CHIP claims; however, 36% of adolescents without vaccination claims reported initiating HPV vaccination series
Selective reporting (reporting bias)	Low risk	Reported results for all groups and subgroups, answering study questions
Other bias	Unclear risk	Study methods not sufficiently detailed to assess other potential sources of bias
Baseline measurement	Unclear risk	Baseline vaccination rates initially differed between HIT and non-HIT providers; investigators modified geographic areas to create better balance; did not present demographic characteristics, stratified by study group

Stehr-Green 1993

Methods	Study design: randomized trial Study duration: 1-month follow-up period for each child; enrollment during February and March 1990 Study aim: evaluate effect of computer-generated telephone reminders on improving on-time vaccinations among children attending public clinics
Participants	Inclusion: previously vaccinated at 2 public health clinics in southwest Fulton County; listed in clinics' file of current patients; due to receive DTP, OPV, or MMR during 6-week study enrollment period; Atlanta, Georgia (USA) Participating clinics provide care for poor, minority populations Age: younger than 2 years n = 222 randomized
Interventions	Intervention: autodialer, 1 per patient; calls made by telecomputer with pre-programmed standard message using a normal human voice; message indicated the health department was reminding family that the child was due for an immunization or shot, bring child to health center any day during cur-

Stehr-Green 1993 *(Continued)*

	rent week, immunizations are important to protect child's health from specific diseases, and immunizations are required for day care or school; calls made at beginning of the day before child was due for an immunization; up to 9 attempts were made, not counting wrong numbers; some attempts were made during evenings; n = 112 Control: no intervention; n = 110
Outcomes	Childhood vaccines: number and percent of children receiving vaccinations on time Intervention group: 2.8 percentage point increase over control group Girls were slightly more likely to be vaccinated on time than boys Blacks, Hispanics, and children attending the larger clinic were somewhat more likely to have been vaccinated on time than whites, non-Hispanics, and those attending the smaller clinic Younger children were more likely to receive vaccinations on time compared with older children
Notes	67.3% of intervention homes were reached with autodialer system Estimated intervention costs

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomization methods not described
Allocation concealment (selection bias)	Unclear risk	Reviewed clinic files to identify eligible children; randomized children; specific allocation method not described; intervention was delivered by telecomputer
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Followed children for 1 month beginning the date they became due to receive an immunization Abstracted data from clinic records at end of study Of 229 who met eligibility criteria, 6 were lost to follow-up, and 1 was deferred from needing additional immunizations; randomized remaining 222 to study groups
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Unclear risk	Reviewed immunization records of children less than 2 years of age; abstracted information from patients' charts: date of birth, sex, race, ethnicity, date and type of previous immunizations, telephone number, and other services received at health center Children in control group were slightly younger, more likely to be female, and more likely to attend the larger clinic, than intervention participants

Stehr-Green 1993 *(Continued)*

	Control participants were less likely to participate in other services offered by clinics than intervention participants

Stockwell 2012a

Methods	Study design: controlled before and after for adolescent study; "randomized trial"; 2 intervention sites and 4 control sites Selected random sample and compared to age- and sex-matched controls Study duration: January 2009 to June 2009 Study aim: assess feasibility and efficacy of text message reminder-recall on return of adolescents to their medical home for routine vaccinations
Participants	Inclusion: parents or guardians of 11- to 18-year olds with any visits at participating study site within previous 12 months; patients in need of meningococcal (MCV-4), tetanus-diphtheria-acellular pertussis (Tdap) or both; and cell phone number was listed in registration system Age: adolescents, 11 to 18 years Exclusion: parents of adolescents who had received a different tetanus-containing vaccine within previous 2 years Setting: network of 6 community-based clinics affiliated with an academic medical center in New York City (USA); clinics primarily served low-income minority populations n = 361; 195 parents randomly selected for the intervention group; included 166 controls, matched for age and sex 1656 patients at intervention sites and 1460 at control sites needed Tdap or MCV; 625 of these had a cell phone listed in registration system
Interventions	Intervention: Text 4 Health - Adolescents; parents received text messages at weeks 1, 2, 3, 6, and 7, to notify them of child's need for vaccination(s); messages were stopped if vaccination was recorded in electronic system; n = 2 practice sites and 195 patients Text messages included patient's first name, clinic name, a list of when immunizations could be obtained at the clinic, and how to discontinue additional messages Messages were sent in English or Spanish, based on listed preference Control: standard of care; did not include immunization reminders; n = 4 practice sites and 166 patients
Outcomes	Primary outcome: receipt of 1 or both of 2 routinely recommended adolescent vaccines, meningococcal (MCV-4) and tetanus-diphtheria-acellular pertussis (Tdap), at 4, 12, and 24 weeks after study assignment Secondary outcome: receipt of any vaccine, including MCV, Tdap, HPV, influenza, or others Intervention, for primary outcome at 12 weeks: 12.8 percentage points over control group; 26.7% versus 13.9% Intervention, for primary outcome at 4 weeks: 11.2 percentage points over control group; 15.4% versus 4.2%
Notes	EzVac text messaging platform was developed and integrated into the hospital's immunization information system; system is linked to hospital registration and computerized order entry systems; immunization data synchronized with New York City's immunization registry

Stockwell 2012a *(Continued)*

	Reported power calculations; sample size of 150 participants, 80% power, and alpha of 5% was conservatively powered to detect a 15 percentage point difference between intervention and control groups; this outcome was achieved by 24 weeks of follow-up Authors report limitation of not knowing how persons without cell phone numbers in their system would differ from those with cell phone numbers in the system, other than demographic data

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	"Two intervention and four control sites were assigned to provide comparable baseline populations…"
Allocation concealment (selection bias)	High risk	Each week a computer algorithm was used to automatically randomly select sample of eligible parents from intervention sites; selected control participants from control practices, matching for age and sex with intervention participants
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Collected immunization data from EzVac; outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	New York City Citywide immunization registry captures more than 85% of the immunizations administered in the city and an estimated 93% of free immunizations distributed through Vaccines for Children program
Selective reporting (reporting bias)	Unclear risk	"We did not include the human papillomavirus (HPV) and influenza vaccines because their uptake may have reflected unique parental attitudes and beliefs; in addition, the intervention extended beyond the influenza season."
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Baseline characteristics similar between study groups for sex, race and ethnicity, insurance status, primary language, and adolescent and childhood immunizations

Suh 2012

Methods	Study design: randomized trial Study duration: February 2008 to August 2009 Study aim: assess effect of letter and autodialer reminder-recall interventions on adolescent immunization rates
Participants	Inclusion: adolescents seen at their practice at least once in 2 years before the study; needed one or more targeted adolescent vaccinations, including tetanus-diphtheria-acellular pertussis (Tdap), meningococcal conjugate (MCV4), or first dose of human papillomavirus (HPV1) vaccine for females Age: 11 to 18 years Setting: 4 suburban private pediatric practices in metropolitan Denver, Colorado (USA)

Suh 2012 *(Continued)*

	n = 1600; 400 adolescents from each of 4 practices
Interventions	Intervention: up to 2 letters separated by 2 autodialer telephone calls; all families were sent a first letter and autodialer call; adolescents who needed a targeted vaccination 1 month later received a second autodialer call; a second letter was sent 2 months after initial reminder-recall if adolescent still needed immunizations Letters were printed on practice letterhead Letters and autodialer indicated that adolescents were due for at least 1 vaccine and briefly described each vaccination; n = 800 Control: usual care; did not include reminder-recall; n = 800
Outcomes	Outcome 1: received at least 1 targeted vaccine, or more than 1 vaccine, 6 months after the intervention; described inconsistently between the abstract and page e1438 Outcome 2: received all targeted vaccines, 6 months after intervention Intervention - Outcome 1: 12.5 percentage points above control group Intervention - Outcome 2: 11 percentage points above control group Intention-to-treat used for all analyses
Notes	751 of 800 adolescents in intervention group received at least 1 recall autodialer call and letter If more than 1 adolescent in a family met the inclusion criteria, 1 was randomly selected to have data included; siblings received same intervention type as the enrolled sibling Power calculations were reported; with 200 adolescents per practice, study would have 80% power to detect a 7 percentage point difference in immunization rates between study groups

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomized patients within each practice using random number generation (SAS 9.1)
Allocation concealment (selection bias)	Low risk	Practices participate in the Colorado Immunization Information System, a statewide immunization registry and share a common billing system; used data combined from these systems to determine study eligibility; randomized within each practice using random number generator
Blinding of participants and personnel (performance bias) All outcomes	Low risk	"Providers were blinded to group allocation"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Outcome assessment blinding not specified; however, providers were blinded and outcome data were obtained from registry and billing data
Incomplete outcome data (attrition bias) All outcomes	Low risk	Obtained outcome data from Colorado Immunization Registry; supplemented with billing data Final cohort sizes were 799 intervention and 797 control
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes

Suh 2012 *(Continued)*

Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Administrative data from practices' electronic billing systems were merged with the Colorado Immunization Registry data to determine eligibility at baseline based on immunization records Intervention and control groups similar for age, sex, and insurance status Baseline vaccination rates varied by practice; not clear whether baseline rates varied by study group

Szilagyi 1992

Methods	Study design: randomized trial Study duration: 4 months Study aim: evaluate effectiveness of computerized database and reminder letters on improving vaccination rates among children with asthma
Participants	Inclusion: moderate to severe asthma; had acute asthma attack with administration of bronchodilators in prior year, or use of medications on a chronic basis Age: 1 to 18 years Setting: Pediatric Clinic at Strong Memorial Hospital of the University of Rochester School of Medicine and Dentistry; clinic serves impoverished urban children, Rochester, New York (USA) 70% of visits are covered by Medicaid n = 124 patients
Interventions	Intervention: sent 1 computer-generated letter to parents during October 1990; explaining that influenza season was approaching, child may develop influenza complications, influenza shot is highly protective and has minimal side effects, and asking parents to schedule a visit for influenza shot; written in sixth grade reading level; n = 63 Control: standard practice; provider education and computerized checklist on medical record; n = 61
Outcomes	Number and percent of patients receiving at least 1 influenza vaccination Intervention group: 23 percentage point increase over control group
Notes	Initiated computerized database in 1987; database included 5400 patients by November 1989 Instructed all clinic nurses and doctors about importance of influenza vaccination for children with asthma; reminded them about clinic vaccination policy Placed checklist in front of medical charts of all eligible patients Did not report cost of intervention data

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Randomized children; allocation method not described
Allocation concealment (selection bias)	Unclear risk	Computer database was used to identify children with diagnosis of asthma; conducted chart review for those children to assess study eligibility; randomized children; method not described

Szilagyi 1992 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	January 1991: reminder group parents that received letter were contacted to determine parent characteristics February 1991: influenza vaccination status was determined by medical chart review
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Children in intervention and control groups were similar for age, sex, Medicaid enrollment, taking chronic asthma medications, and emergency department visit for asthma within 6 months of study enrollment Conducted cross-validation study the next year by sending computer-generated reminders to all patients with active asthma to assess whether influenza immunization rates would be similar; vaccination rates were similar between this group (27%) and prior year intervention group (29%)

Szilagyi 2006

Methods	Study design: randomized trial Study duration: 18 months; 8 August 1998 to 29 February 2000 Study aim: assess the effect of telephone reminder-recall interventions on adolescent immunization rates in urban practices
Participants	Inclusion: adolescents with 1 or more visits at participating clinics Age: 11 to 14 years at beginning of intervention Exclusion: siblings, randomly selecting one adolescent per family; no practice visits within 24 months; residing outside the county; no telephone number in database Setting: 4 large urban primary care practices located in Rochester, New York (USA), serve approximately 19% of county's children; 1 hospital-based pediatric clinic, 2 pediatric group practices, 1 family medicine neighborhood health center Rochester has high rates of childhood poverty N = 3006 randomized and analyzed
Interventions	Intervention: autodialer; automated telephone message reminder system; number of calls varied per participant, based on need for immunizations or well child visits and responses to reminder calls Calls attempted 6 of 7 days a week, during day or early evening; made in English using a voice recording Interventions managed by central office; n = 1496; 132 considered inactive but included Control: not clear; n = 1510; 168 considered inactive but included

Szilagyi 2006 *(Continued)*

Outcomes	Intervention group, hepatitis B: 4.2 percentage point increase over control group; 62.0% versus 57.8%; difference is reported as 2.2 in Table 2 Intervention group, tetanus diphtheria (Td): 2.1 percentage point increase over control group; 52% versus 49.9% Intervention group, average values: 3.2 percentage point increase over control group Used intention-to-treat analysis
Notes	Power calculations reported; more than 750 adolescents per practice were required to detect a "10%" improvement in vaccination rates; 3006 were eligible for randomization 62.8% did not respond to reminders; 3.4% were no longer clinic patients; 9.8% wanted calls discontinued Conducted medical record review to identify participant telephone numbers at beginning of study; investigators experienced difficulty with obtaining accurate numbers

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Allocated adolescents into study groups using random-number generator
Allocation concealment (selection bias)	Low risk	Eligible adolescents identified through practice billing databases; stratified adolescents into 2 groups based on age, 11 to 12 years and 13 to 14 years, then randomly allocated into groups using random-number generator; research personnel located at a central office
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Health services personnel unaware of group allocation for study participants
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Obtained primary outcome measures by blinded medical record review at study end using abstraction form
Incomplete outcome data (attrition bias) All outcomes	Low risk	Tracked adolescents and need for reminders using database; research assistant verified weekly upcoming appointments, immunizations, and telephone number changes Conducted medical chart review at study end; records not found for 132 intervention and 168 control participants Some adolescents may have received vaccinations in other locations
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Conducted quality assessment checks for 5% of participant records; 98% reliability
Baseline measurement	Low risk	At baseline, intervention and control groups were similar for hepatitis B, Td coverage and well child visit rates Collected demographic data from billing files

Szilagyi 2006 *(Continued)*

	Intervention and control groups similar for age group, sex, practice distribution, insurance, race, and ethnicity

Szilagyi 2011

Methods	Study design: randomized trial Study duration: conducted intervention from 1 October 2007 to 31 December 2008; assessed outcomes for 3 months after intervention Study aim: evaluate effect of tiered patient immunization navigator intervention, which included telephone calls and letters, on improving immunizations among adolescents living in urban areas
Participants	Inclusion: adolescents enrolled in participating practices Age: 11 to 15 years; birth dates from 1 July 1992 to 30 June 1997 Setting: 8 largest urban primary care practices serving adolescents in Rochester, New York; included 2 federally qualified community health centers, 2 pediatric hospital-based clinics, 1 family medicine teaching clinic, 1 hospital-associated medicine-pediatrics practice, and 2 urban private practices (USA) n = 7546 from 6682 families; 5910 families had one adolescent Almost 80% of adolescents in Rochester live below poverty line
Interventions	Intervention: tiered intervention; population-based approach with progressively more intensive intervention, based on need; n = 3707 Step 1: track participants in tracking system Step 2: reminders and recall for vaccination or preventive care visit with 1 month grace period; 2 telephone calls at least 1 week apart, made by navigators; offered transportation assistance, if needed; 2 letters 2 weeks apart after calls or if telephone numbers not available Step 3: navigators made home visit to assess barriers to seeking care, promote prevention, and encourage appointments Control: standard of care; n = 3839
Outcomes	Immunization rates for 3 individual vaccine types, and all 3 vaccines combined; meningococcus, pertussis, and HPV for girls Differences in immunization rates between intervention and control groups ranged between "12% to 16%," depending on vaccine Intervention - MCV4: 14.3 percentage points over control group; 63.9% versus 49.6% Intervention - Tdap: 12.1 percentage points over control group; 65.5% versus 53.4% Intervention - first HPV: 15.6 percentage points over control group; 58.5% versus 42.9% Intervention - second HPV: 15.8 percentage points over control group; 52.0% versus 36.2% Intervention - third HPV: 12.4 percentage points over control group; 36.5% versus 24.1% Intervention - all 3 vaccines: 12.3 percentage points over control group; 44.7% versus 32.4%
Notes	Data not entered in RevMan data tables; allocated families, grouping siblings; stratified by practice, age and sex Intervention complexity makes it difficult to determine effectiveness of each component

Szilagyi 2011 *(Continued)*

	Study occurred before practices used state's immunization registry for adolescent immunizations All participating practices routinely used telephone or letter reminders for families with upcoming scheduled visits; reminders did not include active immunization reminders or recall

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomly assigned each family to study groups using commercially available software program, stratifying on practice, age and sex
Allocation concealment (selection bias)	Low risk	Identified families with age-eligible adolescents from major insurance company databases and billing systems; randomly selected referent adolescent; randomly assigned families using computer program
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Health services providers not aware of study group assignment
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Trained patient immunization navigators delivered the intervention and used a web-based database to track adolescents and document immunizations, preventive care visits, and tasks performed
Incomplete outcome data (attrition bias) All outcomes	Low risk	Created web-based database for navigators to track adolescents and document immunizations, preventive care visits, and tasks Reviewed medical records after intervention period and used abstraction form to obtain all adolescent immunization dates Searched New York State immunization registry for additional immunizations given
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Assessed reliability of medical record review abstraction using 5% sample; Kappa >= 0.89 for interrater reliability
Baseline measurement	Low risk	Obtained vaccination history from medical record review Identified eligible participants using lists from 2 major insurance plan databases for 8 practices and from billing systems Searched New York State immunization registry for additional immunizations given at baseline Intervention and control groups similar for demographic characteristics and baseline immunization and preventive care visit rates

Szilagyi 2013

Methods	Study design: randomized trial Study duration: 1 year; 11 December 2009 to 12 December 2010

