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Improving Immunization Coverage Rates: An Evidence-based Review of the Literature

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PURPOSE

This systematic review evaluates the effectiveness of population-based interventions to improve vaccination coverage. The paper 1) presents a framework for evaluating interventions to improve vaccination coverage, 2) describes selected strategies for improving coverage, and 3) systematically reviews available information on the effectiveness of these strategies in improving vaccination coverage and other outcomes to assess their effectiveness.

INTRODUCTION

Disease burden

Vaccine-preventable diseases among children, adolescents, and adults represent major continuing causes of morbidity and mortality in the United States. During the last 50 years, the success of childhood vaccination programs has led to a greater than 95 percent decline in most of the vaccine-preventable diseases of childhood. However, more than 400,000 cases of illness and more than 30,000 deaths caused by vaccine-preventable diseases still occur each year ((1), Centers for Disease Control and Prevention (CDC), unpublished data).

Diphtheria, invasive *Haemophilus influenzae* type b (Hib) disease, measles, poliomyelitis, rubella, tetanus, mumps, varicella, and pertussis are typically referred to as vaccine-preventable diseases of childhood. Vaccinations primarily indicated for adults include influenza, pneumococcal, and hepatitis B; however, the distinction between childhood and adult vaccine-preventable diseases has become less clear in the last decade. Many childhood vaccine-preventable infections, including measles and pertussis, are found increasingly among adults (2, 3), and hepatitis B vaccination is now routinely recommended for infants and adolescents.

In children, more than 50,000 cases of varicella occur each year, making it the most common vaccine-preventable disease among children (4); in adults, influenza, pneumococcal disease, and hepatitis B are all still common vaccine-preventable diseases, with hundreds of thousands of cases occurring each year (5).

Mortality attributable to vaccine-preventable diseases is still substantial. Each year, approximately 500 persons in the United States die of vaccine-preventable diseases of childhood, and more than 30,000 adults die of influenza, pneumococcal infections, and hepatitis B (1). Influenza, which accounts for an average of 20,000 deaths per year, is usually the largest killer (5).

Vaccination coverage

Vaccination coverage levels among US schoolchildren continues to exceed 98 percent for vaccination with diphtheria toxoid, tetanus toxoid, pertussis (DTP) vaccine/diphtheria and tetanus toxoids (for children not able to get P component) (DT), poliovirus vaccine, measles-containing vaccine, and Hib vaccine (6). Vaccination coverage among US children aged 19–35 months now exceeds 90 percent for three or more doses of DTP/DT, three or more doses of poliovirus vaccine, one or more doses of measles-containing vaccine, and three or more doses of Hib vaccine (7), but is lower for four or more doses of DTP vaccine (81 percent), three or more doses of hepatitis B vaccine (84

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Abbreviations: CDC, Centers for Disease Control and Prevention; CME, continuing medical education; DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; DT, diphtheria and tetanus toxoids (for children not able to get the pertussis component); Td, diphtheria and tetanus toxoids (adult/adolescent vaccine); *Guide*, *Guide to Community Preventive Services*; HEDIS, Healthplan Employer Data and Information Set; Hib, *Haemophilus influenzae* type b vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine; Task Force, Task Force on Community Preventive Services; WIC, Women, Infants, and Children.

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percent), and varicella vaccine (26 percent). In addition, certain populations remain at higher risk for underimmunization. Recent data suggest that coverage levels for children aged 2 years remain significantly lower among urban populations and among low-income populations (7, 8).

Vaccinations recommended for adults, and more recently for adolescents, remain underutilized. Recent estimates suggest that <60 percent (9) of adults over age 65 years are protected against such diseases as influenza and pneumococcal infection. No reliable estimates exist for immunization coverage levels among adolescents.

Vaccination effectiveness

The effectiveness of individual vaccines in preventing disease for adults, adolescents, and children is well established, and recommendations for their use have been summarized in several documents (10–17). Because effectiveness of these vaccines is well-established, this review will focus on interventions to improve coverage.

The *Guide to Community Preventive Services* and the relation of this review to it.

The *Guide to Community Preventive Services* (hereafter called the *Guide*) is an initiative of the US Department of Health and Human Services and is being developed by a 15-member, independent, non-federal Task Force on Community Preventive Services (hereafter called the Task Force) in cooperation with many public and private sector partners (18). The Task Force is supported by staff of the CDC and others who are developing, disseminating, and implementing the *Guide*. The *Guide* will make specific recommendations on selected preventive interventions defined as activities that prevent disease or injury or that promote health in a group of people.

The *Guide* builds on many previous successes in evidence-based reviews and recommendations (14, 19–23). The *Guide* shares with those processes a commitment to a systematic process and to explicitness. However, the *Guide*'s evolving methods differ from those that have been typically used to evaluate clinical efficacy. First, the *Guide* gives greater weight to a broader range of study designs for assessing effectiveness. Second, it considers a broad range of evidence-effectiveness, generalizability, other effects including harms and positive and negative non-health side effects, cost effectiveness, and barriers to implementation.

This review of the effectiveness of interventions to improve or maintain vaccine coverage was performed in support of the Task Force's work. It reflects methods of summarizing information on effectiveness that were used by the Task Force as of December 1998. This report summarizes information about effectiveness but does not include recommendations, which will be provided in separate reports.

METHODS

This report reviews the effectiveness of interventions to improve the routine delivery of universally-recommended vaccines (i.e., vaccines recommended for most or all people in specific age groups). Vaccinations recommended for all young children include measles, mumps, rubella (MMR) (currently combined and given in two doses), DTP (currently combined and given in four doses), poliomyelitis (four doses), Hib (three to four doses), hepatitis B (three doses), and varicella (one dose). Vaccines recommended for previously unvaccinated or partially vaccinated adolescents include hepatitis B, varicella, MMR, and tetanus-diphtheria (Td). Vaccines recommended for all older adults include annual influenza vaccine (one dose), Td (one dose every 10 years), and pneumococcal vaccine (one dose). This report does not address vaccines with more targeted indications, such as those recommended for people with specific medical conditions (e.g., asthma) or vaccines for travelers.

A "logic framework" (figure 1) illustrates the conceptual approach to the review. It describes hypothesized links between a population, environmental and health system determinants, and various outcomes. The logic framework describes population-based interventions to reduce vaccine preventable disease and characterizes the outcomes that they attempt to influence. This review focused on four broad categories of interventions to increase vaccination coverage: 1) interventions to increase community demand for immunizations, 2) interventions that enhance access to immunization services, 3) interventions that mandate immunizations, and 4) provider-based interventions. This paper reviews evidence on the effectiveness of 17 interventions within these categories. Other interventions were not evaluated because of time and resource constraints.

We categorized interventions based on the definitions shown in the results. Sometimes, our classification or nomenclature was different from that used in the original reports. We assessed the effectiveness of both single-component interventions (involving only one activity) and multicomponent interventions (using more than one related activity together) to improve outcomes whether or not the contribution of the individual components of multicomponent interventions could be ascribed.