Szilagyi 2013 *(Continued)*

	Study aim: evaluate effect of managed care-based letter and autodialer reminders and recall on immunization rates among low-income adolescents
Participants	Inclusion: adolescents enrolled in Monroe Plan on 31 December 2009; primary care provider participating in study Age: 10.5 through 17 years; mean age at study start was 14.4 years Exclusion: adolescents enrolled in Monroe Plan for less than 6 months because insufficient data on prior health care services and immunizations; contraindication to vaccinations, such as anaphylaxis caused by vaccination Setting: 15 counties in upstate New York state; 37 participating primary care practices that each served at least 30 eligible adolescents, enrolled in Monroe Plan for Medical Care, a large not-for-profit managed care organization that serves more than 72,000 publicly insured children enrolled in Medicaid or New York State Children's Health Insurance Program Practices: 22 pediatric; 13 family medicine; 2 internal medicine; 1 other dropped out n = 7404 adolescents from 5559 families were randomized into 3 study groups; 3289 lacked a telephone or geocodable address; 4115 youths remained in the study
Interventions	Intervention group 1: mailed letter asking parents to call primary care practice to schedule appointment; listed telephone number; centralized reminder and recall; letters written in English and Spanish; 2-sided; written at less than seventh grade reading level; specified age of child, but not name, managed care organization, primary care practice, and recommended services; letters sent at 10-week intervals for Tdap, MCV4, and first HPV dose; sent letters at 5-week intervals for HPV-2 and HPV-3, with maximum of 8 reminders per vaccine dose; n = 1396 Intervention group 2: autodialer telephone reminders in English or Spanish; centralized reminder-recall; same content and frequency as letters; n = 1423 Managed care organization developed automatic algorithm that reviewed vaccination status every 5 weeks, triggering reminders, starting at 10.8 years of age Control: standard of care; some practices used visit or immunization reminders or recall; n = 1296
Outcomes	Immunizations rates for routine adolescent vaccines: meningococcus, pertussis, HPV Outcome 1: received all needed immunizations among adolescents missing any vaccinations at study beginning Outcome 2: immunization rates at study end, among all eligible adolescents at study start Group 1, letter, outcome 1: 8 percentage points over control group; 21% versus 13% Group 2, autodialer, outcome 1: 4 percentage points over control group; 17% versus 13% Group 1, letter, outcome 2: 6 percentage points over control; 56% versus 50% Group 2, autodialer, outcome 2: 3 percentage points over control; 53% versus 50%
Notes	Data not entered in RevMan; allocated siblings to same study group; 73% of families had 1 adolescent Survey of participating practices revealed 12 of 24 respondents used telephone or mailed reminders for adolescents with scheduled preventive care visits; 6 of 24 used telephone or mailed reminders for patients behind on vaccines Managed care organization lacked telephone numbers for 41% of those initially randomized to study groups

Risk of bias

Bias	Authors' judgement	Support for judgement

Szilagyi 2013 *(Continued)*

Random sequence generation (selection bias)	Low risk	Used Stata to randomly assign referent adolescent per family and age-eligible siblings to study groups
Allocation concealment (selection bias)	Low risk	Study was based at a managed care organization serving 72,404 children and adolescents; used managed care database to select practices serving at least 30 adolescents; randomized families and adolescents within each participating practice using computer program (Stata); allocated siblings to same group based on address and geo-coding software Stratified based on practice, age in years, and sex
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Health services providers not aware of study group assignments
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Outcome assessment blinding not specified; however, immunization outcomes obtained from claims data and immunization registry data; and health services providers not aware of study group assignments
Incomplete outcome data (attrition bias) All outcomes	Low risk	Used managed care organization claims files to obtain vaccination data; merged data with New York immunization registry data
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Unclear risk	Survey of participating practices revealed 12 of 24 respondents used telephone or mailed reminders for adolescents with scheduled preventive care visits; 6 of 24 used telephone or mailed reminders for patients behind on vaccines; randomized within practices to minimize so the effect of these interventions would be similar across study groups Many adolescents did attend clinic visits
Baseline measurement	Low risk	Determined eligibility for vaccines based on 2010 Advisory Committee on Immunization Practices (ACIP) guidelines Obtained demographic data from managed care organization's enrollment files and vaccination data from claims files Intervention and control groups similar, at baseline, for demographic characteristics, immunization status, and preventive visit rates

Tollestrup 1991

Methods	Study design: randomized trial Study duration: 12-week study enrollment period, from February to April 1987; followed each child for 5 months; 8-month full study period Study aim: design a pilot follow-up system for immunizations in 1 large county health department and evaluate effectiveness of system and use of postcards in increasing childhood immunization rates
Participants	Inclusion: received first or second DTP from main health department clinic Age: less than 5 years Exclusion: siblings of included participants Setting: county health department in urban area in western Washington state; Snohomish County, Everett, Washington (USA)

Tollestrup 1991 *(Continued)*

	Main clinic and study site in Everett; 2 other clinics in southern and eastern sections of county; immunizations also available at well-child clinics throughout county, 1 day each month n = 425 enrolled; 393 followed; 32 eliminated because of recording errors, lack of current mailing address, or another family member was enrolled
Interventions	Intervention: sent 1 to 2 postcard reminders to parent or guardian listed in immunization record; sent first postcard to children overdue for immunizations 1 month after due date; sent second postcard a month later if immunization not received; n = 182 followed Control: no intervention; n = 211 followed
Outcomes	Number and percent immunized for DTP Intervention group: 33.9 percentage point increase over control group
Notes	Washington State Immunization Program required use of manual or computerized follow-up and recall system in all local health departments that obtain state-purchased vaccines; each county had flexibility to develop their own systems and methods

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Sequence generated by week children received vaccination at time of enrollment
Allocation concealment (selection bias)	High risk	Allocated children to the intervention or control group systematically using alternate weeks
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Followed 393 children, including 182 intervention and 211 control, for 5 months from enrollment or until the next DTP was administered At study end, parents of children in both groups without evidence of returning to clinic for immunizations were sent letter explaining study and enclosed questionnaire to determine if immunizations obtained at different location and name of site; made telephone calls to parents not returning questionnaire Immunization status obtained for 87.9% of children in intervention group and 84.4% in control group
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Used birth certificates to collect demographic and other data about child and family Study groups similar for family size at birth, socioeconomic status, race, age of child, age of parents, and month prenatal care began

Vivier 2000

Methods	Study design: randomized trial Study duration: 10 weeks follow-up; reviewed medical records between October 1998 to December 1998 to determine baseline immunization levels Study aim: evaluate whether mailed and telephone recall systems are effective for increasing immunization among young children in Medicaid managed care practice
Participants	Inclusion: children enrolled in Rite Care, Rhode Island's Medicaid managed care program; continuously enrolled in participating primary care clinics during July, August, and September 1998; underimmunized, defined as overdue for diphtheria and tetanus toxoids, pertussis, polio, *Haemophilus influenzae* type b, measles-mumps-rubella, or hepatitis B vaccines Age: less than 6 years as of 30 September 1998 Setting: primary care clinics at Hasbro Children's Hospital - Rhode Island Hospital, university-affiliated teaching hospital; Rite Care, Rhode Island's Medicaid managed care program, Providence, Rhode Island (USA) Clinics serve more than 10% of 50,000 children enrolled in Rite Care n = 264; control = 71; telephone group = 60; mail reminder = 63; sequential mail and telephone = 70
Interventions	Intervention group 1: telephone reminder; telephone calls made to families by clinic receptions who spoke English and Spanish; informed parents that children were overdue for immunizations and requested they make appointments with primary care provider during the call, if possible; made at least 3 call attempts per family, morning, afternoon, and early evening; n = 60 Intervention group 2: mail reminder; sent letter to family, indicating child was overdue for immunizations; parents were encouraged to call clinic to schedule appointment with primary care provider; n = 63 Intervention group 3: sequential mail and telephone reminder; mailed letter, following by telephone call one week later, if appointment not in scheduling system; n = 70 Control: no intervention; n = 71
Outcomes	Outcome 1: children received all needed immunizations at end of 10-week follow-up period Outcome 2: children received immunizations during study period Group 1, telephone, outcome 1: 10.5 percentage points over control group; 13.3% versus 2.8% Group 2, letter, outcome 1: 11.5 percentage points over control group; 14.3% versus 2.8% Group 3, letter and telephone, outcome 1: 14.3 percentage points over control group; 17.1% versus 2.8% Group 1, telephone, outcome 2: 11.5 percentage points over control group; 16.7% versus 4.2% Group 2, letter, outcome 2: 14.8 percentage points over control group; 19.0% versus 4.2% Group 3, letter and telephone, outcome 2: 21.5 percentage points over control group; 25.7% versus 4.2%
Notes	Participating clinics did not have immunization outreach program before this study 53% in phone reminder group not contacted; 30.2% of letters returned
Risk of bias	

Vivier 2000 *(Continued)*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Used computer-generated random numbers to randomize children
Allocation concealment (selection bias)	Low risk	Children were enrolled in Rhode Island's Medicaid managed care program; determined eligibility and randomized children using computerized immunization tracking system, which operated in a commercially available database
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	English and Spanish-speaking receptions made calls for the telephone reminder group Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified for medical record reviews, conducted to obtain baseline data, and to determine nurse-only visits and newly received or documented immunizations after 10-week follow-up Assessed immunization status using these data and immunization tracking system
Incomplete outcome data (attrition bias) All outcomes	Low risk	Used immunization tracking system to obtain immunization outcome data Reviewed medical records to determine nurse-only visits, and newly received or newly documented vaccinations
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes to answer study questions
Other bias	Low risk	Study seems to be free of other sources of bias
Baseline measurement	Low risk	Used computerized immunization tracking system to identify immunization status at baseline Groups similar at baseline for age, sex, and vaccine-specific rates

Winston 2007

Methods	Study design: randomized trial Study duration: 6-month follow-up period; telephone calls made to persons with chronic conditions during June 2004 and older adults during July 2004 Study aim: evaluate effect of telephone reminder on pneumococcal vaccination rates, and compare effectiveness among primarily non-Hispanic black versus non-Hispanic white patient populations
Participants	Inclusion: all patients at 5 participating managed care network general medicine clinics; unvaccinated based on administrative database; chronic disease specified as diabetes mellitus, chronic heart failure, or coronary artery disease in database Age: 18 years and older for chronic disease group; older than 65 years for older adult group Exclusion: patients vaccinated or indicated, by postcard, they had received vaccine at different site within 3 months after mailed reminder Setting: 5 managed care network general medicine clinics; Atlanta, Georgia (USA) n = 6106; 3711 with chronic disease; 2395 older adults

Winston 2007 *(Continued)*

Interventions	Intervention: telephone reminder; nurses made calls, asked patients about pneumococcal vaccination and explained vaccine is recommended and is covered benefit of health plan with copayment; asked patients if they wanted to receive vaccine; could schedule vaccination appointment during call; n = 3043, including 1845 with chronic diseases and 1198 older than 65 years During spring 2004, before intervention, practice sent letter to intervention and control participants, to introduce study and indicate a nurse would call in next few weeks Control: usual care; did not receive introductory study letter; n = 3063, including 1866 with chronic diseases and 1197 older than 65 years Sent mailed reminders to both groups during March and April 2004, encouraging patients to schedule clinic visit to receive pneumococcal vaccination, or return enclosed postcard if received at different setting
Outcomes	Number and percent of persons receiving pneumococcal vaccination Intervention - chronic disease group: 10 percentage points over control group; 16% versus 6% Intervention - greater than 65 years: 9 percentage points over control group; 17% versus 8% Intervention - combined: 9.2 percentage points over control group; 16.1% versus 6.9% Intention-to-treat analysis
Notes	Posted preventive services reminders in all medical offices

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Allocated patients to intervention and control groups using random number generator; one-to-one ratio
Allocation concealment (selection bias)	Low risk	Identified eligible participants using administrative database for 5 clinics; allocated patients to intervention and control groups using random number generator; one-to-one ratio
Blinding of participants and personnel (performance bias) All outcomes	Low risk	"The study was blinded; randomization assignment was not known to the patient's primary care physician or home medical office."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	"Used Current Procedural Technology code for vaccination as the outcome"; "The study was blinded"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Obtained primary outcome by identifying participants with CPT code 90732 in administrative database
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes to answer study questions
Other bias	Unclear risk	Sent mailed reminders to intervention and control patients during spring 2004 At baseline, "large proportion" of intervention participants reported receipt of pneumococcal vaccination previously, but not documented in their records; these patients were included in study; similar data not available for controls

Winston 2007 *(Continued)*

Baseline measurement	Low risk	Identified vaccination status at baseline and enrolled participants without pneumococcal vaccination Compared study groups for age, length of HMO enrollment, sex, and chronic disease distribution; observed minor differences between intervention and control group

Wood 1998

Methods	Study design: randomized trial Study duration: enrolled during 3-month period from February to early May 1994; 15 months of follow-up Study aim: evaluate effectiveness of telephone calls and case management in increasing childhood vaccination rates among African American children in an inner city
Participants	Inclusion: inner-city children within 10 zip code areas; born to African American woman; enrolled infants during the first few weeks of life Area children predominantly African American and from low income families Age: infants; mean of 17.8 days and range of 0 to 42 days at enrollment Setting: low-income area of Los Angeles, California (USA) n = 419 mother-infant pairs
Interventions	Intervention: case management with phone calls and health passport Case managers conducted in-depth assessments in home before children were 6 months of age; home visits scheduled 2 weeks before next immunization due date; discussed immunization schedules and misconceptions about contraindications for vaccinations; made telephone calls or home visits after scheduled well-child visits to assess compliance with care; assisted families with overcoming barriers, such as transportation or lapses in Medicaid coverage Visit frequency varied based on parent compliance with care Home visits occurred at approximately 3.5 and 5.5 months of age for children receiving timely visits and immunizations; n = 209 Control: health passport, which consisted of schedule of recommended well child visits and immunizations; n = 210
Outcomes	Number and percent up-to-date with childhood immunizations at 1 year of age Intervention group: 13.2 percentage point increase over control group
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	RAND survey employees randomized mother-infant pairs in blocks of 4, prior to baseline interview
Allocation concealment (selection bias)	Low risk	Obtained lists of names and addresses from the county vital statistics branch to identify births in 10 target zip code areas; randomization was conducted centrally by RAND survey employees
Blinding of participants and personnel (performance bias)	Unclear risk	Blinding of participants and personnel not specified

Wood 1998 *(Continued)*
All outcomes

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Survey staff made one contact with parent when infants were 4 to 5 months of age to update addresses and telephone numbers Collected information from both groups by face-to-face interview at end of intervention period; included recalled information only if parents had complete dates and specific immunization provided 71% of mothers provided written records with valid immunization information at exit interview Immunization data also obtained by abstracting provider charts for 299 (82%) children Provider records incomplete or unavailable for 40 children Combined data, then omitted redundant information; immunization data available for 89% of final sample
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes to answer study questions
Other bias	Low risk	Compared immunizations recorded in provider records and hand-held records with recall data, if provided; 7.4% of group recalled at least 1 immunization not recorded in provider or hand-held records Validated recall data with provider records for 66 of 106 respondents Recall data for 17 children (4.7%) met data inclusion criteria
Baseline measurement	Low risk	Collected baseline data from both groups by face-to-face interviews Intervention and control groups were similar for child's birth order, mother's educational level, maternal age, knowledge of immunization schedule, level of support available from family, maternal work in past year, life difficulties score, and receipt of prenatal care Control group less likely to be living with a partner than intervention group

Young 1980

Methods	Study design: randomized trial Study duration: enrollment using birth records from 1 month, March 1978 Study aim: assess effect of letter reminder on increasing immunization rates among infants at high risk of failing to complete immunization schedule
Participants	Inclusion: 25% sample from Ohio's live, legitimate resident births during March 1978, classified as "high risk"; High risk: had at least 1 parent with less than high school education, regardless of family size; or only 1 parent with some college education and family consisted of 4 or more children, including enrolled child Age: 6 months Controls: selected 10% sample from infants identified as "high risk" Setting: Ohio (USA)

Young 1980 *(Continued)*

	n = 507 patients randomized; 355 respondents
Interventions	Intervention: reminder letter to parents of high risk children, timed to be received 1 October 1978; n = 253 randomized; 179 responded to questionnaire (69.2%) Control: no reminder letter; n = 254 selected at random; 179 responded to questionnaire (70.5%)
Outcomes	Outcome 1, number and percent of children receiving childhood vaccines: 16 percentage point increase over control group Outcome 2, number and per cent of children receiving all needed vaccinations: 12 percentage point increase over control group
Notes	Based on survey of 2-year old immunization levels, parental education and family size were found to be risk factors for failing to complete immunization series by 2 years of age

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Selected 10 percent sample from a list of all live births from 1 month and 1 state, classified as high risk children, to serve as controls; parents of other high risk children received the intervention; randomization method not described
Allocation concealment (selection bias)	Unclear risk	Used Ohio Department of Health birth certificate data to identify eligible children and classify them, by computer, as high or low risk; randomization procedures not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding of participants and personnel not specified
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Outcome assessment blinding not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	November 1978: sent questionnaire to intervention and control parents to inquire about immunization actions taken during October 1978 Contacted parents by telephone if did not respond to mailed questionnaire Obtained questionnaire responses from 70% of participants, 70.5% of control and 69.6% of intervention parents
Selective reporting (reporting bias)	Low risk	Study purpose and methods are described; published data included all expected outcomes to answer study questions
Other bias	Low risk	Compared random sample of mailed questionnaire and telephone responses with provider records; "No inaccuracies were detected"; size of this sample not clear
Baseline measurement	Unclear risk	Based on the questionnaire and telephone data, groups similar for DTP and polio immunization rates before letter was sent; did not report comparisons for other characteristics

Abbreviations:
ACIP: Advisory Committee on Immunization Practices
CBA: controlled before and after study
CHIP: Children's Health Insurance Program

CI: confidence interval
DTP or DTaP: diphtheria tetanus pertussis vaccine
GP: general practitioner
H. flu: *Haemophilus influenzae*
Hib: *Haemophilus influenzae* type B vaccine
HIT: health information technology
HMO: health maintenance organization
MCV: meningococcal vaccine
MMR: measles, mumps, rubella vaccine
OPV: oral poliovirus vaccine
OR: odds ratio
PCV: pneumococcal vaccine
PV: poliovirus
Td: tetanus diphtheria
Tdap: tetanus diphtheria acellular pertussis vaccine
TOPV: trivalent oral polio vaccine
VAR: varicella vaccine

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Abramson 1995	Article was retracted (USA)
Abramson 2010	Multi-modal intervention, consisting of lecture, email reminders, and recruitment of key staff member in each clinic who personally approached each staff member to ask them to get influenza vaccine (Israel)
Ahlers-Schmidt 2012	Primary intervention was text messages; however, intervention and comparison group used appointment card and financial incentives for enrollment; intervention group also received financial incentive for completing post-intervention interview (USA)
Ahmed 2004	Influenza vaccination collected through self-report by telephone and mailed survey; 4 study groups included: 1 postcard; 2 postcards; 1 postcard and employer toolkit; 2 postcards and employer toolkit; no true control group (USA)
Alemi 1996	Study design: not randomized trial, CBA, or ITS (USA)
Anderson 1979	Study design: cross-sectional; no controls (USA)
Aragones 2015	Self-selected participants; first 24 consecutive participants received intensive educational intervention; next 45 participants received educational intervention and text message follow-up; HPV vaccination data obtained by self-report by telephone (USA)
Armstrong 1999	Obtained immunization data by self-report through telephone survey; compared postcard reminder to mailed informational brochure; not a true control group (USA)
Arthur 2002	Compared reminder letter with invitation letter for home visit health check by nurse with immunization offered in home; no true control group; Melton Mowbray, Leicestershire (England)
Asch-Goodkin 2006	Not a study
Bar-Shain 2015	4 potential interventions, varied based on contact information; no control (USA)
Barnes 1999	Primary intervention was use of community volunteers to conduct outreach, generally home visits, with some telephone follow-up and initial letters to introduce study (USA)
Barton 1990	Study design: not randomized trial, CBA, or ITS (USA)

Study	Reason for exclusion
Bell 1993	Study design: survey (Australia)
Berg 2004	Intervention: mailed "marketing" piece Primary outcomes: inpatient hospitalizations and emergency department visits Secondary outcomes: immunizations; clustered participants by family (USA)
Berg 2008	Sent intervention letters in bulk mail, those not delivered were not identified or tracked; presented immunization outcome data as numbers per 10,000 persons rather than presenting numerators and denominators; influenza vaccination was measured using insurance claims data only (USA)
Berhane 1993	Sticker intervention did not meet intervention type inclusion criteria. (Ethiopia)
Bjornson 1999	Immunization data obtained by parent report from approximately 43% of participants; MMR vaccination rates may have been influenced by other vaccination campaigns that occurred in relation to large, university-based measles outbreak (Canada)
Bjorsness 2003	Only 3 time periods in a time series; Great Fall, Montana (USA)
Bond 2009	Intervention included standing order policies (USA)
Bond 2011	Intervention included audit and feedback, provider education, and other interventions (USA)
Britto 2006	Study design unclear, possible ITS; cannot determine effects of patient reminder because a package of interventions was tested; no true baseline data (USA)
Browngoehl 1997	Not randomized trial, CBA, or ITS; retrospective cohort study design (USA)
Bryan 2011	Study results not presented; letter intervention not clearly described, possibly a handout when patients went to a pharmacy
Burns 2002	Intervention was provider reminders through chart-based prompts (USA)
Bussey 1979	Outcome was measles, not vaccination (England and Wales)
Busso 2015	Health workers in all communities were expected to provide some type of reminder; no true control group (Guatemala)
Byrne 1970	Not CBA, randomized trial or ITS (USA)
Campbell 2007	Offered participants free vaccines on a flexible schedule (USA)
Caskey 2011	Intervention included educational posters and clinical reminder in electronic health record
Cassidy 2014	Quasi-experimental design; possibly before and after with historical comparison; convenience samples (USA?)
CDC 2005	Tested multiple interventions to improve influenza vaccinations, such as use of vaccine cart, vaccine days, free vaccinations, and education; not specifically patient reminder or recall (USA)
Cecinati 2010	Compared 3 different types of personal telephone calls (Italy)
Charles 1994	Assessed whether a required signed written consent affected influenza vaccination acceptance among older adults; sent letters to study and control participants (Canada)
Chen2016	Both study groups received text messages (China)

Study	Reason for exclusion
Christensen 2000	Intervention is not fully clear; included tracking effort and clinician notification (USA)
Chung 2015	Multiple interventions including mailed reminders, clinician training, quality improvement, clinician financial incentives to send reminders, school-based intervention with phone calls (USA)
Clayton 1999	Sent postcard to intervention group; comparison group received standard educational intervention, not clearly described (USA)
Cleary 1995	Study design: not randomized trial, CBA, or ITS (USA)
Coleman 2014	Text messages and letter versus letter; no true control group; outcomes were timeliness of vaccination (USA)
Coyne 2000	Intervention involved clinician education and surveys
Crawford 2011	Intervention was postcard-sized handout distributed at a clinic (Australia)
Crittenden 1994	Study design: not randomized trial, CBA, or ITS (UK)
Daniels 2007	Church-based intervention; one group received immunization education; other group involved onsite immunizations (USA)
Desai 2013	Intervention included point-of-service provider reminders (USA)
Dexheimer 2006	Intervention was computerized provider reminder system in emergency department (USA)
Dey 2001	Intervention was public health nurse visit to work sites that included distribution of promotional materials and information about where to obtain free vaccines (UK)
Dini 1995	Outcome: kept immunization appointments (USA)
Djibuti 2009	Intervention consisted of several activities, including guidelines for managers, training in supportive supervision, monitoring and evaluation, and funding for immunization-related activities (Republic of Georgia)
Dombkowski 2014b	Probably retrospective cohort study; if reminders were not received, participants were classified as controls; controls were not-comparable (USA)
Domek 2016	Outcome vaccination data were collected by nurse from parents, possibly by self-report; usual care comparison received written reminders in immunization card; study protocol was reviewed with all participants (Guatemala)
Doratotaj 2008	Comparison group received general intervention, including exposure to posters, newsletters, t-shirts, buttons, departmental meetings, access to expanded hours at influenza vaccination stations; no true control group (USA)
Esposito 2009	Compared 3 different telephone recall interventions contrasting different people making calls (Italy)
Eubelen 2011	Intervention was audiovisual message about tetanus booster vaccination in clinic waiting rooms (Belgium)
Eze 2015	Participants were swapped from intervention and control group after randomization if they did not have cell phones (Nigeria)
Fiks 2009	Intervention was influenza vaccine provider clinical alerts (USA)

Study	Reason for exclusion
Fishbein 2006	Intervention included provider prompts and tested the Immunization Action Coalition's "Do I need any vaccinations today?" (USA)
Frank 1985	Methods described in separate report (Canada)
Frank 2004	Intervention: provider reminders (Australia)
Franzini 2000	Cost and cost-effectiveness study (USA)
Franzini 2007	Intervention was academic detailing (USA)
Freed 1999	Sent letters and postcards to intervention groups; health information group received message "Health is the prize when you immunize"; Law Message group received message "If your kids don't get their shots on time -- it's a crime"; interventions not specifically reminders or recall (USA)
Froehlich 2001	Randomized study groups to 2 different immunization schedules; used various interventions to remind parents about vaccination, including home visits, telephone calls, and postcards; may have provided interventions to both study groups (USA)
Fu 2012	Uncontrolled before and after study with family reminders, provider reminders, education and other interventions (USA)
Fuchs 2006	Intervention is in person discussion between patient and pharmacist and provision of vaccine record to patient; before and after study design (Germany)
Gargano 2011	Adolescents in one county received school-based influenza vaccination education and free vaccination at school-based vaccine clinic; in provider-based county, adolescents received education and free vaccination by local health provider; and controls received neither intervention; non-randomized study (USA)
Garr 1992	Study design: not randomized trial, CBA, or ITS (USA)
Gerace 1988	Study design: not randomized trial, CBA, or ITS (Canada)
Gill 2000	Intervention included patient and provider reminders; before and after study design (USA)
Glenton 2011	Systematic review; interventions delivered by lay health workers
Gnanasekaran 2006	Randomly assigned participants to telephone interview group or comparison group; some telephone reminders occurred; not clearly reminder or recall study; tested effect of parental survey of attitudes on immunization rates (USA)
Goldstein 1999	Intervention consisted of door-to-door outreach by emergency medical technicians to determine immunization status and encourage participants to get well-care visits and immunizations; before and after study design (USA)
Goodyear-Smith 2012	Randomized practices to multi-component intervention group or usual care control group; intervention consisted of brief introduction letter, enclosed immunization information, and follow-up telephone calls; intervention was only delivered to 42% of eligible children; some practices were doing recall before the study (New Zealand)
Gottlieb 2001	Tested Put Prevention Into Practice intervention utilizing office-based interventions; before and after study design (USA)
Grabowski 1996	Editorial

Study	Reason for exclusion
Greengold 2009	Randomized trial with 3 study groups: nurse case management plus tracking and incentives; standard management, incentives, and tracking; standard management and incentives (USA)
Guay 2003	Compared clinic-based vaccination with school-based vaccination (Canada)
Gupta 2003	Study of mammography with discussions of immunizations (Canada)
Hak 1997	Study design: not randomized trial, CBA, or ITS; retrospective questionnaire of one-third of all 4758 general practitioners (The Netherlands)
Hambidge 2004	Intervention includes intensive reminder and recall with audit and feedback, incentives, and other interventions; does not specifically test effect for patient reminder or recall intervention (USA)
Harper 1994	Study design: compared 2 interventions; no real control group Study location: Minnesota (USA)
Hawe 1998	Compared postcard with message based on health belief model to postcard with neutral message (Australia)
Hellerstedt 1999	Intervention included health education, reminders, registry, newsletter, and refrigerator memo with contact information; insufficient data points in time series (USA)
Henderson 2004	Comparison practices used own call or recall system; not a true comparison (Scotland)
Herrett 2016	Comparison practices implemented usual seasonal influenza vaccination campaign, such as posters, and letters to patients (UK)
Hicks 2007	Uncontrolled before and after study with recall cards combined with posters in clinic examination rooms (USA)
Hoekstra 1999	Intervention participants enrolled in Women's Infant and Children (WIC) food and nutrition program were given vouchers once per month instead of every 3 months, until child was up-to-date; intervention was supplemented with telephone calls and mailings when voucher intervention did not work (USA)
Hofstetter 2015a	Usual care control group included influenza vaccine clinical decision support in the electronic health record and "automated phone call reminders for appointments and general information about influenza vaccination procedures provided in the clinic." (USA)
Hofstetter 2015b	Usual care included automated telephone appointment reminders (USA)
Honkanen 1997	Study design: controlled study without baseline data (Finland)
Hutchinson 1995	Study design: survey (USA)
Hutchison 1991	Study design: longitudinal study without control group (Canada)
Irigoyen 2000	Postcard and telephone reminders focused on appointments and were blinded to immunization status; unclear whether reminders focused on immunizations (USA)
Jacobson 1999	Intervention was brochure given to patients at visits (USA)
Johnson 2003	Study design: possibly CBA; randomly selected intervention participants from rural area to receive immunization reminder letter; this geographic area also received multi-faceted community-wide pneumococcal immunization campaign, including television and newspaper advertisements, posters, and brochures; additional participants were selected from a geographic area that did not

Study	Reason for exclusion
	receive media campaign; compared pneumococcal vaccination rates between patient reminder letter group and education campaign plus letter group (USA)
Jordan 2015	Randomized to "usual" text message or "enhanced" text message; no true control group (USA)
Juon 2016	Control participants were sent mailing with list of resources that offered free vaccines (USA)
Kellerman 2000	Intervention was postcard reminder followed by telephone reminder; comparison group also received postcards; no true control group (USA)
Kempe 2004	Intervention not patient reminders; study design not randomized trial, CBA, or ITS (USA)
Kempe 2012a	Involved 3 recall methods within school setting: sent pass to students in class to go to clinic; phone call was made to classroom; and clinic staff member went to classroom to take student to clinic (USA)
Kempe 2012b	Compared centralized versus practice-based reminder and recall; no true control group (USA)
Kempe 2013	Practice-based versus population-based recall (USA)
Kempe 2015	Compared centralized reminder and recall intervention with practice-based reminder and recall interventions (USA)
Kempe 2016	Text messages were either delivered alone, with autodialer, or with email; results not provided separately (USA)
Kempe 2017	Centralized reminder and recall versus practice-based reminder and recall; no true control group (USA)
Kennedy 1994	Study design: not randomized trial, CBA, or ITS (USA)
Kharbanda 2011a	Parents self-selected to receive text messages; parents who opted not to receive test messages served as comparison group; also used historical comparison group (USA)
Kharbanda 2011b	Parents self-selected into intervention group to receive text message reminders; controls had opted out of text message interventions (USA)
Kljakovic 1994	Study design: cohort study (New Zealand)
Kreuter 1996	Study design: pre-test post-test (USA)
Krieger 2000	Obtained immunization outcomes by self-report; control group received some interventions; multiple interventions (USA)
Larson 1979	Study design: cross-sectional (USA)
Leirer 1989	Study design: not randomized trial, CBA, or ITS (USA)
Loeser 1983	Study design: survey; used registry for intervention (Canada)
Ludwig-Beymer 2001	Study design: not randomized trial, CBA, or ITS (USA)
MacIntyre 2003	Study design: compared 2 reminders; no true control group (Australia)
Macknin 2000	Telephone reminder focused on well-child visits (USA)

Study	Reason for exclusion
Margolis 2004	Patient reminders may have been integrated into broader intervention, consisting of continuing medical education and office systems; immunization outcomes cannot be clearly associated with patient reminders (USA)
Marshall 1995	Study design: not randomized trial, CBA, or ITS (Hong Kong)
McDowell 1990	Sustainability of previous study (Canada)
Melnikow 2000	Study design: not randomized trial, CBA, or ITS; multiple interventions and outcomes; complete data not presented (USA)
Milkman 2011	Sent reminder letters to all participants; some were influenza vaccine reminder letters; some with either a prompt to write date when planning to get vaccine or date and time to get vaccine; mid-western utility firm
Minor 2010	Some outcomes were assessed by self-report (USA)
Moore 1981	Study design: not randomized trial, CBA, or ITS (USA)
Moore 2006	Probably a retrospective or prospective cohort study design (USA)
Morgan 1998	In one intervention group, sent questionnaire to parents to obtain details about immunization status; data source for analysis not clearly described (Wales)
Morris 2015	Primary control group comprised people who declined participation; secondary control group comprised people who "were not contacted by phone" but met eligibility criteria (USA)
Muehleisen 2007	Intervention was immunization reminders to parents when child was hospitalized, reminding parents to contact care provider for immunization appointment after hospitalization; measured immunization status by self-report (Switzerland)
Nace 2007	Intervention included vaccine planning, staff education, paycheck notices reminding employees where to obtain vaccines, vaccination access at work, contact with unimmunized staff, data tracking, and performance feedback; time series lacked sufficient data points (USA)
Newman 1983	Study design: not randomized trial, ITS, or CBA; study of computer intervention (England and Wales)
Nichol 1990	Study design: not randomized trial, CBA, or ITS (USA)
Nichol 1992	Study design: cross-sectional; not randomized trial, CBA, or ITS (USA)
Nichol 1998	Multiple interventions, including annual publicity mailing, walk-in clinics, and nurse standing orders; time series did not include sufficient baseline data collection or clear intervention points; vaccination status obtained by survey (USA)
Niederhauser 2015	All participants received routine reminders from health services providers; financial incentives were given to encourage study participation (USA)
Norman 1995	Report; not a study Location: Swedish Family Medicine Clinic (USA)
Nowalk 2005	Each of 5 intervention sites delivered combination of patient-, provider-, and system-oriented strategies; specific interventions not clearly described for each site (USA)