We conducted an electronic search of Medline, Embase, Psychlit, CAB Health, and Sociological

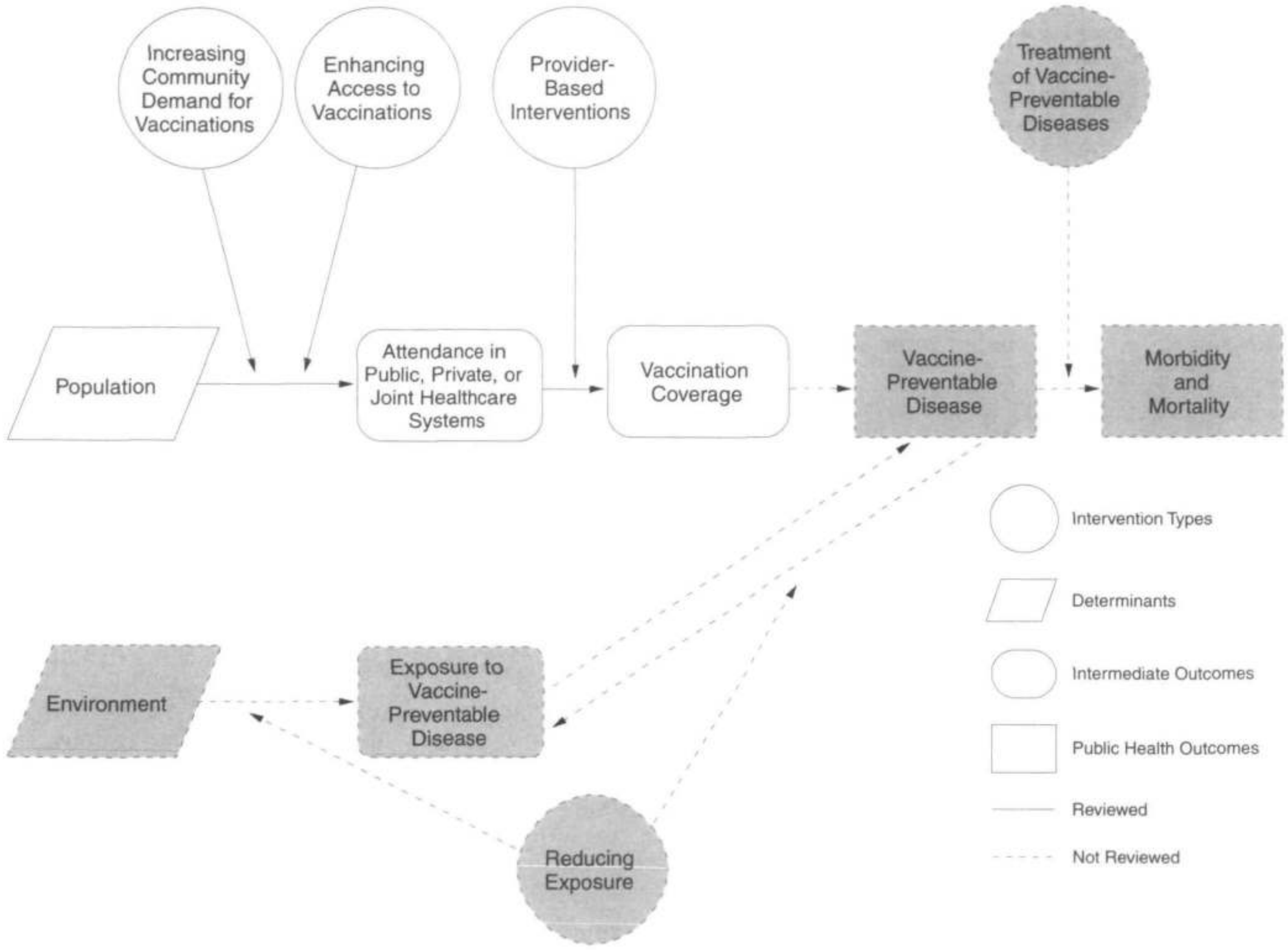

FIGURE 1. Logic framework for vaccine-preventable diseases showing hypothesized links between a population, environmental determinants, and various outcomes.

Abstracts, reviewed reference lists, and consulted with experts. Studies were included if they 1) were published in books or journals from 1980 through 1997; 2) addressed universally recommended adult, adolescent, or childhood vaccines; 3) were primary studies rather than, for example, guidelines or reviews; 4) came from industrialized countries; 5) were written in English; 6) were relevant to one or more of the interventions listed in table 1; 7) provided information on one or more outcomes selected for review (the outcomes for each intervention are available from the authors on request); and 8) compared a group of people who had been exposed to the intervention with a group who were not exposed, or were less exposed (i.e., concurrent or pre/post). Where studies existed that did not meet these criteria but that had been recommended by one or more experts as having the potential to change a preliminary assessment of effectiveness, those studies were also reviewed. This resulted in reviewing unpublished studies of interventions involving use of the US Department of Agriculture's Special Nutrition Program for Women, Infants, and Children (WIC) to improve children's vaccination coverage and 1998 publications on home visiting.

Multiple reports on a single study were treated as one study but different intervention arms were treated as separate observations. For both of these reasons, the number of studies shown will not necessarily match the numbers of references cited.

After the individual studies making up the body of evidence of effectiveness for an intervention were identified, they were evaluated, their results extracted, the body of evidence summarized, and the strength of the body of evidence (i.e., the confidence with which it demonstrates that changes in outcomes are attributable to the interventions) assessed.

Each study meeting the explicit inclusion criteria was read by two reviewers who used a standardized

TABLE 1. **Interventions to increase vaccination coverage***

	Studies identified
Increasing community demand for immunizations	
Multicomponent strategies including education	34
Patient reminder/recall	60
Communitywide education	6
Clinic-based education	5
Patient or family incentives	3
Client-held medical records	8
Enhancing access to immunization services	
Reducing out-of-pocket costs	26
Immunization interventions in nonmedical settings	
Interventions in WIC† settings	10
Home visits	15
Interventions in child-care facilities	1
Interventions in schools	4
Expanding access in health-care settings	25
Mandating immunizations	
School, child-care, and college-entry requirements	10
Provider-based strategies	
Provider reminder/recall	60
Assessment and feedback for vaccination providers	27
Standing orders	16
Provider education	6

* Numbers of studies of individual interventions exceeds the total numbers of studies because some studies evaluate more than one intervention.

† WIC, Women, Infants, and Children.

TABLE 2. **Suitability of study design for assessing effectiveness in the *Guide to Community Preventive Services***

Suitability	Attributes
Greatest	Concurrent comparison groups *and* prospective measurement of exposure and outcome
Moderate	All retrospective designs *or* multiple pre- or postmeasurements, but no concurrent comparison group
Least	Single pre- and postmeasurements and no concurrent comparison group *or* exposure and outcome measured in a single group at the same point in time

abstraction form to record 1) information about the intervention being studied, 2) the context in which the study was done (e.g., population or setting), 3) descriptions of the evaluation and the results; and 4) an assessment of how well the study was executed. Any disagreements between the two reviewers were reconciled by consensus among the chapter development team during the process of summarizing results into evidence tables.

We assessed the suitability of each study's design for assessing effectiveness as shown in table 2. For the two interventions where the literature was most extensive (provider reminder/recall; patient reminder/recall), we excluded studies with least suitable designs. Studies that did not make a concurrent or before-after comparison were never included.

We assessed the quality of study execution by systematically considering eight threats to validity: 1) definition and selection of study and comparison population(s); 2) definition and measurement of exposure/intervention; 3) assessment of outcomes; 4) follow-up/completion rates; 5) other bias; 6) data analysis; 7) confounding; and 8) other (e.g., lack of statistical power). Execution was characterized as good, fair, or limited based on the total number of categories with limitations. Good studies had zero to one limitation; fair studies had two to four limitations; and limited studies had five or more limitations. Studies with serious problems in quality of execution (i.e., "limited" execution) were not considered further in the review.

To summarize the findings on the effectiveness of an intervention across multiple studies, we displayed the results of individual studies in tables and reported the median and range of reported effect measures. In addition, the body of evidence is characterized as strong, sufficient, or insufficient based on the numbers of available studies, the strength of their design and execution, and the size and consistency of reported effects (table 3).

The primary outcome of interest was always a measure of vaccination (i.e., vaccine coverage or doses delivered). Information on disease outcomes and other outcomes (such as knowledge or attitudes for educational interventions) could also be abstracted if available and relevant.