Study	Reason for exclusion
Nowalk 2008	Interventions were menu of patient reminders, provider reminders, provider education, and systems-based interventions; combination interventions did not clearly fit into our comparison categories (USA)
Nowalk 2010	Control group received emails and other advertising; collected data from employer surveys; one intervention group received financial incentive (USA)
Nuttall 2003	Study groups included: invitation letter to receive influenza vaccination; letter and "leaflet"; and letter and invitation to visit at home; no true control group (United Kingdom)
Nyamathi 2009	Interventions included nurse case management with incentives and tracking, standard care with incentives and tracking, and standard care with incentives (USA)
Ornstein 1995	Study design: ITS with fewer than 2 data points (USA)
Parraga-Martinez 2015	Focus on adherence to lifestyle and other medical recommendations; not clear if immunizations will be an outcome in this proposed trial (Spain)
Paskett 2016	Financial incentive for questionnaire; mailing of information to intervention and comparison group; no true control group; multi-level intervention (USA)
Patel 2012	Intervention: face-to-face discussion at clinic, review of written information, and mailing of packet with reminder letter and information; comparison: given flier about HPV vaccination at clinic visit; used self-report for some outcomes (USA)
Patel 2014	Mailed reminders were sent from 2 control practices; participants self-selected intervention types, including text, email, phone, Facebook, or standard mail; excluded patients who did not want to be contacted with reminders (USA)
Paunio 1991	Study design: not clear; polio campaign may distort findings (Finland)
Payaprom 2011	Compared 3 different brochures to enhance influenza vaccination (Thailand)
Payne 1993	Study aim: validate computer tracking system (USA)
Persell 2011	Intervention involved outreach, telephone call attempts, and mailed brochures about 5 refused preventive services; may be refusal conversion study rather than reminder or recall; possibly CBA study design (USA)
Phibbs 2006	Study design: post-hoc analysis of clustered randomized trial; tracked "inactive" infants; not focused specifically on patient reminders (USA)
Pierce 1996	Intervention is "Standards for Pediatric Immunization Practice" rather than patient reminders Study location: New Mexico (USA)
Quinley 2004	Intervention was audit and feedback with supplemental outreach to intervention group providers (USA)
Reid 1984	Study design: not randomized trial, CBA, ITS; no control group (probably New Zealand)
Rhew 1999	Study design: "prospective controlled trial"; possibly prospective cohort study; no true control group; not patient reminders (USA)
Richman 2016	Participants received financial incentive and opportunity to receive Apple iPad; text message and email reminder data not separated; data collect by survey (USA)

Study	Reason for exclusion
Rock 2009	Combination intervention, including SMS texting regarding availability of influenza vaccination; cannot clearly distinguish effect of patient reminder
Rosenberg 1995	Study design: not randomized trial, CBA, or true ITS; not enough data points (USA)
Russell 2012	Compared text message appointment reminder with traditional appointment reminder on visit attendance and immunization series completion
Saunders 1970	Study aim: cost analysis (England and Wales)
Sellors 1997	Study design: randomized trial of 2 interventions; compared telephone and mail reminder with mail only reminders; no true control group (Canada)
Shefer 2006	Not a study; results of symposium (USA)
Shoup 2015	3 intervention groups; no true control group (USA)
Smith 1999	Obtained vaccination data from self-report; Indiana (USA)
Stewart 1997	Study design: not randomized trial, ITS, or CBA; compared 2 interventions (Canada)
Stockwell 2012b	Intervention and control groups received automated telephone reminder for influenza vaccination; intervention group also received text message reminder (USA)
Stockwell 2014	Intervention was text message reminders for influenza vaccination; both groups received telephone reminders; no true control group (USA)
Stockwell 2015	Compared written reminder, basic text reminder, and educational text reminder; no true control group (USA)
Szilagyi 2002	Electronic abstract only (USA)
Terrell-Perica 2001	Launched full immunization campaign during study period, including press releases, special immunization clinics at pharmacies and stores, and health education kits mailed to physicians; interventions were reminder letters for influenza vaccination only and pneumococcal and influenza vaccination; Medicare beneficiaries (USA)
Thompson 1995	Discussion of large number of preventive practices over 20 years, but study details not reported (USA)
Tiro 2015	Financial incentive; all participants had scheduled visits; invitational letters and educational materials sent to all 1 to 2 weeks before the visit (USA)
Tucker 1987	Study design: post-test; mailed cues (USA)
Turner 1990	Intervention: patient carried cards; not true patient reminder (USA)
Turner 1994	Intervention: patient carried cards; no real control group (USA)
Van Essen 1997	Study design: "non-equivalent control group design"; pre-test, post-test; interventions include organizational changes, such as mail prompt, stocking of vaccine, and others; not able to measure effect of mail prompt (The Netherlands)
Vernon 1976	Study design: not randomized trial, CBA, or ITS; no control group; not patient reminder or recall intervention study (USA)

Study	Reason for exclusion
Vilella 2004	Study design: not randomized trial, CBA, or ITS (Spain)
Vincent 1995	Study design: pre-test post-test (USA)
Wakadha 2013	Comparison group included interventions; provided financial incentives as conditional cash transfers ("mMoney") or airtime (Kenya)
Walter 2008	Compared 2 postcard reminders; sent postcard reminder with educational message about influenza vaccination safety for persons with asthma to intervention group; comparison postcard did not include educational message; no true control group (USA)
Waterman 1996	Multiple interventions (USA)
Weaver 2003	Obtained vaccination data from mailed surveys and telephone follow-up Veterans Affairs centers (USA)
Weaver 2007	Combined mailed reminder letters with other interventions; time series lacked sufficient number of measures; no control group (USA)
Wilcox 2001	Reported data on community outreach intervention (USA)
Wojciechowski 1993	Published abstract; manuscript unpublished (USA)
Wright 2012	Intervention: combination of patient reminder within electronic personal health record and provider reminders, with both groups receiving provider reminder; convenience sample of patients who agreed to participate in study (USA)
Yanagihara 2005	Combination of population-based and other interventions; not clear who received various types of interventions; study design not clear (USA)
Yokley 1984	Outcome: number of immunization visits and number of immunizations (USA)
Yudin 2017	Obtained outcome data by telephone interview (Canada)
Zimmerman 2003	Study design: not randomized trial, CBA, or ITS; no true control group; interventions varied by practice; possibility of patient reminders being included (USA)

CBA: controlled before and after study
HPV: human papillomavirus
ITS: interrupted time series
MMR: measles, mumps, rubella

DATA AND ANALYSES

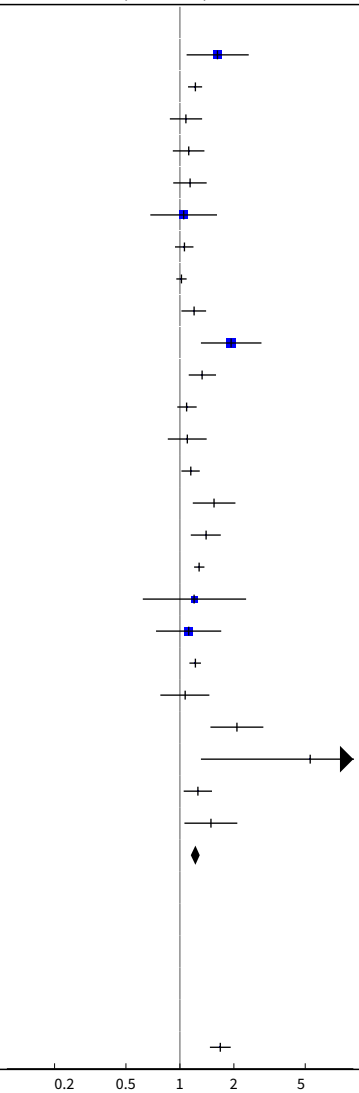
Comparison 1. Patient reminders (summary)

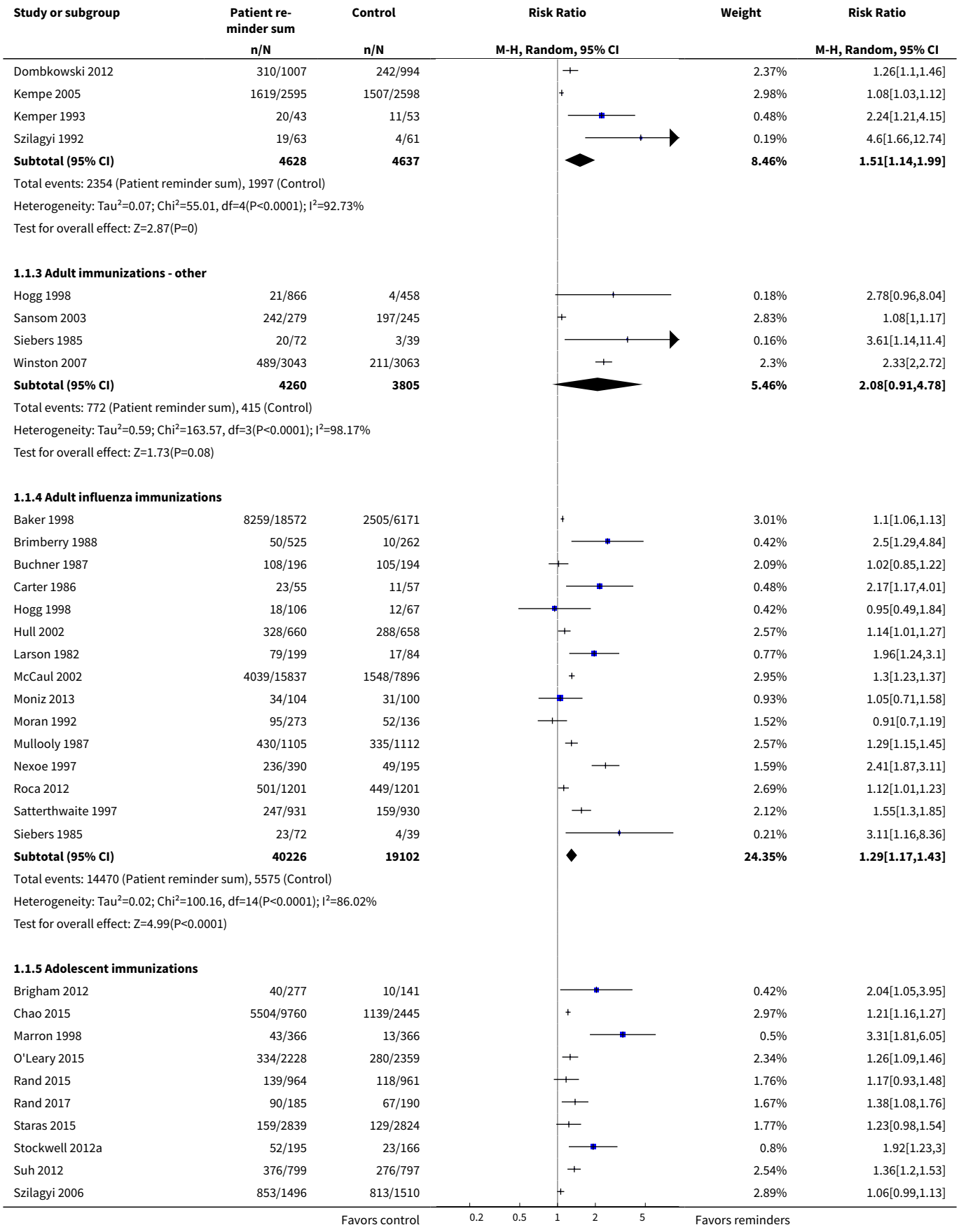
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	55	138625	Risk Ratio (M-H, Random, 95% CI)	1.28 [1.23, 1.35]
1.1 Childhood immunizations	23	31099	Risk Ratio (M-H, Random, 95% CI)	1.22 [1.15, 1.29]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.2 Childhood influenza immunizations	5	9265	Risk Ratio (M-H, Random, 95% CI)	1.51 [1.14, 1.99]
1.3 Adult immunizations - other	4	8065	Risk Ratio (M-H, Random, 95% CI)	2.08 [0.91, 4.78]
1.4 Adult influenza immunizations	15	59328	Risk Ratio (M-H, Random, 95% CI)	1.29 [1.17, 1.43]
1.5 Adolescent immunizations	10	30868	Risk Ratio (M-H, Random, 95% CI)	1.29 [1.17, 1.42]

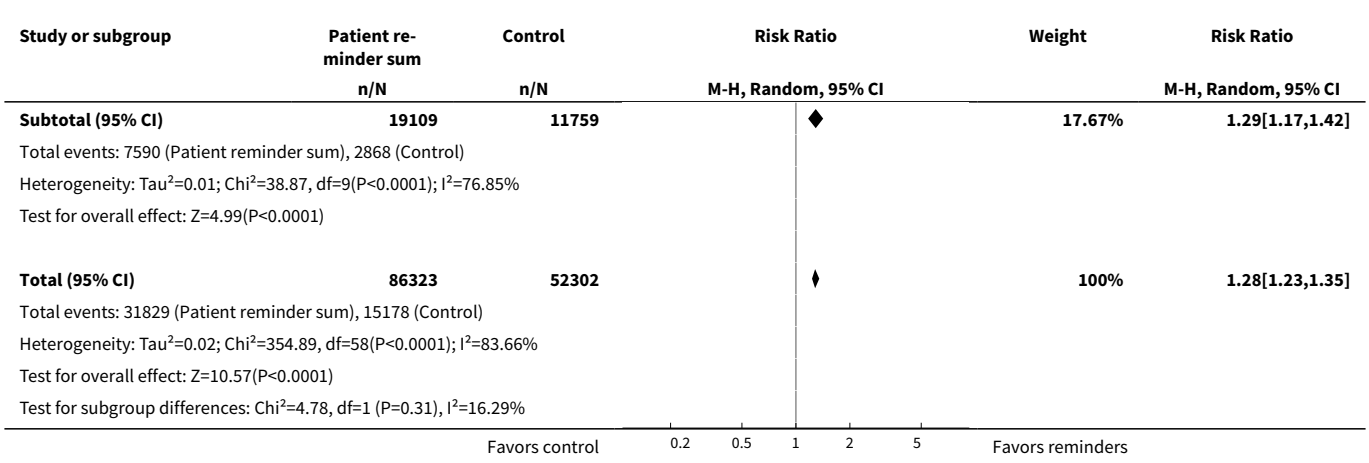
Analysis 1.1. Comparison 1 Patient reminders (summary), Outcome 1 Immunized.

Study or subgroup	Patient reminder sum n/N	Control n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
1.1.1 Childhood immunizations					
Alto 1994	49/213	33/233		0.94%	1.62[1.09,2.42]
Bangure 2015	146/152	120/152		2.76%	1.22[1.11,1.33]
Campbell 1994	111/183	59/105		1.92%	1.08[0.88,1.33]
CDC 2012	139/438	125/440		1.94%	1.12[0.91,1.37]
Daley 2002	140/610	126/624		1.86%	1.14[0.92,1.41]
Daley 2004b	35/205	35/215		0.85%	1.05[0.68,1.61]
Dombkowski 2014	370/1058	335/1014		2.54%	1.06[0.94,1.19]
Dombkowski 2014	871/1741	863/1761		2.88%	1.02[0.95,1.09]
Dombkowski 2014	628/3489	167/1112		2.27%	1.2[1.02,1.4]
Ferson 1995	35/49	20/54		0.97%	1.93[1.31,2.85]
Hambidge 2009	180/408	132/399		2.12%	1.33[1.12,1.59]
Irigoyen 2006	275/549	257/561		2.52%	1.09[0.97,1.24]
Kempe 2001	89/294	85/309		1.62%	1.1[0.86,1.41]
LeBaron 2004	599/1527	260/763		2.57%	1.15[1.02,1.29]
Lieu 1997	82/153	47/136		1.48%	1.55[1.18,2.04]
Lieu 1998	322/648	78/219		2%	1.4[1.15,1.69]
Linkins 1994	1684/4636	955/3366		2.89%	1.28[1.2,1.37]
Mason 2000	18/255	15/256		0.42%	1.2[0.62,2.34]
Oeffinger 1992	33/116	31/122		0.88%	1.12[0.74,1.7]
Soljak 1987	539/709	382/613		2.84%	1.22[1.13,1.31]
Stehr-Green 1993	46/101	41/96		1.27%	1.07[0.78,1.46]
Tollestrup 1991	53/81	29/92		1.16%	2.08[1.48,2.92]
Vivier 2000	29/193	2/71		0.11%	5.33[1.31,21.78]
Wood 1998	119/186	92/181		2.1%	1.26[1.05,1.51]
Young 1980	51/106	34/105		1.16%	1.49[1.06,2.09]
Subtotal (95% CI)	**18100**	**12999**		**44.06%**	**1.22[1.15,1.29]**
Total events: 6643 (Patient reminder sum), 4323 (Control)					
Heterogeneity: Tau^2=0.01; Chi^2=66.55, df=24(P<0.0001); I^2=63.94%					
Test for overall effect: Z=6.7(P<0.0001)					
1.1.2 Childhood influenza immunizations					
Daley 2004a	386/920	233/931		2.44%	1.68[1.47,1.92]





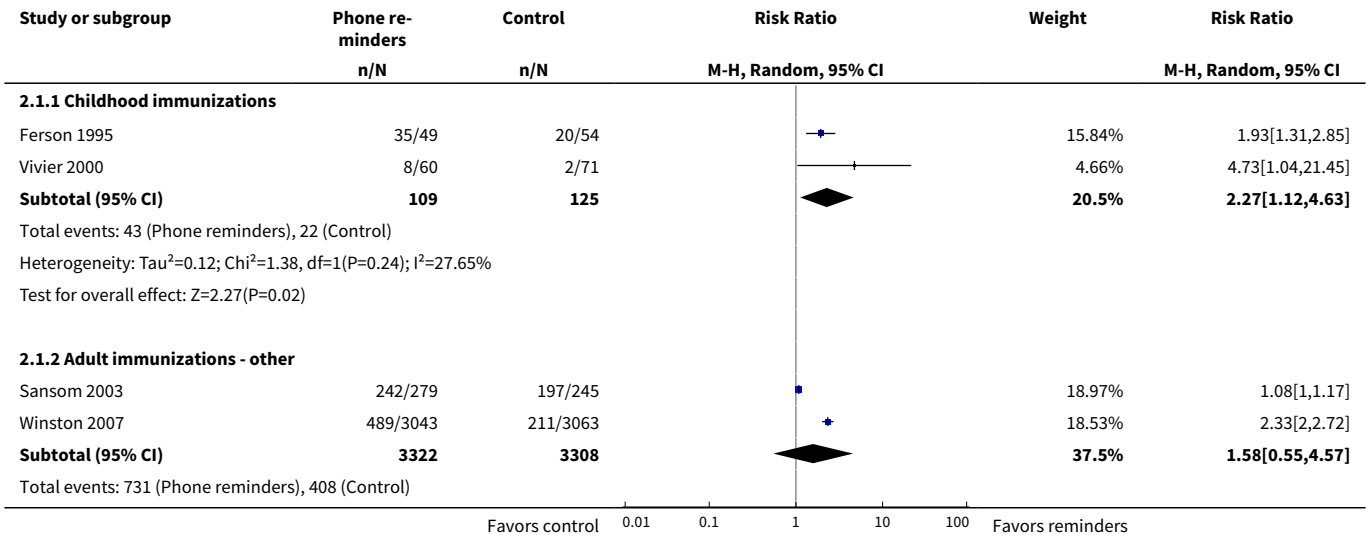
Study or subgroup	Patient reminder sum n/N	Control n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
Dombkowski 2012	310/1007	242/994		2.37%	1.26[1.1,1.46]
Kempe 2005	1619/2595	1507/2598		2.98%	1.08[1.03,1.12]
Kemper 1993	20/43	11/53		0.48%	2.24[1.21,4.15]
Szilagyi 1992	19/63	4/61		0.19%	4.6[1.66,12.74]
Subtotal (95% CI)	**4628**	**4637**		**8.46%**	**1.51[1.14,1.99]**
Total events: 2354 (Patient reminder sum), 1997 (Control)					
Heterogeneity: Tau²=0.07; Chi²=55.01, df=4(P<0.0001); I²=92.73%					
Test for overall effect: Z=2.87(P=0)					
1.1.3 Adult immunizations - other					
Hogg 1998	21/866	4/458		0.18%	2.78[0.96,8.04]
Sansom 2003	242/279	197/245		2.83%	1.08[1,1.17]
Siebers 1985	20/72	3/39		0.16%	3.61[1.14,11.4]
Winston 2007	489/3043	211/3063		2.3%	2.33[2,2.72]
Subtotal (95% CI)	**4260**	**3805**		**5.46%**	**2.08[0.91,4.78]**
Total events: 772 (Patient reminder sum), 415 (Control)					
Heterogeneity: Tau²=0.59; Chi²=163.57, df=3(P<0.0001); I²=98.17%					
Test for overall effect: Z=1.73(P=0.08)					
1.1.4 Adult influenza immunizations					
Baker 1998	8259/18572	2505/6171		3.01%	1.1[1.06,1.13]
Brimberry 1988	50/525	10/262		0.42%	2.5[1.29,4.84]
Buchner 1987	108/196	105/194		2.09%	1.02[0.85,1.22]
Carter 1986	23/55	11/57		0.48%	2.17[1.17,4.01]
Hogg 1998	18/106	12/67		0.42%	0.95[0.49,1.84]
Hull 2002	328/660	288/658		2.57%	1.14[1.01,1.27]
Larson 1982	79/199	17/84		0.77%	1.96[1.24,3.1]
McCaul 2002	4039/15837	1548/7896		2.95%	1.3[1.23,1.37]
Moniz 2013	34/104	31/100		0.93%	1.05[0.71,1.58]
Moran 1992	95/273	52/136		1.52%	0.91[0.7,1.19]
Mullooly 1987	430/1105	335/1112		2.57%	1.29[1.15,1.45]
Nexoe 1997	236/390	49/195		1.59%	2.41[1.87,3.11]
Roca 2012	501/1201	449/1201		2.69%	1.12[1.01,1.23]
Satterthwaite 1997	247/931	159/930		2.12%	1.55[1.3,1.85]
Siebers 1985	23/72	4/39		0.21%	3.11[1.16,8.36]
Subtotal (95% CI)	**40226**	**19102**		**24.35%**	**1.29[1.17,1.43]**
Total events: 14470 (Patient reminder sum), 5575 (Control)					
Heterogeneity: Tau²=0.02; Chi²=100.16, df=14(P<0.0001); I²=86.02%					
Test for overall effect: Z=4.99(P<0.0001)					
1.1.5 Adolescent immunizations					
Brigham 2012	40/277	10/141		0.42%	2.04[1.05,3.95]
Chao 2015	5504/9760	1139/2445		2.97%	1.21[1.16,1.27]
Marron 1998	43/366	13/366		0.5%	3.31[1.81,6.05]
O'Leary 2015	334/2228	280/2359		2.34%	1.26[1.09,1.46]
Rand 2015	139/964	118/961		1.76%	1.17[0.93,1.48]
Rand 2017	90/185	67/190		1.67%	1.38[1.08,1.76]
Staras 2015	159/2839	129/2824		1.77%	1.23[0.98,1.54]
Stockwell 2012a	52/195	23/166		0.8%	1.92[1.23,3]
Suh 2012	376/799	276/797		2.54%	1.36[1.2,1.53]
Szilagyi 2006	853/1496	813/1510		2.89%	1.06[0.99,1.13]

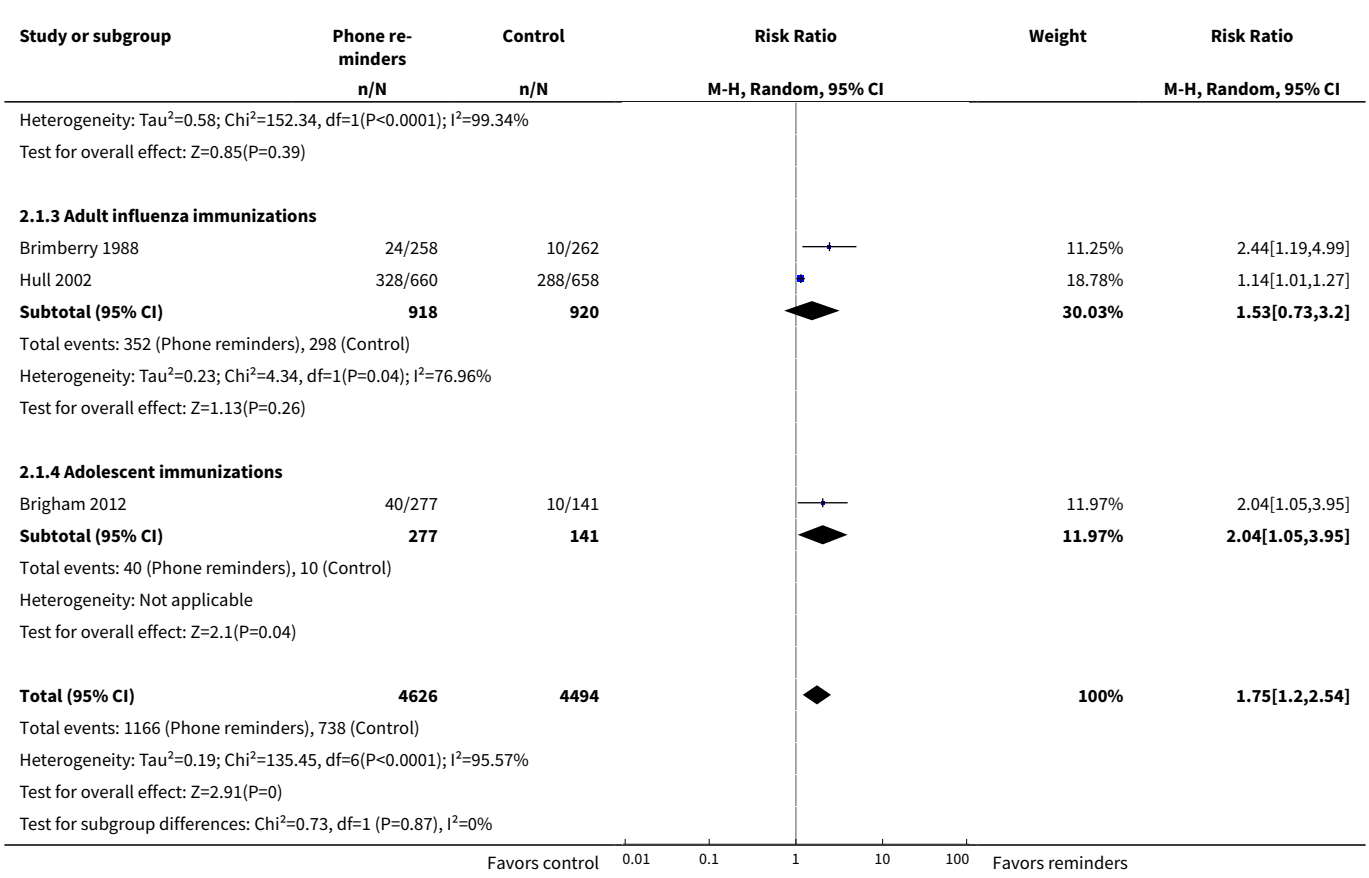


Comparison 2. Patient telephone reminder or recall

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	7	9120	Risk Ratio (M-H, Random, 95% CI)	1.75 [1.20, 2.54]
1.1 Childhood immunizations	2	234	Risk Ratio (M-H, Random, 95% CI)	2.27 [1.12, 4.63]
1.2 Adult immunizations - other	2	6630	Risk Ratio (M-H, Random, 95% CI)	1.58 [0.55, 4.57]
1.3 Adult influenza immunizations	2	1838	Risk Ratio (M-H, Random, 95% CI)	1.53 [0.73, 3.20]
1.4 Adolescent immunizations	1	418	Risk Ratio (M-H, Random, 95% CI)	2.04 [1.05, 3.95]

Analysis 2.1. Comparison 2 Patient telephone reminder or recall, Outcome 1 Immunized.



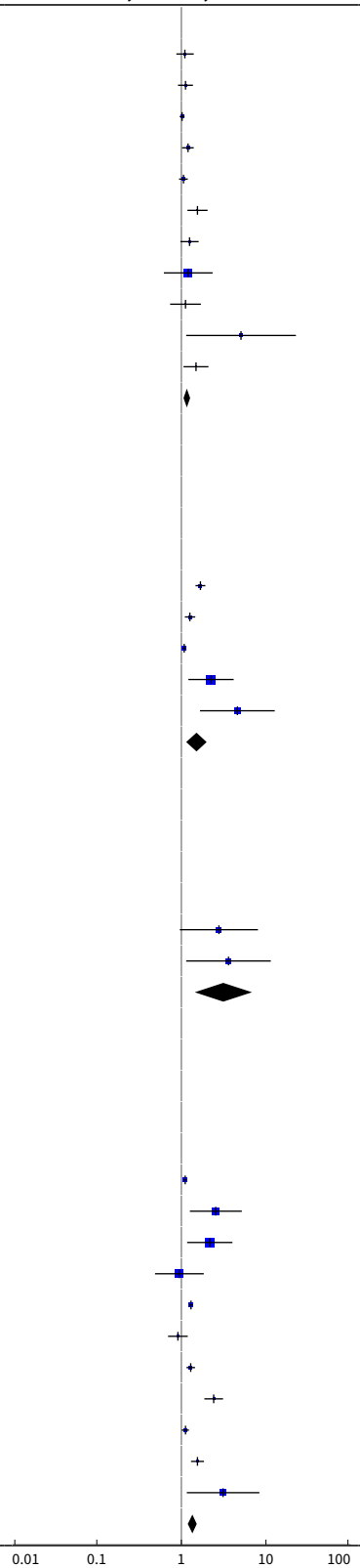


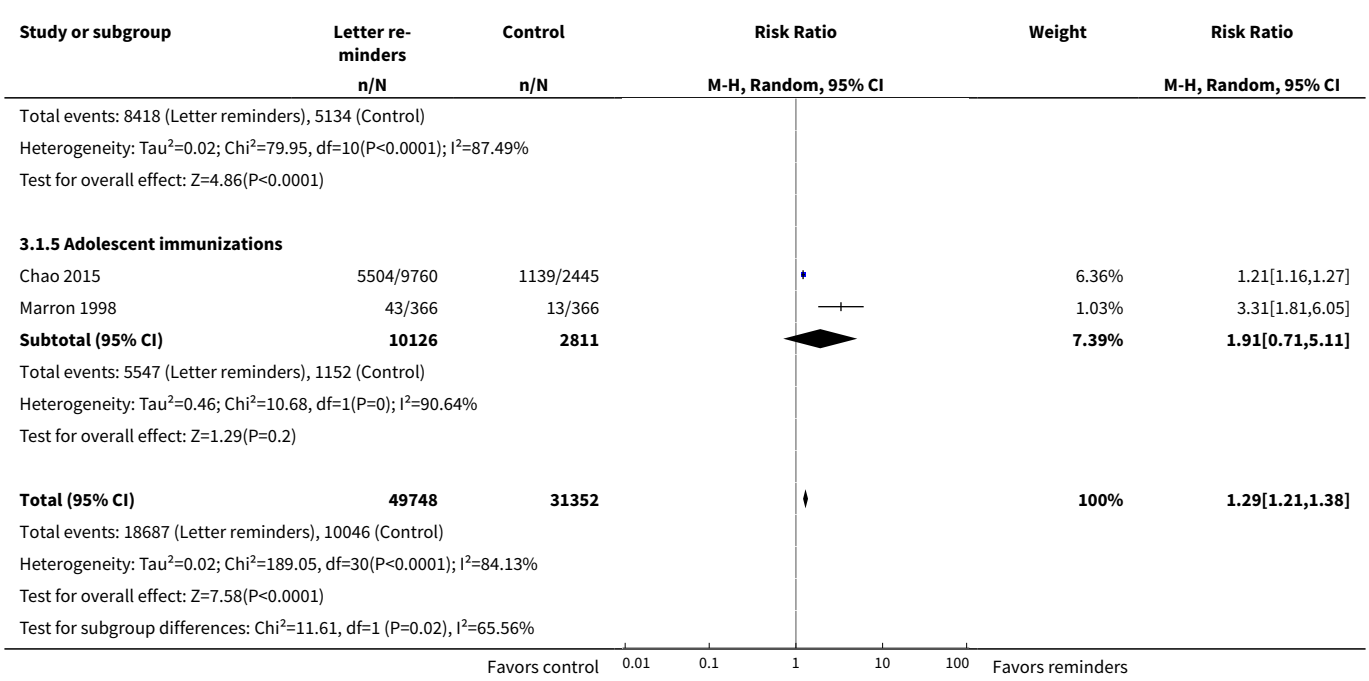
Comparison 3. Patient letter reminder or recall

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	27	81100	Risk Ratio (M-H, Random, 95% CI)	1.29 [1.21, 1.38]
1.1 Childhood immunizations	9	13009	Risk Ratio (M-H, Random, 95% CI)	1.16 [1.06, 1.27]
1.2 Childhood influenza immunizations	5	9265	Risk Ratio (M-H, Random, 95% CI)	1.51 [1.14, 1.99]
1.3 Adult immunizations - other	2	1435	Risk Ratio (M-H, Random, 95% CI)	3.13 [1.44, 6.84]
1.4 Adult influenza immunizations	11	44454	Risk Ratio (M-H, Random, 95% CI)	1.35 [1.19, 1.52]
1.5 Adolescent immunizations	2	12937	Risk Ratio (M-H, Random, 95% CI)	1.91 [0.71, 5.11]

Analysis 3.1. Comparison 3 Patient letter reminder or recall, Outcome 1 Immunized.