We represented results of each of the studies as point estimates for net change in vaccination coverage attributable to the interventions. We calculated net changes and baselines using the following formulas:

For studies with before and after measurements and concurrent comparison groups:

$$(I_{post} - I_{pre}) - (C_{post} - C_{pre}); \text{ baseline} = I_{pre}$$

For studies with post-only coverage measurements and concurrent comparison groups:

$$I_{post} - C_{post}; \text{ baseline} = C_{post}$$

For studies with before and after measurements but no concurrent comparison:

$$I_{post} - I_{pre}; \text{ baseline} = I_{pre}$$

where, I_{post} = last reported coverage in the intervention group after the intervention; I_{pre} = reported coverage in the intervention group most immediately before the intervention; C_{post} = last reported coverage in the comparison group after the intervention; and C_{pre} = reported coverage in the comparison group immediately before the intervention.

TABLE 3. Assessing the strength of a body of evidence on effectiveness of population-based interventions in the *Guide to Community Preventive Services*

Evidence of effectiveness*	Execution—good or fair†	Design suitability—greatest, moderate, or least	Number of studies	Consistent	Effect size‡	Expert opinion§
Strong	Good	Greatest	At least 2	Yes	Sufficient	Not used
	Good	Greatest or moderate	At least 5	Yes	Sufficient	Not used
	Good or fair	Greatest	At least 5	Yes	Sufficient	Not used
Meet design, execution, number, and consistency criteria for sufficient but not strong evidence					Large	Not used
Sufficient	Good	Greatest	1	Not applicable	Sufficient	Not used
	Good or fair	Greatest or moderate	At least 3	Yes	Sufficient	Not used
	Good or fair	Greatest, moderate, or least	At least 5	Yes	Sufficient	Not used
Expert opinion	Varies	Varies	Varies	Varies	Sufficient	Supports a recommendation
Insufficient¶	Insufficient designs or execution		Too few studies	Inconsistent	Small	Not used

* The categories are not mutually exclusive; a body of evidence meeting criteria for more than one of these should be categorized in the highest possible category.

† Studies with limited execution are not used to assess effectiveness.

‡ Sufficient and large effect sizes are defined on a case-by-case basis and are based on Task Force opinion.

§ Expert opinion was not used in this review but can affect the classification of a body of evidence as shown.

¶ Reasons for a determination that evidence is insufficient will be described as follows: insufficient designs or executions, too few studies, inconsistent, effect size too small, expert opinion not used. These categories are not mutually exclusive, and one or more of these will occur when a body of evidence fails to meet the criteria for strong or sufficient evidence.

Depending on the study, vaccination coverages could be with a series-complete coverage measure (i.e., the proportion of persons up-to-date with each of several vaccines) or coverage with one or more individual vaccines. When a study presented more than one vaccine result (but not a series-complete measure) we used an equally weighted average of coverage differences. Studies without coverage outcomes, or for which coverage differences are not calculable, are not included in descriptive statistics, but these studies are described in the tables and text.

We selected effect measures for inclusion in the following ways. When available, we used measures adjusted for potential confounders in multivariate analyses in preference to crude effect measures. In children, we used outcome measures among children closest to age 2 years. In studies that made comparisons between multiple groups, we compared each intervention group with the group that received no intervention (or the least intensive intervention). We included separate effect measures where possible for children, adolescents, and adults, but did not otherwise typically report different effect measures for different subpopulations.

Finally, to assist users in assessing the likely generalizability of available evidence on effective interventions, we defined important characteristics of the interventions (e.g., the specific vaccinations delivered) and characteristics of the target populations and settings where the intervention had been implemented. We then reported on the availability, or lack of availability, of studies (e.g., studies might have been done in urban but not in rural areas, or to increase the delivery of influenza but not MMR vaccination).

RESULTS

Search results

The Medline search identified 3,882 titles and abstracts of which 126 met the inclusion criteria. Searches of other databases, reviews of reference lists, and recommendations from experts identified an additional 71 references meeting the inclusion criteria. Thus, a total of 197 studies were included in the review. Of these, 95 studies had greatest suitability designs, 37 moderate suitability designs, and 64 least suitable designs (one was a modeling study for which suitability of design wasn't assigned). Execution was categorized as good (zero to one limitation) in 10 studies, fair (two to four limitations) in 115 studies, and limited (five or more limitations) in 72 studies.

Interventions to increase demand for immunizations

Interventions included in this category increase community demand for immunizations by motivating people to obtain immunizations for their children or for themselves. These include communitywide education and education in clinical settings, patient reminders about vaccinations, patient incentives to obtain vaccinations, and patient-held medical records. For this review, education was defined to involve only the provision of information about immunizations with or without education to providers. Interventions that combine provision of information with other strategies are categorized elsewhere.

Multicomponent interventions including education. Definition. Multicomponent interventions including education are strategies which provide education about immunizations to a target population with or without provider education in conjunction with at least one other strategy to improve immunization rates.

Background. Multicomponent interventions including education attempt to address a variety of barriers and health concerns in an integrated way. Multicomponent health interventions are based on the premise that prerequisites to health include the physical, social, and political environment in which health risks occur. These interventions enable communities to be aware of immunization services available to them, demonstrate the utility and relevance of these services, provide community members with the knowledge and information base to effectively take advantage of the services, and to also incorporate a variety of associated strategies to improve immunization rates.

Effectiveness. Of 34 studies reviewed (24–60), 17 had fair or good execution (34–36, 39, 41–44, 46, 47, 50, 54–59) (table 4). The remainder had limited execution. The types of interventions used in the 17 strongest studies included a mix of community or client education (17), patient reminders (nine), provider education (six), expanded hours or access in clinical settings (six), provider reminders (six), reducing out of pocket costs (four), WIC interventions (one), patient-held immunization records (two), standing orders (two), patient incentives (one), provider feedback (one), and home visits (one). Fifteen studies (34–36, 41–44, 47, 50, 54–59) which evaluated vaccination coverage as the outcome showed changes in vaccination coverages ranging from –4 percent to 29 percent (median 16 percent) in follow-up times of up to 5 years. Positive effects were shown both in clinical and community settings (range: –4 percent to 25 percent, median 16 percent; versus range: 5 percent to 29 percent, median 12 percent, respectively). Four of four studies that assessed non-immunization outcomes (35, 41, 46, 54) also showed improvements in some other outcomes. The available data do not allow attribution of the portion of the overall effect of the interventions to individual components but suggest that the combined interventions increase vaccination coverages.

It is not entirely clear why these multicomponent interventions seem effective in improving vaccination coverages while some of the components (community-wide education, clinic-based education, expanded clinic hours or access) by themselves show less convincing evidence of effectiveness. It is possible that the apparent difference reflects different levels of intensity (e.g., multicomponent interventions may be more intensive and more intensive interventions may be more effective). It is possible that the components work synergistically and that the multicomponent interventions are more effective than the sum of the individual components. Alternatively, education may not by itself have large effects on acceptance of vaccines but may still be necessary to allow the implementation of other strategies.

Generalizability. Positive effects of multicomponent educational interventions have been shown in adults (34, 36, 43, 46) and children (35, 41, 44, 47). Adolescents have been studied as mothers in mother-infant pairs (35, 41) but have not been studied regarding their own immunizations. Positive effects have been documented in white (34, 36), black (41), and Hispanic (35, 47) populations, and in both poor (41, 46, 47) and non-poor (35, 44) populations. Studies in clinical settings come primarily from academic clinical organizations (34, 35, 41) but have also been done in private physician offices (57), public health clinics (44), and managed care (50). Studies are available for several antigens (including influenza (36, 43), pneumococcal (34), DTP and oral poliomyelitis vaccine (OPV) (44, 47), MMR (47), and Hib (50). No studies were found evaluating multicomponent educational strategies to encourage adolescent immunizations or to improve the delivery of hepatitis B vaccine.

Patient reminder/recall. Definition. Patient reminder/recall involves reminding members of a target population that immunizations which they should receive are due (reminders) or late (recall). Techniques by which reminders are delivered (telephone, letter, postcard, other) and content of the reminders may vary. Interventions that incorporate aspects of both patient reminder/recall and home visits are classified under home visits.