Study or subgroup	Letter reminders n/N	Control n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
3.1.1 Childhood immunizations					
Campbell 1994	54/87	59/105		3.61%	1.1[0.87,1.4]
CDC 2012	139/438	125/440		4.09%	1.12[0.91,1.37]
Dombkowski 2014	871/1741	863/1761		6.15%	1.02[0.95,1.09]
Dombkowski 2014	628/3489	167/1112		4.81%	1.2[1.02,1.4]
Dombkowski 2014	370/1058	335/1014		5.41%	1.06[0.94,1.19]
Lieu 1997	82/153	47/136		3.11%	1.55[1.18,2.04]
Lieu 1998	72/162	78/219		3.44%	1.25[0.97,1.6]
Mason 2000	18/255	15/256		0.88%	1.2[0.62,2.34]
Oeffinger 1992	33/116	31/122		1.83%	1.12[0.74,1.7]
Vivier 2000	9/63	2/71		0.19%	5.07[1.14,22.6]
Young 1980	51/106	34/105		2.43%	1.49[1.06,2.09]
Subtotal (95% CI)	**7668**	**5341**		**35.95%**	**1.16[1.06,1.27]**
Total events: 2327 (Letter reminders), 1756 (Control)					
Heterogeneity: Tau^2=0.01; Chi^2=20.49, df=10(P=0.02); I^2=51.18%					
Test for overall effect: Z=3.17(P=0)					
3.1.2 Childhood influenza immunizations					
Daley 2004a	386/920	233/931		5.17%	1.68[1.47,1.92]
Dombkowski 2012	310/1007	242/994		5.03%	1.26[1.1,1.46]
Kempe 2005	1619/2595	1507/2598		6.37%	1.08[1.03,1.12]
Kemper 1993	20/43	11/53		0.99%	2.24[1.21,4.15]
Szilagyi 1992	19/63	4/61		0.4%	4.6[1.66,12.74]
Subtotal (95% CI)	**4628**	**4637**		**17.98%**	**1.51[1.14,1.99]**
Total events: 2354 (Letter reminders), 1997 (Control)					
Heterogeneity: Tau^2=0.07; Chi^2=55.01, df=4(P<0.0001); I^2=92.73%					
Test for overall effect: Z=2.87(P=0)					
3.1.3 Adult immunizations - other					
Hogg 1998	21/866	4/458		0.37%	2.78[0.96,8.04]
Siebers 1985	20/72	3/39		0.32%	3.61[1.14,11.4]
Subtotal (95% CI)	**938**	**497**		**0.69%**	**3.13[1.44,6.84]**
Total events: 41 (Letter reminders), 7 (Control)					
Heterogeneity: Tau^2=0; Chi^2=0.11, df=1(P=0.74); I^2=0%					
Test for overall effect: Z=2.87(P=0)					
3.1.4 Adult influenza immunizations					
Baker 1998	2780/6151	2505/6171		6.4%	1.11[1.07,1.16]
Brimberry 1988	26/267	10/262		0.78%	2.55[1.26,5.18]
Carter 1986	23/55	11/57		1%	2.17[1.17,4.01]
Hogg 1998	18/106	12/67		0.88%	0.95[0.49,1.84]
McCaul 2002	4039/15837	1548/7896		6.31%	1.3[1.23,1.37]
Moran 1992	95/273	52/136		3.18%	0.91[0.7,1.19]
Mullooly 1987	430/1105	335/1112		5.47%	1.29[1.15,1.45]
Nexoe 1997	236/390	49/195		3.35%	2.41[1.87,3.11]
Roca 2012	501/1201	449/1201		5.73%	1.12[1.01,1.23]
Satterthwaite 1997	247/931	159/930		4.48%	1.55[1.3,1.85]
Siebers 1985	23/72	4/39		0.43%	3.11[1.16,8.36]
Subtotal (95% CI)	**26388**	**18066**		**37.99%**	**1.35[1.19,1.52]**

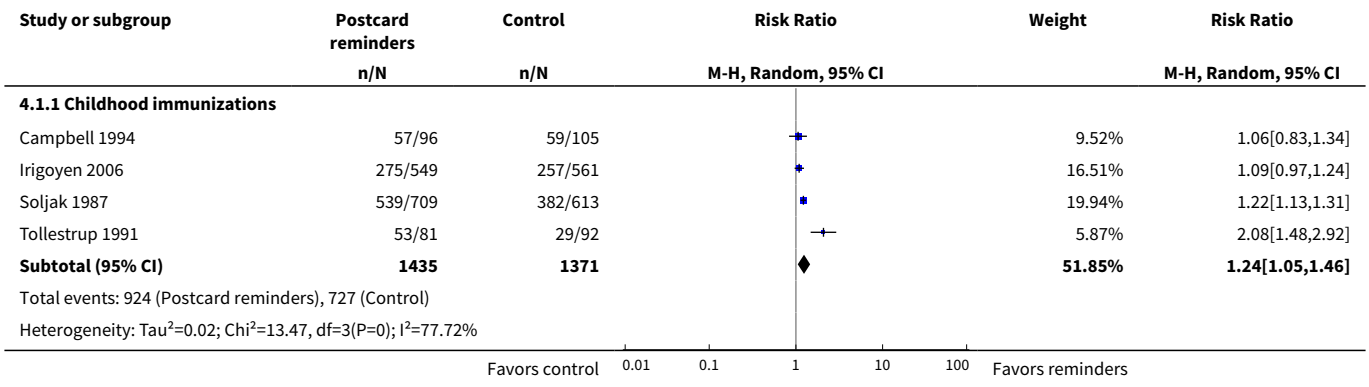


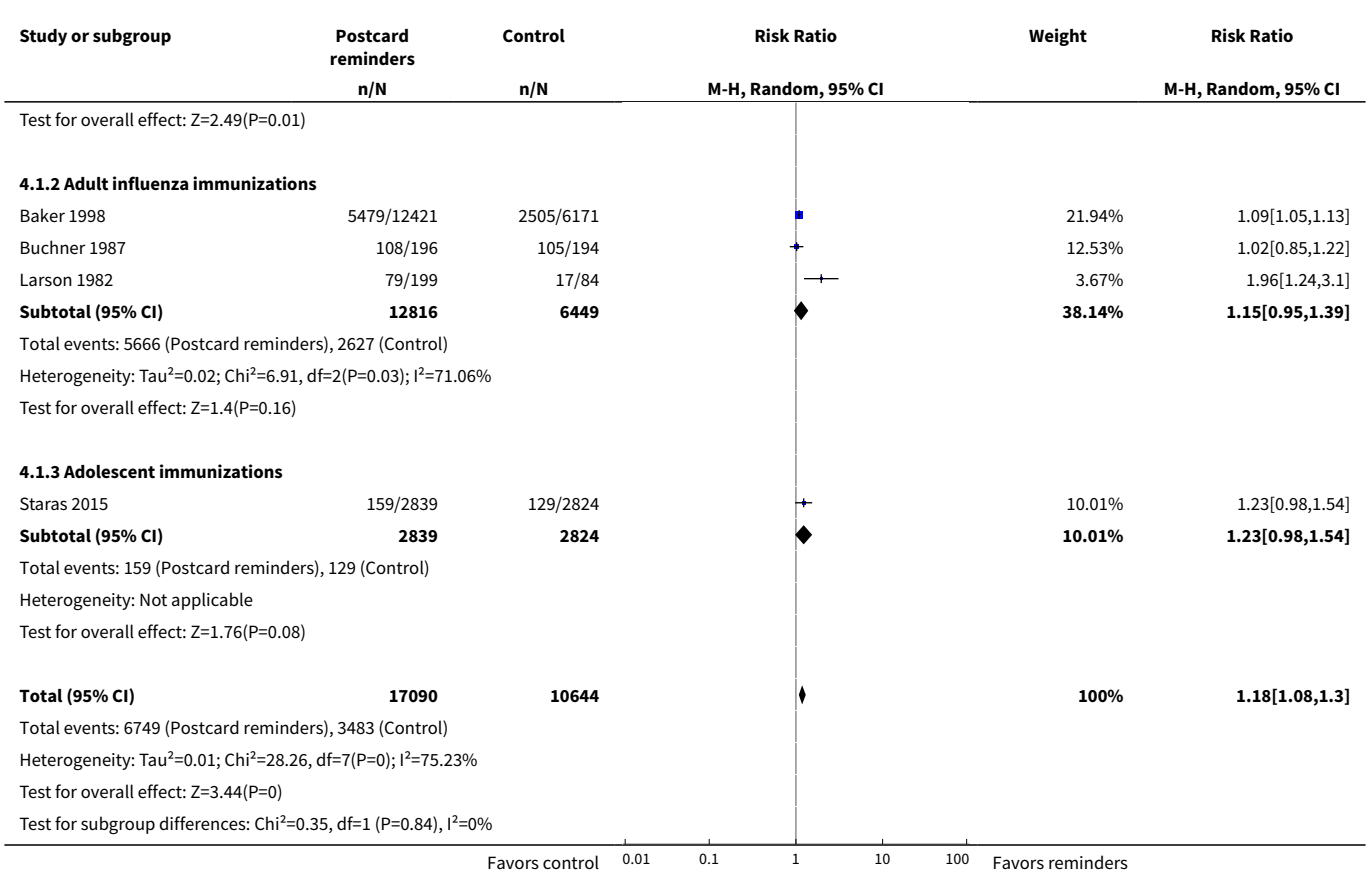


Comparison 4. Patient postcard reminder or recall

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	8	27734	Risk Ratio (M-H, Random, 95% CI)	1.18 [1.08, 1.30]
1.1 Childhood immunizations	4	2806	Risk Ratio (M-H, Random, 95% CI)	1.24 [1.05, 1.46]
1.2 Adult influenza immunizations	3	19265	Risk Ratio (M-H, Random, 95% CI)	1.15 [0.95, 1.39]
1.3 Adolescent immunizations	1	5663	Risk Ratio (M-H, Random, 95% CI)	1.23 [0.98, 1.54]

Analysis 4.1. Comparison 4 Patient postcard reminder or recall, Outcome 1 Immunized.

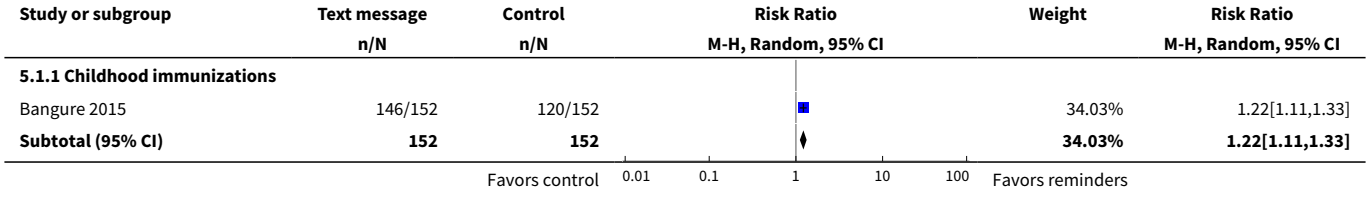


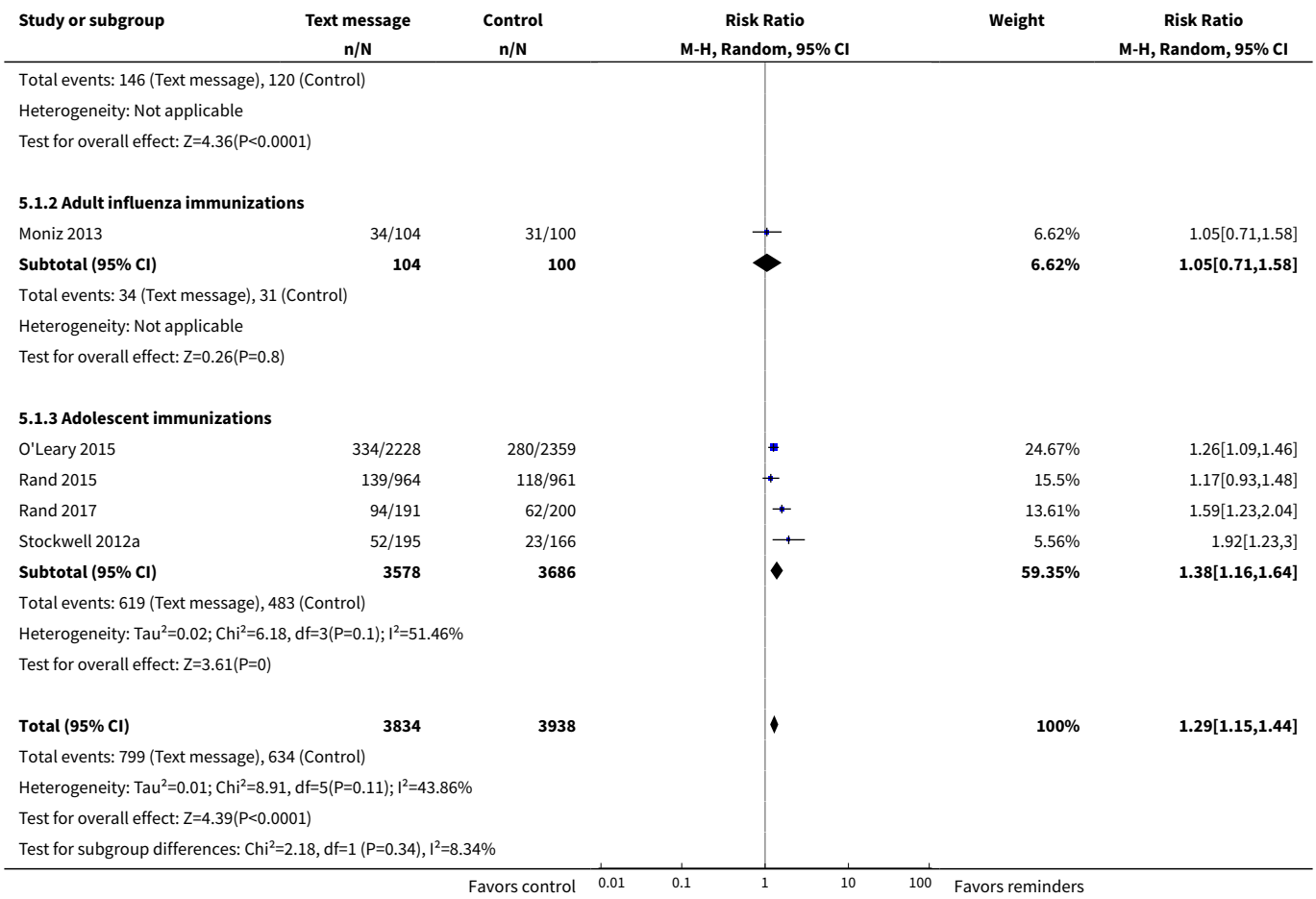


Comparison 5. Patient text message reminder or recall

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	6	7772	Risk Ratio (M-H, Random, 95% CI)	1.29 [1.15, 1.44]
1.1 Childhood immunizations	1	304	Risk Ratio (M-H, Random, 95% CI)	1.22 [1.11, 1.33]
1.2 Adult influenza immunizations	1	204	Risk Ratio (M-H, Random, 95% CI)	1.05 [0.71, 1.58]
1.3 Adolescent immunizations	4	7264	Risk Ratio (M-H, Random, 95% CI)	1.38 [1.16, 1.64]

Analysis 5.1. Comparison 5 Patient text message reminder or recall, Outcome 1 Immunized.

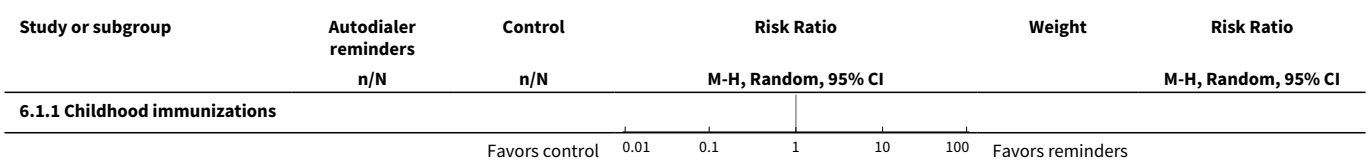


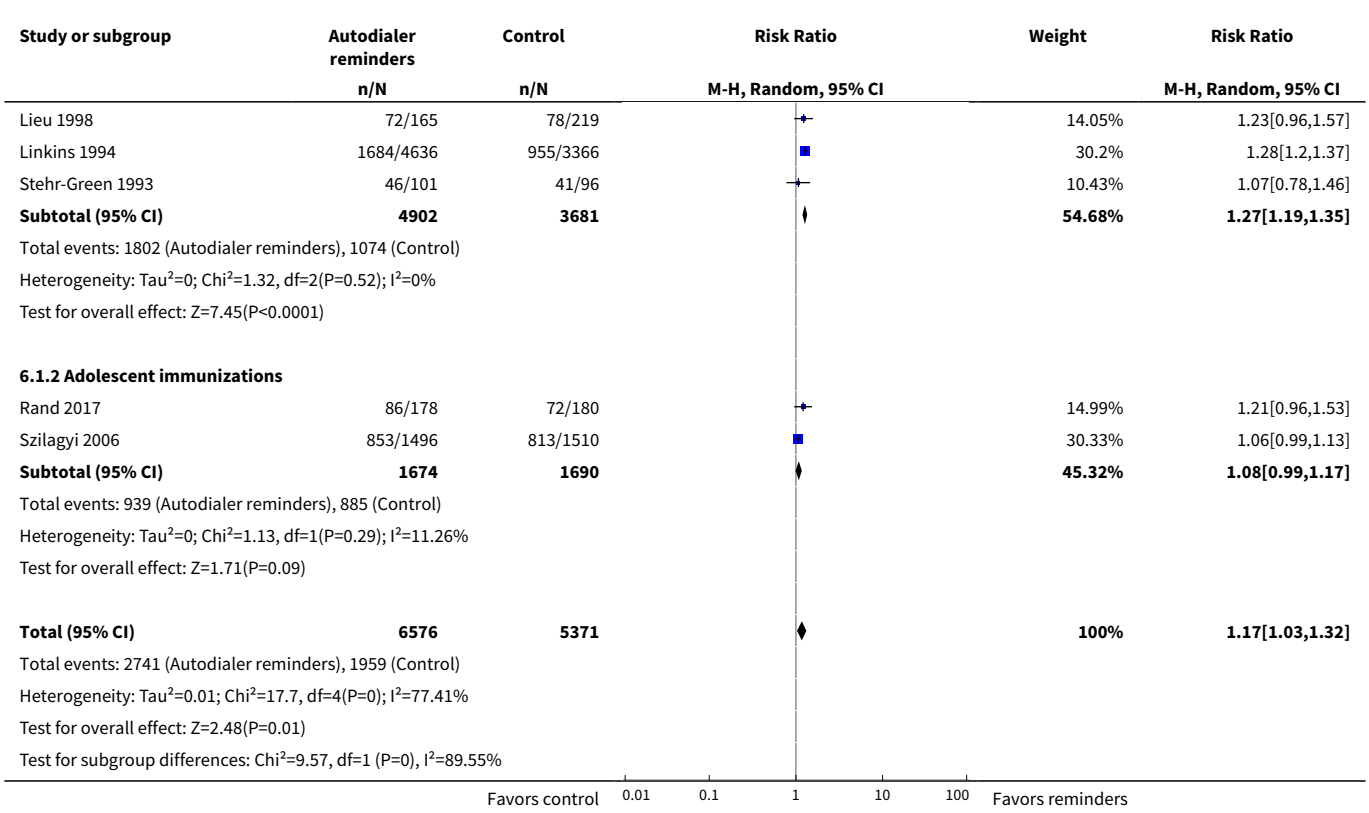


Comparison 6. Patient autodialer message reminder or recall

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	5	11947	Risk Ratio (M-H, Random, 95% CI)	1.17 [1.03, 1.32]
1.1 Childhood immunizations	3	8583	Risk Ratio (M-H, Random, 95% CI)	1.27 [1.19, 1.35]
1.2 Adolescent immunizations	2	3364	Risk Ratio (M-H, Random, 95% CI)	1.08 [0.99, 1.17]

Analysis 6.1. Comparison 6 Patient autodialer message reminder or recall, Outcome 1 Immunized.