Background. With increasing complexity of the vaccination schedule, reminders allow the patient to know when vaccinations are due/overdue, or when they should contact their immunization provider to determine if immunizations are due. Reminders can be made by either mail or telephone, and telephone reminders can be automated by use of an autodialer. Patient reminders can be either specific (i.e., certain vaccine due on a specific date) or general.

Effectiveness. Of 60 studies (29, 30, 33, 41–44, 47, 50–53, 56–59, 61–113), 42 had good or fair execution and greatest or moderate suitability (41–44, 47, 50, 57–59, 61–65, 67–72, 74, 78, 80, 82, 84, 86, 88–92, 95, 97, 99, 103–107, 110–112) (table 5). The available studies showed a median coverage difference of 12

TABLE 4. Multicomponent strategies that include education

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Effects of multicomponent communitywide strategies that include education					
Etkind et al. (36)	1988–1992	Nonrandomized trial, greatest suitability, fair	Essex and Worcester Counties, Massachusetts; communitywide; Essex County target population 90% urban; aged ≥65 years; predominantly white; socio-economic status not reported	1. Multiple approaches to promoting influenza vaccination to target population *plus* provider education *plus* administration fee to providers (91,621 Medicare part B enrollees) versus 2. Baseline in intervention county (number not given) versus 3. Usual practice in comparison county (95,234 Medicare part B enrollees)	1 versus 2 = 29% net change (statistical significance not shown); 1 versus 3, doses distributed in Essex County increased from ~25,000/year before to ~57,400/year after versus no change in comparison county
Holtmann (56)	1989–1990	Cross-sectional study, least suitable, fair	United States nationwide; communitywide; aged 2 years, otherwise target population not well described	1. Presence of "education and tracking systems" *or* free vaccines as reported by states to GAO* or to CDC* versus 2. Lack of those interventions as reported by states	By ordinary least squares regression, states with universal vaccine provision programs have vaccine coverages among 2 year olds that are higher than states with neither a universal vaccine provision plan or a vaccine replacement plan, all else equal (10% difference, p = 0.11, CDC data; 9% difference, p = 0.035, GAO data) Presence of an education and tracking system had variable relations to vaccination coverage (0% difference, p = 0.99, CDC data; 9% difference, p = 0.011, GAO data)
MacDonald and Roder (39)	1979–1981	Before-after study, least suitable, fair	South Australia; communitywide; target population not described	1. Provider education *plus* mass-media campaign *plus* dedicated vaccination clinics versus 2. Usual care before campaign (Size of target population not shown)	Survey of a convenience sample found 19% could recall campaign without promoting (2 of 3 could recall with prompting); attendance for MMR* in 1981 versus 1979–1980 was 14% greater before the campaign and 90% greater after
Ohmit et al. (43)	1989–1991	Time series study, moderately suitable, fair	Southwest Michigan; community-wide; clinics/offices target population ≥65 years; otherwise incompletely described	1. Communitywide education of physicians and patients *plus* free vaccination *plus* mailed postcard patient reminders *plus* outreach in senior centers (evaluation in 1,315 participants in 1990–1991 and 1,663 in 1991–1992) versus 2. Prior usual care (patient numbers not given)	Influenza vaccination 1 versus 2 = 16% net change (statistical significance not found)

Paunio et al. (59)	1982–1986	Time series study, moderate suitability, fair	Finland; communitywide; target population aged 0–11 years	1. Registry *plus* mass-media reporting of local data on vaccination coverage *plus* provider reminders *plus* parent reminders versus 2. Usual care before registry	MMR, 1 versus 2 = 8% net change (no significance testing) Fitted weekly time series models of number of MMR delivered 1 versus 2, no effect on number of vaccinations administered to children aged 14–18 months; mass media might have increased vaccinations administered to children aged 6 years; all three interventions increased numbers of children aged 6 years who received first MMR
Waterman et al. (47)	1992–1994	Nonrandomized trial, greatest suitability, fair	San Diego County, California; target population children aged 2–4 years; 87% Hispanic; low socioeconomic status	1. Free walk-in vaccination clinics *plus* patient reminders *plus* provider education *plus* multiple education and health promotion strategies *plus* assessment referral and education of WIC* clients versus 2. Comparison community of usual care	DTP*/OPV*/MMR (4:3:1 doses, respectively), 1 versus 2 = 12% (statistical significance not found)
Effects of multicomponent strategies that include education in clinical settings					
Browngoehl et al. (50); Kennedy and Browngoehl (51)	1992–1993	Retrospective cohort study, moderate suitability, fair	Philadelphia, Pennsylvania; Medicaid-managed care group; clients: children aged 30–35 months (control group) and 18–24 months (study group), low socioeconomic status	1. Tracing and reminders *plus* provider education and incentives *plus* parent education and incentives *plus* transportation assistance *plus* home visits (n = 1,254) versus 2. Control group of older children (n = 1,257)	4 DTP/3 OPV; 1 MMR at 35 months, 1 versus 2 = 7% net change (p < 0.05); 4 DTP/3 OPV/1 MMR/1 Hib* at 35 months, 1 versus 2 = 2% net change (not significant) Higher coverage in children who received home visits (significance not given)
Dickey and Petitti (54)	1988–1989	Nonrandomized trial, greatest suitability, fair	San Francisco, California; family practice residency clinic; clients: mean age 55 years; urban; 49–55% Spanish speaking	1. "Health diary" on vaccinations and other preventive services given to providers and patients *plus* posters in waiting room (200 participants) *plus* patient education delivered by nursing staff versus 2. "Health diary" given to providers	Influenza, 1 versus 2 = 15% net change (significant) at 6 months and –7% at 18 months; Td,* 1 versus 2 = 4% at 6 months and 7% (significant) at 18 months; pneumococcal, 1 versus 2 = –1% at 6 months and 16% at 18 months; performance in eight preventive services, 1 versus 2 = 11% net change at 6 months (p < 0.001) and 9% at 18 months (p = 0.006)
Elangovan et al. (34)	1995	Before-after study, least suitable, fair	Wichita, Kansas; university ambulatory care clinic; clients aged ≥65 years; 70% white	1. Patient educational materials about pneumococcal vaccinations provided in waiting room and discussed if necessary; if patient consented, chart was flagged for provider (535 participants) versus 2. Usual care prior to campaign	Pneumococcal vaccination, 1 versus 2 = 25% net change (p < 0.001)

Table continues

TABLE 4. Continued

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Elster et al. (35)	1983–1984	Nonrandomized trial, greatest suitability, fair	Utah; University of Utah School of Medicine; mothers aged ≤19 years; 14–22% of study population Hispanic; mixed socioeconomic status	1. Adolescent mother and child program included nutritional and psychosocial assessments, medical care for mother-infant pairs, counseling, nutritional and medical services, staff available nights and weekends versus 2. Usual care for patients recruited from the local WIC program	Up-to-date vaccinations among infants, 1 versus 2 = 13% net change at 12 months and 17% net change at 26 months ($p < 0.05$ both comparisons); multiple non-vaccination outcomes also improved
Herman et al. (55)	1989–1990	Randomized trial, greatest suitability, good	Cleveland Ohio; academic clinical organization; clients ≥65 years, 67% female, predominantly white	1. Standing orders/patient education/ provider education (prevention team) (387 participants) versus 2. Patient/provider education (389) versus 3. Provider education (426)	Influenza, 1 versus 3 = 13% net change; pneumococcal, 19% (significant); 2 versus 3 = 3% influenza and 2% pneumococcal (not significant)
Karuza et al. (57); Calkins et al. (52)	1990–1992; 1991–1992	Group randomized trial, both greatest suitability good and fair respectively	Buffalo, New York; private practices; providers: 33% family practice and 67% internal medicine; clients: adults, urban; 80% male	1. Provider feedback *plus* one or more of: provider reminders on chart *and/or* waiting room posters *and/or* provider education *and/or* standing orders *and/or* special appointments versus 2. Comparison group underwent similar process for nonsteroidal drug prescribing (number = 51 physicians)	Influenza, 1 versus 2 = 16% net change ($p < 0.01$); no net change in pre/post knowledge or attitudes
Lukasik and Pratt (58)	1985	Nonrandomized trial, greatest suitability, fair	London, Ontario, Canada; Victoria Family Medicine Center; clients aged ≥65 years; otherwise, not well described	1. Provider reminders on chart *plus* patient education *plus* waiting room poster *plus* patient reminders *plus* increased access (120 participants) versus 2. Provider reminders on chart *plus* patient education *plus* poster (123) 3. Previous usual care	Influenza, 1 versus 2 = 22% net change ($p = 0.002$), 1 versus 3 = 44%; 2 versus 3 = 22%
Oeffinger et al. (42)	Not reported	Nonrandomized trial, greatest suitability, fair	McLennan County, Texas; family practice residency program in hospital and clinic; clients aged <1 year with 35–39% adolescent mothers; 28–36% Hispanic, 33–47% black	1. Patient education at clinic *plus* patient reminder letter (non-specific) 2 months after birth versus 2. Comparison group of usual care	Up-to-date with 3 doses of DTP/3 OPV by 12 months, 1 versus 2 = –4% net change ($p = 0.41$)
O'Sullivan and Jacobsen (41)	Not reported	Randomized clinical trial, greatest suitability, fair	Eastern United States; large urban teaching hospital; target population maternal aged ≤17 years; 100% black; low socio-economic status	1. Education and rigorous follow-up relating to family planning, parenting behaviors, return to school, health education, recall phone calls/letters, patient-held vaccination records, lower costs versus 2. Usual care	At 18 months, 1 versus 2 = 15% net change in up-to-date vaccination coverage ($p < 0.02$); clinic attendance and repeat pregnancy rates better in intervention group; return to school and emergency room use did not differ

Pierce et al. (44)	1989 (pre) 1993 (post)	Nonrandomized trial, greatest suitability, fair	Albuquerque, New Mexico; public health clinics; clients: children aged ≤12 months; 29–70% Hispanic; most of remainder, white; 34% below poverty level	1. Implementation of "Standards for Pediatric Vaccination Practices;" including evening and Saturday clinic hours *plus* patient and provider education *plus* patient reminders *plus* community involvement and outreach (846 participants pre, 309 post) versus 2. Usual care (753 pre, 138 post)	Dropout, late start, and missed opportunities declined at intervention site relative to comparison; 3 doses DTP/2 OPV, 1 versus 2 = 17% increase at 7 months and 24% at 12 months (significance not tested because whole population included)
Turner et al. (46)	1984	Nonrandomized trial, greatest suitability, fair	Philadelphia, Pennsylvania; internal medicine resident physician clinic; providers: junior and senior resident physicians; clients: adults, mean age 60–62 years; urban; 69–78% female; low socioeconomic status	1. Computerized provider reminders (103 charts audited) versus 2. Written patient educational materials *plus* questionnaire reviewed by provider (86 charts audited) versus 3. Both (64 charts audited) versus 4. Prior usual care for all groups (total 39 resident physicians)	Td was <10% all groups pre and post and had not improved 1 year later; other preventive care significantly improved in 3 versus 4; physician knowledge by questionnaire increased (not significant)

* CDC, Centers for Disease Control and Prevention; GAO, US General Accounting Office; DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine; Td, tetanus-diphtheria vaccine; WIC, Women, Infants, and Children.

percent (range: –8 percent to 47 percent). The 24 studies (34 intervention arms) which evaluated patient reminder interventions alone showed a median coverage difference of 8 percent (range: –7 percent to 31 percent). The 22 studies (25 intervention arms) which evaluated patient reminders as part of a multicomponent intervention showed a median coverage difference of 16 percent (range: –8 percent to 47 percent). These interventions included expanded access (10), patient education (10), provider reminders (eight), provider education (six), reducing vaccine costs (six), provider feedback (three), patient incentives (three), standing orders (three), WIC interventions (one), patient-held medical records (one), and home visits (one). Baseline coverage ranged from 5 percent to 89 percent. Patient reminder/recall systems appear to be effective in improving vaccination coverage when used by themselves or as part of a multicomponent strategy.

Generalizability. Patient reminders were effective in populations of adults and children, in a wide range of settings, and for all antigens studied. Patient reminders appear to work whether as a telephone contact, letter, or postcard. Two studies (67, 88) directly compared mailed reminders with telephone reminders and did not find a difference in effectiveness between these strategies. Six studies evaluated intensity of reminders (e.g., general to more specific, generic to personalized and signed by physician) (71, 72, 82, 111, 112); five of the six studies found greater increases in coverage with more intensive reminders. Patient reminders have not been studied specifically in adolescents.

Communitywide education—single component. Definition. Communitywide education involves providing education to most or all of a population or population subgroup in a geographic area (not including site-specific educational efforts that are implemented only among the clients of a specific site such as a clinic or senior center). Educational strategies that have additional features (e.g., enabling factors like reminders) or are used in conjunction with one or more other strategies (termed multicomponent strategies including education) are categorized elsewhere.

Background. In general, health interventions based on communitywide education come from the belief that low education and few information channels that limit knowledge impede behavioral changes. Community education programs about immunizations provide people with knowledge and information that may change their behavior in favor of acceptance of vaccines. In addition to mailings, educational messages to a community may be delivered through the media (i.e., radio, newspapers, television), telephone calls, and posters. Communitywide education could result in increases in

TABLE 5. Patient reminder/recall systems

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
			Effects of patient reminders/recall alone		
Alemi et al. (61)	1993–1994	Nonrandomized trial, greatest suitability, fair	Cleveland, Ohio; clinics/offices; clients aged <6 months; urban; 81–88% black; low socio-economic status	1. Computer-generated patient telephone reminders and recalls versus 2. Comparison group of usual care (Total study population, 213 participants)	Up-to-date with DTP*/OPV*/MMR*/Hib* vaccinations, 1 versus 2 = 25% net change ($p < 0.005$)
Alto et al. (62)	1991	Randomized trial, greatest suitability, fair	Colorado; family practice residency clinic; clients aged >2 months and <7 years; 17% Hispanic; urban; 51% male; low socio-economic status	1. Mailed and telephone patient reminders versus 2. Comparison group of usual care (Total study population, 464 participants before randomization)	Up-to-date with DTP/OPV/MMR/Hib vaccinations, 1 versus 2 = 8% net change ($p < 0.011$)
Barnas and McKinney (63)	Not reported	Randomized trial, greatest suitability, fair	Milwaukee, Wisconsin; primary care clinic; clients aged ≥65 years, mean 74 years; urban/suburban; 51% black; 70% female	1. Mailed patient reminder for influenza *plus* reminders to attend clinic versus 2. Comparison group receiving reminder to attend clinic (Total study population, 804 participants)	Influenza, 1 versus 2 = −7% net change ($p < 0.04$)
Brimberry (67)	1984–1985	Randomized trial, greatest suitability, fair	Little Rock, Arkansas; family practice residency clinic, clients: adults; urban/suburban/rural; otherwise, not well described	1. Mailed patient reminder versus 2. Telephone patient reminder versus 3 Comparison group of usual care (Total study population, 787 participants)	Influenza, 1 versus 3 = 5.9% net change ($p < 0.02$); 2 versus 3 = 5.5% net change ($p < 0.02$); no difference between mail and telephone reminders
Buchner et al. (68)	1984	Randomized trial, greatest suitability, fair	Seattle, Washington; private practice offices; clients aged ≥65 years, mean 76 years; suburban/rural; 66% female; low/middle socioeconomic status	1. Mailed patient reminder versus 2. Comparison group of usual care (Total study population, 540 analyzed)	Influenza, 1 versus 2 = 1% net change (not significant)
Campbell et al. (70)	Not reported	Randomized trial, greatest suitability, good	Rochester, New York; pediatric community clinic at Strong Memorial Hospital; clients aged 0–13 months; urban; 49–55% female; 60–67% black; low socioeconomic status	1. Mailed letter reminders for well-child care (87 participants) versus 2. Mailed postcard reminders (96) versus 3. Comparison group of usual care (105)	DTP by age 7 months, 1 versus 3 = 6% net change; 2 versus 3 = 2% net change ($p = 0.72$ for differences between the three groups)
Carter et al. (71)	Not reported	Randomized trial, greatest suitability, fair	Seattle, Washington; ambulatory clinic at Veterans Administration hospital; clients: adults; urban; not vaccinated in the year prior to the intervention	1. Standard patient reminder letter *plus* brochure (66 participants) versus 2. Augmented patient reminder letter *plus* brochure (55) versus 3. Augmented patient reminder letter (57) 4. Comparison group of standard patient reminder letter (57)	Influenza, 1 versus 4 = 13% net change ($p < 0.05$); 2 versus 4 = 23% ($p < 0.05$), 3 versus 4 = 7% (not significant); influenza, combined 1 and 2 versus 3 and 4 = 13% ($p < 0.025$)