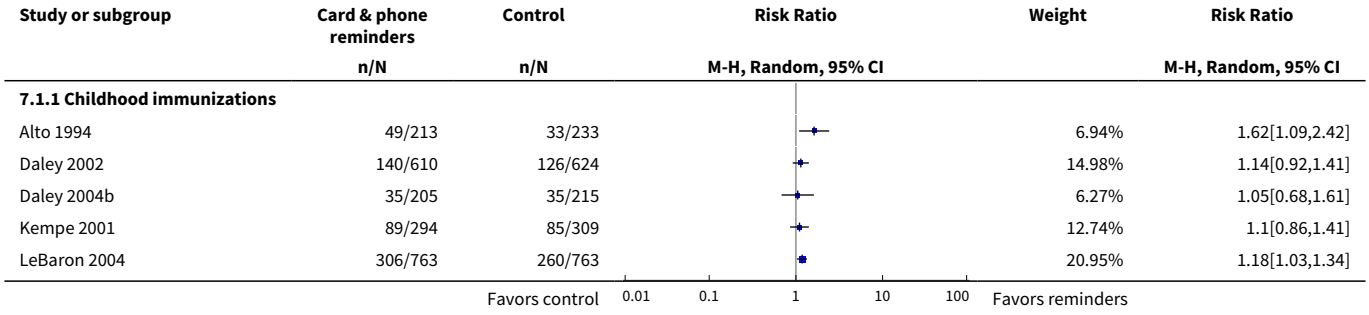


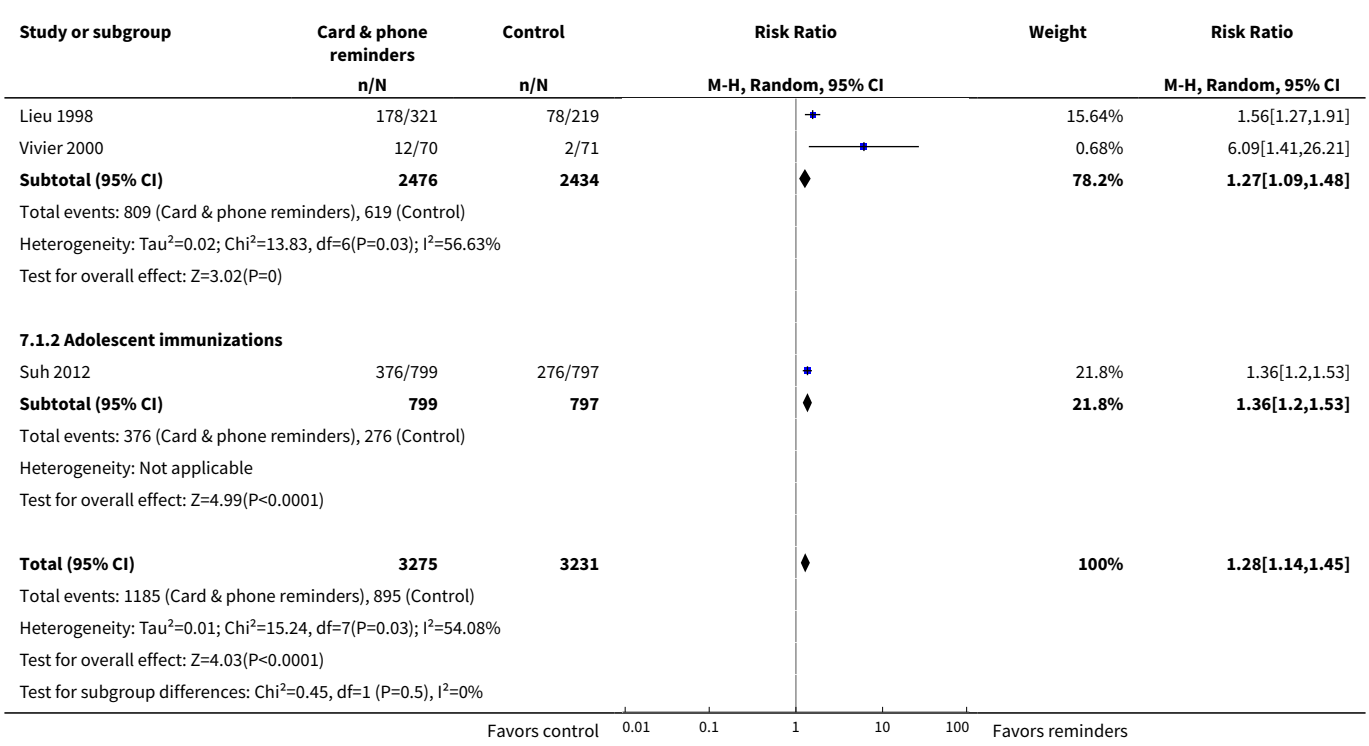


Comparison 7. Combination patient mail and telephone reminder or recall

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	8	6506	Risk Ratio (M-H, Random, 95% CI)	1.28 [1.14, 1.45]
1.1 Childhood immunizations	7	4910	Risk Ratio (M-H, Random, 95% CI)	1.27 [1.09, 1.48]
1.2 Adolescent immunizations	1	1596	Risk Ratio (M-H, Random, 95% CI)	1.36 [1.20, 1.53]

Analysis 7.1. Comparison 7 Combination patient mail and telephone reminder or recall, Outcome 1 Immunized.



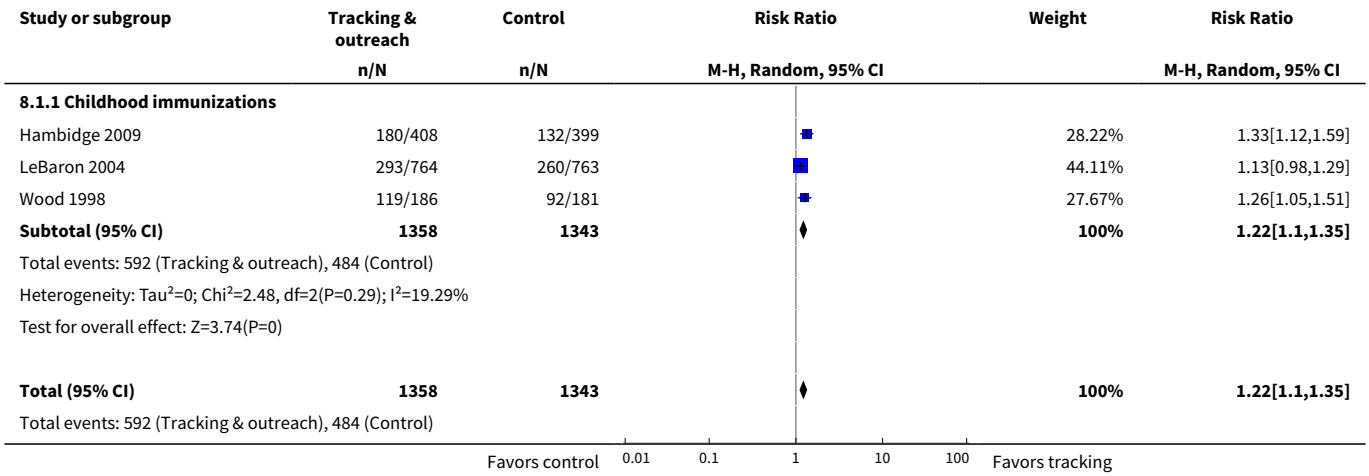


Study or subgroup	Card & phone reminders	Control	Risk Ratio	Weight	Risk Ratio
	n/N	n/N	M-H, Random, 95% CI		M-H, Random, 95% CI
Lieu 1998	178/321	78/219		15.64%	1.56[1.27,1.91]
Vivier 2000	12/70	2/71		0.68%	6.09[1.41,26.21]
Subtotal (95% CI)	**2476**	**2434**		**78.2%**	**1.27[1.09,1.48]**
Total events: 809 (Card & phone reminders), 619 (Control)					
Heterogeneity: Tau^2=0.02; Chi^2=13.83, df=6(P=0.03); I^2=56.63%					
Test for overall effect: Z=3.02(P=0)					
7.1.2 Adolescent immunizations					
Suh 2012	376/799	276/797		21.8%	1.36[1.2,1.53]
Subtotal (95% CI)	**799**	**797**		**21.8%**	**1.36[1.2,1.53]**
Total events: 376 (Card & phone reminders), 276 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Z=4.99(P<0.0001)					
Total (95% CI)	**3275**	**3231**		**100%**	**1.28[1.14,1.45]**
Total events: 1185 (Card & phone reminders), 895 (Control)					
Heterogeneity: Tau^2=0.01; Chi^2=15.24, df=7(P=0.03); I^2=54.08%					
Test for overall effect: Z=4.03(P<0.0001)					
Test for subgroup differences: Chi^2=0.45, df=1 (P=0.5), I^2=0%					

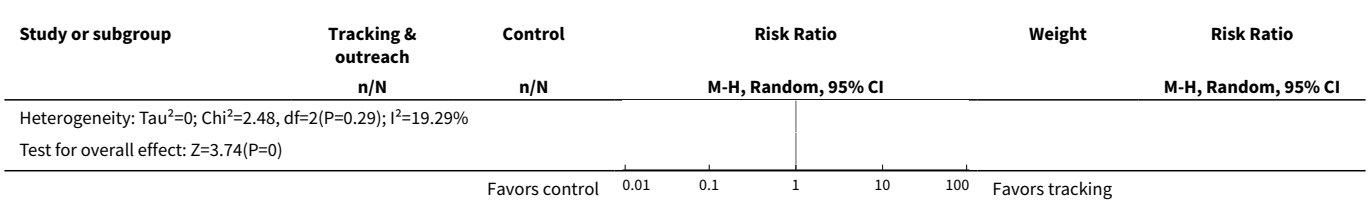
Comparison 8. Combination patient reminder or recall with outreach

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	3	2701	Risk Ratio (M-H, Random, 95% CI)	1.22 [1.10, 1.35]
1.1 Childhood immunizations	3	2701	Risk Ratio (M-H, Random, 95% CI)	1.22 [1.10, 1.35]

Analysis 8.1. Comparison 8 Combination patient reminder or recall with outreach, Outcome 1 Immunized.



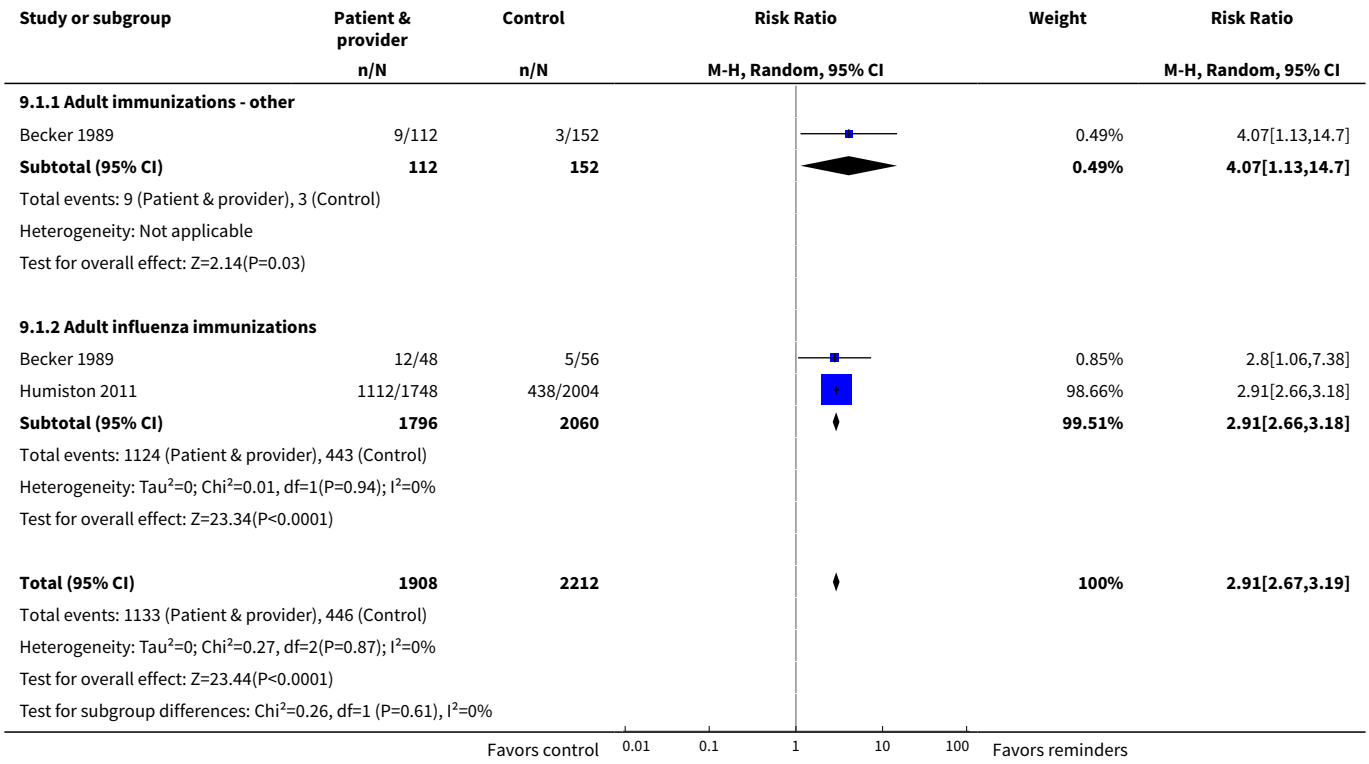
Study or subgroup	Tracking & outreach	Control	Risk Ratio	Weight	Risk Ratio
	n/N	n/N	M-H, Random, 95% CI		M-H, Random, 95% CI
8.1.1 Childhood immunizations					
Hambidge 2009	180/408	132/399		28.22%	1.33[1.12,1.59]
LeBaron 2004	293/764	260/763		44.11%	1.13[0.98,1.29]
Wood 1998	119/186	92/181		27.67%	1.26[1.05,1.51]
Subtotal (95% CI)	**1358**	**1343**		**100%**	**1.22[1.1,1.35]**
Total events: 592 (Tracking & outreach), 484 (Control)					
Heterogeneity: Tau^2=0; Chi^2=2.48, df=2(P=0.29); I^2=19.29%					
Test for overall effect: Z=3.74(P=0)					
Total (95% CI)	**1358**	**1343**		**100%**	**1.22[1.1,1.35]**
Total events: 592 (Tracking & outreach), 484 (Control)					



Comparison 9. Combination patient reminder or recall with provider reminder

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Immunized	2	4120	Risk Ratio (M-H, Random, 95% CI)	2.91 [2.67, 3.19]
1.1 Adult immunizations - other	1	264	Risk Ratio (M-H, Random, 95% CI)	4.07 [1.13, 14.70]
1.2 Adult influenza immunizations	2	3856	Risk Ratio (M-H, Random, 95% CI)	2.91 [2.66, 3.18]

Analysis 9.1. Comparison 9 Combination patient reminder or recall with provider reminder, Outcome 1 Immunized.