CDC* (72)	1994	Group randomized trial, greatest suitability, fair	Montana and Wyoming; community-wide; aged ≥65 years; mostly rural	1. Mailed "personal letter" reminders (87 participants) versus 2. Mailed brochure reminders (96) versus 3. Comparison group of usual care (105) All groups received public service announcements and provider reminders	Influenza, 1 and 2 combined versus 3 = 6.1% (confidence interval: 5.5%, 6.7%)
Grabenstein et al. (78)	1993	Randomized trial, greatest suitability, good	Durham County, North Carolina; community pharmacies; clients: adults mean age 67 years, 62% female, 79% white, socioeconomic status mid/high	1. Mailed letter on pharmacy stationary telling about risk and availability of vaccine (242 participants) versus 2. Mailed letter about "poison proofing" home (240) Both groups received reminder letter 2–3 weeks later	Influenza, 1 versus 2 = 10% (confidence interval: 1%, 19%)
Larson et al. (82)	1978–1979	Randomized trial, greatest suitability, fair	Seattle, Washington; University of Washington Family Medicine Center; clients: adults, mean age 67 years; 68% female	1. Neutral card stating availability of vaccinations versus 2. Health belief model card versus 3. Personal card signed by physician versus 4. Comparison group of usual care (Total study population, 283 participants)	Influenza, 1 versus 4 = 5% net change; 2 versus 4 = 31% ($p < 0.001$); 3 versus 4 = 21% ($p < 0.025$); 2 versus 1 = 26% ($p < 0.01$); 3 versus 1 = 16% ($p < 0.1$)
Lieu et al. (84)	1994–1995	Randomized trial, greatest suitability, fair	Northern California; managed care organization; clients aged 20–24 months; middle/upper socioeconomic status	1. Computer-generated personalized letter patient re recalls (172 participants) versus 2. Comparison group of usual care (149)	MMR by age 24 months, 1 versus 2 = 1.7% net change ($p < 0.001$)
McDowell et al. (87, 88); Rosser et al. (101, 102)	1983–1985	Group randomized trial (by family); greatest suitability, fair	Ottawa, Canada; University of Ottawa Family Medicine Center at Civic Hospital; providers: staff and resident physicians, nurses; clients aged ≥65 years	1. Computer generated provider reminder (218 participants) versus 2. Patient reminder by telephone (226) versus 3. Patient reminder by letter (231) versus 4. Comparison group of randomized controls (230)	Influenza, 1 versus 4 = 13% net change ($p < 0.005$); 2 versus 4 = 26% ($p < 0.005$); 3 versus 4 = 26% ($p < 0.005$); Td, 1 versus 4 = 20% (confidence interval: 17%, 22%); 2 versus 4 = 21% (confidence interval: 18%, 24%); 3 versus 4 = 27% (confidence interval: 25%, 31%)
Moran et al. (90)	Not reported	Randomized trial, greatest suitability, fair	North Carolina ambulatory general internal medicine and gerontology clinic; clients: adults; mean age 76 years; 65% female	1 Patient reminded with brochure (450 participants) versus 2. Comparison group of usual care (450)	Influenza, 1 versus 2 = 1% net change ($p > 0.5$)
Mullooly (92)	1984–1985	Nonrandomized trial, greatest suitability, fair	Portland, Oregon; managed care organization; clients aged >65 years; 47–52% female	1. "Personalized" patient reminder letter (1,105 participants) versus 2. Comparison group of usual care (1,112)	Influenza, 1 versus 2 = 9% net change (confidence interval: 5%, 13%); adjustment for the excess of males in the intervention group moderated the net change to 8%

Table continues

TABLE 5. Continued

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Siebers and Hunt (104)	1982–1983	Randomized trial, greatest suitability, fair	Madison, Wisconsin; general internal medicine clinic, University of Wisconsin hospital; clients aged ≥65 years; otherwise target population not described	1. Patient reminder letter (173 participants) versus 2. Comparison group of usual care (92)	Pneumococcal, 1 versus 2 = 13% net change (significant)
Spaulding and Kugler (106)	1983–1984	Randomized trial, greatest suitability, fair	Fort Lewis, Washington; military-affiliated family practice department; clients aged 0–>64 years; 43–50% female	1. Patient reminder postcard (519 participants) versus 2. Comparison group of usual care (549) All patients received enhanced clinic access and free vaccination	Influenza, 1 versus 2 = 27% net change ($p < 0.001$) for those aged >65 years; influenza, 1 versus 2 = 16% ($p < 0.001$) for all ages
Stehr-Green et al. (107)	Not reported	Randomized trial, greatest suitability, fair	Atlanta, Georgia; public health clinics; clients aged <2 years, average 8.7–9.2 months	1. Computer-generated telephone reminder (101 participants) versus 2. Comparison group of usual care (96)	DTP, 1 versus 2 = 3% net change (not significant)
Tollestrup and Hubbard (110)	1987	Nonrandomized trial, greatest suitability, fair	Everett and Snohomish Counties, Washington; county health department clinic; clients aged <5 years	1. Patient recall letter if 1 month overdue (182 participants) versus 2. Comparison group of usual care (211)	DTP vaccination within 5 months, 1 versus 2 = 18% net change ($p < 0.01$)
Tucker and DeSimone (111)	1980–1983	Time series, moderate suitability, fair	Syracuse, New York; family practice residency model office, faculty private office; clients aged ≥65 years; otherwise not well described	1. Mailed patient reminder letter from residency director (856 clients of model office) versus 2. Same but stronger wording and signed by patient's physician (1,251 clients of model office, 249 clients of private office) versus 3. Prior usual care (75 clients of model office, 75 clients of private office)	Model office—Influenza, 1 versus 3 = 7% net change (not significant); 2 versus 3 = 7% (not significant); private office—influenza, 2 versus 3 = 7% (not significant)
Effects of patient reminders/recall in combination with other interventions					
Barton and Schoenbaum (64)	1983–1987	Time series, moderate suitability, fair	Boston, Massachuetts; clinic/provider's offices; clients aged >65 years; urban	1. Patient reminders *plus* patient education *plus* provider reminders versus 2. Same *plus* feedback to individual physicians versus 3. Previous usual care (Total study population, 647 participants)	Influenza, 1 versus 3 = 18% net change; 2 versus 3 = 36% (statistical significance not reported)
Becker et al. (65)	1986–1987	Randomized trial, greatest suitability, fair	Charlottesville, Virginia; University of Virginia medicine clinic; providers: residents; clients aged 40–60 years, mean 51–52 years; 64–72% female; 50–60% black; low socioeconomic status	1. Physician and patient reminders (168 participants) versus 2. Physician reminders (203) versus 3. Comparison group (192)	Influenza, pneumococcal, and Td*, 2 versus 3 = 9%, 2% and 6% net change; 1 versus 3 = 16%, 1%, 8% (analysis of variance for groups 1, 2, and 3 only significant for Td)