ADDITIONAL TABLES

Table 1. Sensitivity analyses - omitted studies from patient reminder or recall summary measure

Group or subgroup	RR (CI) for full set of included studies	RR (CI) after deleting studies with 'high' risk of bias for random sequence generation, allocation concealment, and/or incomplete outcomes	RR (CI) after deleting studies with primary outcome of received all needed vaccinations
Summary measure	1.28 (1.23 to 1.35)	1.29 (1.23 to 1.36)	1.32 (1.25 to 1.39)
Child	1.22 (1.15 to 1.29)	1.19 (1.12 to 1.27)	1.24 (1.15 to 1.34)
Influenza – child	1.51 (1.14 to 1.99)	1.51 (1.14 to 1.99)	1.37 (1.05 to 1.77)
Adult – other	2.08 (0.91 to 4.78)	2.35 (2.02 to 2.74)	2.08 (0.91 to 4.78)
Influenza – adult	1.29 (1.17 to 1.43)	1.33 (1.20 to 1.48)	1.29 (1.17 to 1.43)
Adolescent	1.29 (1.17 to 1.42)	1.26 (1.15 to 1.39)	1.33 (1.20 to 1.48)

CI: confidence interval
RR: risk ratio

APPENDICES

Appendix 1. Search strategies

MEDLINE (OVID)

Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R), 1946 to Present

No.	Search terms	Results
1	reminder systems/	2870
2	preventive health services/	12000
3	primary prevention/	16132
4	immunization/	47274
5	vaccination/	70736
6	or/2-5	141554
7	1 and 6	305
8	(postcard? or post-card? or mail* or text messag* or sms or short messag* service or letter? or brochur* or pamphlet?).ti,ab.	126817
9	(recall or remind*).ti,ab.	58576
10	8 or 9	182258

(Continued)

11	(vaccine? or vaccinat* or immunis* or immuniz* or flu).ti,ab.	331177
12	10 and 11	3890
13	((vaccine? or vaccination? or immunization? or immunisation?) adj3 (registry or registries)).ti,ab.	461
14	or/7,12-13	4431
15	randomized controlled trial.pt.	446587
16	controlled clinical trial.pt.	91788
17	multicenter study.pt.	217408
18	pragmatic clinical trial.pt.	521
19	(randomis* or randomiz* or randomly).ti,ab.	723931
20	groups.ab.	1670897
21	(trial or multicenter or multi center or multicentre or multi centre).ti.	205750
22	(intervention? or effect? or impact? or controlled or control group? or (before adj5 after) or (pre adj5 post) or ((pretest or pre test) and (posttest or post test)) or quasiexperiment* or quasi experiment* or pseudo experiment* or pseudoexperiment* or evaluat* or time series or time point? or repeated measur*).ti,ab.	7875589
23	non-randomized controlled trials as topic/	119
24	interrupted time series analysis/	236
25	controlled before-after studies/	213
26	or/15-25	8803258
27	exp animals/	20689610
28	humans/	16378297
29	27 not (27 and 28)	4311313
30	review.pt.	2218518
31	meta analysis.pt.	74177
32	news.pt.	180911
33	comment.pt.	677926
34	editorial.pt.	424399
35	cochrane database of systematic reviews.jn.	12903
36	comment on.cm.	677925

(Continued)

37	(systematic review or literature review).ti.	89860
38	or/29-37	7513987
39	26 not 38	6141300
40	14 and 39	1849

Embase (OVID)

1974 to 2017 January 30

No.	Search terms	Results
1	reminder system/	2189
2	preventive health service/	27782
3	primary prevention/	37986
4	immunization/	101462
5	vaccination/	140849
6	or/2-5	278922
7	1 and 6	300
8	(postcard? or post-card? or mail* or text messag* or sms or short messag* service or letter? or brochur* or pamphlet?).ti,ab.	206800
9	(recall or remind*).ti,ab.	76062
10	8 or 9	278359
11	(vaccine? or vaccinat* or immunis* or immuniz* or flu).ti,ab.	382994
12	10 and 11	5296
13	((vaccine? or vaccination? or immunization? or immunisation?) adj3 (registry or registries)).ti,ab.	554
14	or/7,12-13	5896
15	randomized controlled trial/	476973
16	controlled clinical trial/	470972
17	quasi experimental study/	4383
18	pretest posttest control group design/	352
19	time series analysis/	24245

(Continued)

20	experimental design/	25398
21	multicenter study/	163492
22	(randomis* or randomiz* or randomly).ti,ab.	960724
23	groups.ab.	2220371
24	(trial or multicentre or multicenter or multi centre or multi center).ti.	266746
25	(intervention? or effect? or impact? or controlled or control group? or (before adj5 after) or (pre adj5 post) or ((pretest or pre test) and (posttest or post test)) or quasiexperiment* or quasi experiment* or pseudo experiment* or pseudoexperiment* or evaluat* or time series or time point? or repeated measur*).ti,ab.	9891492
26	or/15-25	11047488
27	(systematic review or literature review).ti.	107227
28	"cochrane database of systematic reviews".jn.	5410
29	exp animals/ or exp invertebrate/ or animal experiment/ or animal model/ or animal tissue/ or animal cell/ or nonhuman/	24416220
30	human/ or normal human/ or human cell/	18532434
31	29 not (29 and 30)	5930624
32	27 or 28 or 31	6042488
33	26 not 32	8472209
34	14 and 33	2588

Cochrane Library

No.	Search terms	Results
#1	[mh "reminder system"]	765
#2	[mh "preventive health service"]	28875
#3	[mh "primary prevention"]	4122
#4	[mh immunization]	4715
#5	[mh vaccination]	2485
#6	{or #2-#5}	30429
#7	#1 and #6	328

(Continued)

#8	(postcard? or post-card? or mail* or text messag* or sms or short messag* service or letter? or brochur* or pamphlet?):ti,ab	7408
#9	(recall or remind*):ti,ab	6902
#10	#8 or #9	13394
#11	(vaccine? or vaccinat* or immunis* or immuniz* or flu):ti,ab	12154
#12	#10 and #11	384
#13	((vaccine? or vaccination? or immunization? or immunisation?) near/3 (registry or registries)):ti,ab	2
#14	{or #7, #12-#13}	621

CINAHL (EBSCO)

No.	Search terms	Results
S1	MH Reminder Systems	1,517
S2	(MH "Preventive Health Care")	10,568
S3	(MH "Immunization+")	14,501
S4	S2 OR S3	24,671
S5	S1 AND S4	170
S6	postcard? or post-card? or mail* or text messag* or sms or short messag* service or letter? or brochur* or pamphlet?	31,509
S7	recall or remind*	13,658
S8	S6 OR S7	44,296
S9	vaccine? or vaccinat* or immunis* or immuniz* or flu	35,591
S10	S8 AND S9	804
S11	((vaccine? or vaccination? or immunization? or immunisation?) N3 (registry or registries))	10
S12	S5 OR S10 OR S11	855
S13	PT randomized controlled trial	30,865
S14	PT clinical trial	52,906
S15	PT research	996,158

(Continued)

S16	(MH "Randomized Controlled Trials")	30,097
S17	(MH "Clinical Trials")	87,564
S18	(MH "Intervention Trials")	6,156
S19	(MH "Nonrandomized Trials")	182
S20	(MH "Experimental Studies")	15,224
S21	(MH "Pretest-Posttest Design+")	27,974
S22	(MH "Quasi-Experimental Studies+")	8,859
S23	(MH "Multicenter Studies")	21,526
S24	(MH "Health Services Research")	7,563
S25	TI (randomis* or randomiz* or randomly) OR AB (randomis* or randomiz* or randomly)	119,848
S26	TI (trial or effect* or impact* or intervention* or before N5 after or pre N5 post or ((pretest or "pre test") and (posttest or "post test")) or quasiexperiment* or quasi W0 experiment* or pseudo experiment* or pseudoexperiment* or evaluat* or "time series" or time W0 point* or repeated W0 measur*) OR AB (trial or effect* or impact* or intervention* or before N5 after or pre N5 post or ((pretest or "pre test") and (posttest or "post test")) or quasiexperiment* or quasi W0 experiment* or pseudo experiment* or pseudoexperiment* or evaluat* or "time series" or time W0 point* or repeated W0 measur*)	809,802
S27	S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26	1,347,398
S28	S12 AND S27	650

WHO International Clinical Trials Registry Platform (ICTRP)

vaccination AND reminder
vaccination AND recall
immunisation AND reminder
immunisation AND recall
immunization AND reminder
immunization AND recall

Appendix 2. GRADE evidence profiles

1. Certainty assessment of evidence[a] for each outcome - Patient reminder or recall summary measure

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
Outcome: Receipt of immunizations - for summary measure							
55	Randomized trials	No serious risk of bias	Some inconsistency exists (-0.5)	No serious indirectness	Some imprecision exists (-0.5)	None	Moderate (3)

Footnotes

[a]This can also be referred to as 'quality of the evidence' or 'confidence in the estimate.' The 'certainty of the evidence' is an assessment of how good an indication the research provides of the likely effect; i.e. the likelihood that the effect will be substantially different from what the research found. By 'substantially different' we mean a large enough difference that it might affect a decision.

[b]Indirectness includes consideration of:

- indirect or between-study comparisons;
- indirect or surrogate outcomes;
- applicability: study populations, interventions, or comparisons that are different than those of interest.

[c]Other considerations for downgrading include publication bias. Other considerations for upgrading include a strong association with no plausible confounders, a dose response relationship, and if all plausible confounders or biases would decrease the size of the effect, if there is evidence of an effect, or increase it if there is evidence of no harmful effect (safety).

[d]Overall score:

4 (high): This research provides a very good indication of the likely effect. The likelihood that the effect will be substantially different** is low.
3 (moderate): This research provides a good indication of the likely effect. The likelihood that the effect will be substantially different** is low to moderate.
2 (low): This research provides some indication of the likely effect. However, the likelihood that it will be substantially different** is high.
1 (very low): This research does not provide a reliable indication of the likely effect. The likelihood that the effect will be substantially different** is very high.

** Substantially different = a large enough difference that it might affect a decision.

EPOC resources for authors - Worksheets for preparing Summary of Findings tables using GRADE

2. Certainty assessment of evidence[a] for each outcome - patient telephone reminder or recall

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
7	Randomized trials (4)	No serious risk of bias	Some inconsistency exists (-0.5)	No serious indirectness	Some imprecision exists (-0.5)	None	Moderate (3)

[a-d]See Table 1 above.

3. Certainty assessment of evidence[a] for each outcome - patient letter reminder or recall

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
27	Randomized trials (4)	No serious risk of bias	Some inconsistency exists (-0.5)	No serious indirectness	Some imprecision exists (-0.5)	None	Moderate (3)

[a-d]See Table 1 above.

4. Certainty assessment of evidence[a] for each outcome - patient postcard reminder or recall

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
8	Randomized trials (4)	No serious risk of bias (- 0.5)	No serious inconsistency	No serious indirectness	No serious imprecision	None	High (3.5)

[a-d]See Table 1 above.

5. Certainty assessment of evidence[a] for each outcome - Patient text message reminder or recall

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
6	Randomized trials (4)	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	High (4)

[a-d]See Table 1 above.

6. Certainty assessment of evidence[a] for each outcome - patient autodialer reminder or recall

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
5	Randomized trials (4)	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	High (4)

[a-d]See Table 1 above.

7. Certainty assessment of evidence[a] for each outcome - combination patient mail and phone reminder and recall

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
8	Randomized trials (4)	No serious risk of bias	Some inconsistency exists (-0.5)	No serious indirectness	Some imprecision exists (-0.5)	None	Moderate (3)

[a-d]See Table 1 above.

8. Certainty assessment of evidence[a] for each outcome - combination patient reminder or recall and outreach

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
3	Randomized trials (4)	No serious risk of bias	No serious inconsistencies	No serious indirectness	No serious imprecision	None	High (4)

[a-d]See Table 1 above.

9. Certainty assessment of evidence[a] for each outcome - combination patient reminder or recall and provider reminder

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
2	Randomized trials (4)	Moderate risk of bias (-0.5*)	No serious inconsistency	No serious indirectness	Some imprecision exists (-1)	None	Moderate (2.5)

[a-d]See Table 1 above.

* 0.5 = Midpoint

10. Certainty assessment of evidence[a] for each outcome - childhood vaccinations

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
23	Randomized trials (4)	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	High (4)

[a-d]See Table 1 above.

11. Certainty assessment of evidence[a] for each outcome - childhood influenza vaccinations

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
5	Randomized trials (4)	No serious risk of bias	Some inconsistency exists (-0.5*)	No serious indirectness	Some imprecision (-1)	None	Moderate (2.5)

[a-d]See Table 1 above.

* 0.5 = Midpoint

12. Certainty assessment of evidence[a] for each outcome - adult pneumococcal, tetanus, hepatitis B, and other non-influenza vaccinations

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
4	Randomized trials (4)	No serious risk of bias	Lack of agreement between studies (-1)	No serious indirectness	Some imprecision (-1)	None	Low (2)

[a-d]See Table 1 above.

13. Certainty assessment of evidence[a] for each outcome - adult influenza vaccinations

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
15	Randomized trials (4)	No serious risk of bias	Some inconsistency exists (-0.5*)	No serious indirectness	Some imprecision (-1)	None	Moderate (2.5)

[a-d]See Table 1 above.

* 0.5 = Midpoint

14. Certainty assessment of evidence[a] for each outcome - adolescent immunizations

No of studies	Design	Risk of bias	Inconsistency	Indirectness[b]	Imprecision	Other[c]	Certainty (overall score)[d]
10	Randomized trials (4)	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	High (4)

[a-d]See Table 1 above.

Appendix 3. Examples of systematic reviews

First author last name	Year of publication	Study designs (# of patient reminder-recall studies)	Participants	Types of immunizations	Results
Groom	2015	Not clear (30)	Persons in high-income countries	Vaccination rates	Median percentage point improvement: 6
Harvey	2015	Controlled studies (28 overall)	Children	Childhood	Risk difference (RD)[2]: Postal: RD 0.11 (95% Confidence Interval (CI) 0.08 to 0.13) Telephone: RD 0.04 (95% CI 0.01 to 0.07)
Niccolai	2015	Randomized (4 patient reminder recall (PRR)) and non-randomized (3 PRR)	Adolescents	HPV	All 7 studies reported increases in at least 1 HPV vaccination outcome
Odone	2015	Observational or experimental (7 text messages; 1 smartphone application)	Parents of children and adolescents, pregnant women, providers	Variety of vaccination outcomes	Some evidence that text messaging, patient-held web-based portals and computerized reminders were effective
Oyo-Ita	2011	Randomized trials, non-randomized trials, interrupted time series (1)	Children in low- and middle-income countries	Childhood	Not clear; study was patient card, not matching our eligibility criteria
Thomas	2014	Randomized trials (4)	60 years and older	Influenza	Pooled odds ratio 1.11 (95% CI 1.07 to 1.15) and 3.33 (95% CI 1.79 to 6.22)
Watterson	2015	Randomized trials and observational studies (3 vaccine)	Children in low- or middle-income country	Childhood	9.7 percentage point increase in one study; positive qualitative findings in other studies
Williams	2011	Randomized trials (26), before and after studies (11), controlled intervention (9) (22 PRR)	Children in developed countries	Childhood	Median percentage point change of 11%; range of -11 to 24 percentage points

WHAT'S NEW

Date	Event	Description
31 January 2017	New search has been performed	Updated searches conducted to 31 January 2017.
31 January 2017	New citation required but conclusions have not changed	Added text messages as a new reminder or recall intervention. Changed statistical method from odds ratio to risk ratio. Up-

Date	Event	Description
		dated the review methods and reporting to align with current Cochrane and EPOC guidance. Added one additional author, a biostatistician.

HISTORY

Protocol first published: Issue 4, 1997
Review first published: Issue 4, 2002

Date	Event	Description
30 June 2016	New search has been performed	Updated searches conducted to 31 May 2013; 22 new studies identified. This review includes 69 studies.
12 November 2008	Amended	Minor changes.
14 August 2008	New citation required but conclusions have not changed	New search July 2007; four new studies.
12 June 2008	Amended	Converted to new review format.
15 February 2008	New search has been performed	New searches; no changes to findings.
25 May 2005	New citation required and conclusions have changed	Substantive amendment.

CONTRIBUTIONS OF AUTHORS

Julie Jacobson Vann (JJV): directed and coordinated the review; conceived the review; designed the review; collected data for the review; designed search strategies for grey literature and clinical trials registers; conducted searches; screened search results; organized retrieval of papers; retrieved papers; screened retrieved papers against eligibility criteria; appraised quality of papers; extracted data from papers; wrote to authors for additional information; managed data for the review; entered data into RevMan; analyzed data; interpreted data; provided a methodological perspective; provided a policy perspective; wrote the review; provided general and detailed advice on the review; attempted to secure funding for the review; and performed previous work that was the foundation for the current review.

Robert M Jacobson (RMJ): collected data for the review; screened search results; retrieved papers; screened retrieved papers against eligibility criteria; appraised quality of papers; extracted data from papers; interpreted data; provided a clinical perspective; provided a policy perspective; wrote sections of the review; and attempted to secure funding for the review.

Tamera Coyne-Beasley (TCB): collected data for the review; screened search results; retrieved papers; screened retrieved papers against eligibility criteria; appraised quality of papers; extracted data from papers; and provided a clinical perspective.

Josephine Asafu-Adjei (JAA): analyzed data; interpreted data; provided a methodological perspective; wrote sections of the review; and created funnel plots.

Peter Szilagyi (PS): conceived the original review; designed the original review; interpreted data; provided a clinical perspective; provided a policy perspective; wrote sections of the review; edited the review; provided general and detailed advice on the review; and performed many years of previous work that was the foundation for the current review.

DECLARATIONS OF INTEREST

JCJV: none known

RMJ: while I declare my work as a monitor or referee for vaccines as relevant financial activities outside the submitted work, I do not believe these affect my interpretation of studies.

TCB: none known

KJAA: none known

PS: author on five of the included studies; he did not participate in making inclusion or exclusion decisions or assessing risk of bias in these studies.

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

- Centers for Disease Control & Prevention, USA.

  For initial review only
- Health Technology Assessment Programme, UK.

  For the 2005 update

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

In this update, we changed our analysis method from odds ratio (OR) to risk ratio (RR) because of changes to RevMan (RevMan 5). Because of this change, the current RRs are not comparable to our previously published ORs. However, when we compared the updated patient reminder or recall summary measure, using a random effects OR, with the previous findings the results were nearly identical.

We updated the risk of bias criteria from previous standards to current standards; expanded descriptions in the Characteristics of included studies tables; added 'Risk of bias' tables for each included study; added GRADE assessments; added 'Certainty assessment of evidence for each outcome' methods and tables; added 'Summary of findings' tables for each intervention; added funnel plots to assess for reporting bias; conducted sensitivity analyses; and added text messages as a new intervention type.

Since the last published version we have added three authors: Drs. Robert Jacobson, Tamera Coyne-Beasley, and Josephine Asafu-Adjei, respectively, two pediatric and adolescent physicians and one biostatistician.

NOTES

Minor update November 2002: changed the titles on the graphs to reflect the interventions.

INDEX TERMS

Medical Subject Headings (MeSH)

*Reminder Systems [statistics & numerical data]; Correspondence as Topic; Immunization [*statistics & numerical data]; Immunization Programs [organization & administration]; Randomized Controlled Trials as Topic; Telephone [statistics & numerical data]; Text Messaging [statistics & numerical data]

MeSH check words

Adolescent; Adult; Child; Humans