Browngoehl et al. (50)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Buffington et al. (69)	1989	Randomized trial, greatest suitability, fair	Rochester, New York; private physician offices; clients aged ≥65 years; urban/suburban; otherwise, target population not well described	1. Provider feedback versus 2. Provider feedback *plus* mailed patient reminders versus 3. Comparison group of usual care (Total study population, 10,525 participants)	Influenza, 1 versus 3 = 16% net change ($p < 0.001$); 2 versus 3 = 17% ($p < 0.001$)
Frame et al. (74)	1991–1992	Group randomized trial, greatest suitability, fair	Danville, New York; family practice offices; providers: family physicians and physician's assistants; clients aged ≥21 years; rural; low/middle socio-economic status	1. Computer-based telephone patient reminders *plus* provider reminders on chart (829 participants) versus 2. Comparison group of patient reminders triggered by physician request (836)	Td, 1 versus 2 = 21% net change (confidence interval: 16%, 26%); net change for all preventive care was 11%
Hutchison and Shannon (80); Frank et al. (75)	1981–1987	Time series study; moderate suitability, fair	Hamilton, Ontario, Canada; community clinic; clients aged >65 years; urban; 66% female	1. Mailed patient reminder letter (273 participants) and associated drop in clinics versus 2. Prior usual care	Influenza, 1 versus 2 after 6 years = 35% net change (statistical testing not reported)
Karuza et al. (57)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Lukasik and Pratt (58)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Margolis et al. (86)	1989–1990	Nonrandomized trial, greatest suitability, fair	Urban/suburban Minneapolis-St. Paul; staff model health maintenance organization; clients aged ≥65 years	1. Standing orders, patient reminder/recall, provider education, expanded access versus 2. Usual care Two clinics in each group; outcomes assessed in 150 randomly chosen patients/clinic	Influenza, intervention clinic 1 versus comparison clinic 1 = −8% net change; intervention clinic 2 versus comparison clinic 2 = 20%; post-versus prechange in intervention clinic 2 (significant, $p = 0.01$); changes in other clinics not significant
Moran et al. (91)	1990	Randomized trial, greatest suitability, fair	Location not reported; community health center; clients: adult; urban; 61% female	1. Single patient reminder letter (135 participants) versus 2. Two patient reminder letters (138) versus 3. Comparison group of usual care (136) Vaccine available free and without appointment	Influenza, 1 versus 3 = 2% net change (not significant); 2 versus 3 = −8% (not significant)
Nichol et al. (97); Nichol (96)	1987; 1987–1992	Other designs with concurrent comparison groups, greatest suitability; time series study, moderate suitability; both fair	Minneapolis versus other Mid-western cities; Veterans Administration outpatient services; clients: veterans	1. Standing orders, walk-in "flu-shot" clinics, vaccination stations in busy clinic areas, mailing to all outpatients (378 participants) versus 2. Usual care at three other mid-western academic hospitals (997)	Influenza, 1 versus 2 = 26% net change (not significant); 2 versus 3 = ($p < 0.00001$); time series data found that coverage rates continued to increase for 5 years; additional 15% among all patients ($p < 0.0001$)

Table continues

TABLE 5. Continued

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
O'Sullivan and Jacobsen (41)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Oeffinger et al. (42)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Ohmit et al. (43)	See Table 4. Multicomponent [communitywide] strategies that include education				
Paunio et al. (59)	See Table 4. Multicomponent [communitywide] strategies that include education				
Pierce et al. (44)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Soljak and Handford (105)	1985	Before-after study for provider reminders; least suitable, fair; nonrandomized trial for patient reminders, greatest suitability, fair	Northland, New Zealand; clinics, offices; clients: children; otherwise, not well-described	1. Provider reminders by mail versus 2. Provider reminders by mail *plus* patient reminders versus 3. Prior usual care (Size of target population not found)	Up-to-date with "all appropriate antigens" 1 versus 2 = "no significant difference"; 1 and 2 combined versus 3 = 5% at 5 months (risk ratio significant)
Waterman et al. (47)	See Table 4. Multicomponent [communitywide] strategies that include education				
			Effects of patient reminders/recall alone and in combination		
Moran et al. (89)	1991	Randomized trial, greatest suitability, fair	Boston; community health center clinics; clients: adults, mean age 66 years; urban; 33–35% male; low socioeconomic status	1. Mailed patient reminders versus 2. Lottery-type patient incentive versus 3. Both versus 4. Comparison group of usual care (Total study population, 797 participants) All groups received walk-in vaccinations, free vaccinations, and health fair	Influenza, 1 versus 4 = 16% net change; 2 versus 4 = 9%; 3 versus 4 = 6%; multivariate analysis odds ratios, 1 = 2.29% (confidence interval: 1.45%, 3.61%); 2 = 1.68% (confidence interval: 1.05%, 2.68%); 3 = 1.41% (confidence interval: 0.88%, 2.27%)
Nexoe et al. (95)	1995	Randomized trial, greatest suitability, fair	Denmark; general practices; clients: adults ≥65 years; 60% female	1. Mailed patient reminders (195 participants) versus 2. Mailed patient reminder *plus* free vaccination (195) versus 3. Comparison group of usual care (195)	Influenza, 1 versus 3 = 24% net change; 2 versus 3 = 47% (no statistical tests for these comparisons)
Ornstein et al. (99)	1988–1989	Group randomized trial (by practice group), greatest suitability, fair	South Carolina; family medicine center at University of South Carolina; providers: faculty, residents, and fellows in family medicine; clients aged >18 years, mean age 40 years; urban; 61% female; 61% black; low socioeconomic status	1. Computerized physician reminders on chart (1,988 participants) versus 2. Patient reminders (1,925) versus 3. Physician and patient reminders (1,908) versus 4. Comparison group of usual care (1,576)	Td, 1 versus 4 = 6.7% net change; 2 versus 4 = 5.7%; 3 versus 4 = 8.2%; significant improvements in 3 of 4 other preventive services
Satterthwaite (103)	Not reported	Randomized trial, greatest suitability, fair	Aukland, New Zealand; general practices; clients aged >65 years; otherwise, target population not described	1. "Personal" patient reminder letter (931 participants) versus 2. Same *plus* free vaccination offered in letter (930) versus 3. Comparison group of usual care (930)	Influenza, 1 versus 3 = 10% net change ($p < 0.001$); 2 versus 3 = 28% ($p < 0.001$)

Yokley and Glenwick (112)	Not reported	Group randomized trial by family, greatest suitability, fair	Akron, Ohio; public health clinic; clients aged ≤5 years, mean 37 months; 50% female; 64% white	1. Mailed general patient reminder (195 participants) versus 2. Mailed specific patient reminder (190) versus 3. Mailed specific patient reminder *plus* special off hours clinics (185) versus 4. Mailed specific patient reminder *plus* parent incentive lottery (183) versus 5. Comparison group of usual care (191)	Vaccinated with at least 1 antigen after 3 months, 1 versus 5 = 3% net change (not significant); 2 versus 5 = 13% (not significant); 3 versus 5 = 16% (significant); 4 versus 5 = 18% (significant)

* CDC, Centers for Disease Control and Prevention; DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; Hib, *Haemophilus influenza* type b; OPV, oral poliomyelitis vaccine; MMR, measles, mumps, rubella vaccine; Td, tetanus-diphtheria vaccine.

vaccination coverage by increasing acceptance and demand for vaccinations among clients.

Effectiveness. Of six studies reviewed (59, 79, 100, 114–116), one study had execution that was not limited (59) (table 6). This study was conducted in children and showed some improvements in numbers of measles vaccinations delivered coincident with a mass media campaign among 6-year-old children but not among toddlers aged 14–18 months, but did not report coverage rates. The study did not provide substantial information on the content or intensity of the intervention. No studies evaluated the effect of education on knowledge or attitudes. The single nonlimited study, with limitations in design and conduct and variability in repeated effects in different subpopulations, made it difficult to estimate effectiveness of this intervention.

Clinic-based education—single component. Definition. Clinic-based education involves providing education to a group of people served in a specific medical or public health clinical setting. Clinic-based patient education in conjunction with other interventions are reviewed elsewhere.

Background. Providing education in a clinic setting may include informational brochures (such as vaccine information statements), videotapes, or posters which could enable the client to take advantage of the available services in the clinic. Vaccine information statements commonly use a standardized format and are available to all providers of immunizations; they are distributed to patients both to provide information and obtain consent for vaccination.

Effectiveness. Of five studies (55, 117–120), three met the criteria for good or fair execution (55, 117, 120) (table 7). The remaining two studies were considered limited. One study with greatest design suitability (55) showed a nonsignificant coverage increase of 3 percent for influenza (baseline: 23 percent) and 2 percent for pneumococcal disease (baseline: 3 percent). This study, conducted at an academic hospital clinic, compared a group of patients who received printed educational materials with a group receiving no intervention. Two other studies with least suitable design and good or fair execution evaluated the effect of vaccine information statements on parental knowledge and attitudes. One study (117) found a significant increase in patient knowledge about vaccines and wanting to have their child immunized; the other study (120) found no statistically significant effect on parental beliefs. The small number of studies, limitations in study design and conduct, and variability in results make it difficult to estimate effectiveness of this intervention in improving knowledge and attitudes or vaccination coverage.

Patient or family incentives. Definition. Patient incentives involve providing financial or nonfinancial

TABLE 6. Communitywide education alone

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Paunio et al. (59)	See Table 4. Multicomponent [communitywide] strategies that include education				

TABLE 7. Clinic-based education alone

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Clayton et al. (117)	Not reported	Before-after study, least suitable, fair	Nashville, Tenessee; resident clinic and six private practices; parents 98% female; mean age 29 years (pre) and 30 years (post); 56–60% work outside home; 40–46% have college degrees	1. Vaccination information statements (198 participants) versus 2 Usual care (236)	1 versus 2 = increased numbers of facts recalled ($p < 0.0001$); 40% increase in those reported wanting to have child vaccinated ($p < 0.0001$); 16% increase in persons who thought they had received too much material
Herman et al. (55)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Lieu et al. (120)	1992–1993	Before-after study, least suitable, good	Alamo and San Ramon, California; multispecialty medical group; clients: upper-middle socio-economic status; mostly white and college educated	1. Vaccination information statements (180 participants) versus 2. Usual care (218)	1 versus 2 produced no statistically significant change in parental belief that they had enough information to make informed decisions about vaccinations or in parental anxiety and produced small but statistically significant declines in parental comfort about vaccinations

incentives for a target population to accept immunizations. Incentives may be either positive or negative. Other interventions, including WIC-based interventions and school laws, also have components of incentives but are reviewed elsewhere.

Background. Patient incentives as extrinsic motivators differ from intrinsic self-motivators such as providing health education or other sources of knowledge to the client. Incentives are based on the assumption that parents will be motivated to seek immunizations for their children in an effort to receive rewards such as baby toys, money, or discount coupons for retailers.

Effectiveness. Three studies (50, 51, 89, 112) (table 8) with greatest or moderate suitability and fair execution showed 2–9 percent (median 6 percent) changes in vaccination coverage. Two combined aspects of a lottery type incentive with patient reminders. In one study (89), conducted among adults in a community health center, patients received an incentive (chance for a $50 gift certificate for groceries) by itself or combined with mailed patient reminders. Coverage differences for influenza were 9 percent when the incentive was used by itself and 6 percent when combined with reminders; baseline coverage was 20 percent. In another study (112) conducted in a public health center among children, patients received a lottery type incentive (chance for $25 to $100 cash prizes) combined with mailed patient reminders. Net change in delivery of at least one antigen was 18 percent during the study period. This could not be converted to a coverage difference. The third study (50, 51) conducted among parents of children in managed care clinics combined incentives ($10 gift certificate when immunization obtained) with a multicomponent strategy, including provider and parent reminders and home visiting. Up-to date coverage differences for DPT, OPV, MMR, and Hib at 35 months was 2 percent; baseline coverage was 37 percent. There is insufficient evidence to estimate effectiveness of this intervention because there are too few studies, too much variability in interventions evaluated, and limitation in study design and conduct.

Client-held medical records. Definition. This intervention provides personal medical records to members of a target population or their families showing which immunizations have been received.

Background. Patient-held medical records could be used to assess a client's vaccination status in medical and nonmedical settings. State and local health departments and some providers have encouraged the use of patient-held medical records to varying degrees. Patient-held medical records could result in increases in vaccination coverage by increasing knowledge about and demand for vaccinations among clients or by reducing missed opportunities to vaccinate in health care settings or a combination of the two.

TABLE 8. Patient or family incentives

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Browngoehl et al. (50)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Moran et al. (89)	See Table 5. Patient reminder/recall systems				
Yokley and Glenwick (112)	See Table 5. Patient reminder/recall systems				

Effectiveness. Of eight studies reviewed (32, 41, 54, 121–125), four studies had executions that were not limited (41, 54, 122, 125) (table 9). One of the studies compared the combination of a patient-held record and a provider reminder with provider reminders alone (125). The other studies evaluated patient-held records in conjunction with clinic-based education (54), patient reminders (122), or multiple strategies (41). Baseline coverages in the three studies (41, 54, 125) which looked at vaccination coverage ranged from 18 to 46 percent; coverage differences ranged from 5 to 15 percent (median 8 percent); follow-up times ranged from 4 months to 2 years. The remaining study (122) reported >45 percent influenza coverage in both the intervention and comparison groups, and no significant difference between the groups (actual effect size not shown). The small number of studies, limitations in design and conduct, and variability in interventions evaluated and results make it difficult to estimate effectiveness of this intervention.

Interventions that enhance access to immunizations

Interventions included in this category improve the access to immunizations through several mechanisms: 1) reducing the cost of vaccines to families, 2) providing services in nonmedical settings, and 3) improving the convenience of obtaining immunizations. Interventions in nonmedical settings include contact in the client's home, and immunization interventions in WIC (Special Supplemental Program for Women, Infants, and Children), child care, and schools.

Reducing the cost of vaccines to families. Definition. These interventions reduce the out-of-pocket costs to families of vaccines and/or their administration by paying for vaccines and/or administration, providing insurance coverage for reimbursement, or reducing copays at the point of service.

Background. The out-of-pocket costs of immunizations are commonly cited by clients and providers as a barrier to obtaining immunizations (126). A number of interventions have been used by the federal government (e.g., the Vaccines For Children Program), state governments (e.g., provision of free vaccines), and programs by managed care organizations (e.g., reducing copays) to reduce this barrier. Reducing out-of-pocket costs can result in increases in vaccination coverage either by improving availability of vaccines or increasing demand for vaccines.

Effectiveness. Of 26 studies reviewed (24, 26, 36, 38, 41, 43, 49, 56, 79, 91, 95, 103, 127–142), 15 studies with fair execution showed –8 percent to 47 percent (median 15 percent) changes in vaccination coverage (36, 41, 43, 56, 91, 95, 103, 127, 129, 131–136) (table 10). Seven studies evaluated this intervention by itself;

TABLE 9. Client-held medical records

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Dickey and Petitti (54)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Dietrich and Duhamel (122)	1984–1986	Randomized trial, greatest suitability, fair	New Hampshire; small-town community practice; clients aged ≥65 years; 67–68% female	1. Personal prevention checklist (influenza, blood pressure, cancer) *plus* questionnaires about personal characteristics and recent preventive care (59 participants) versus 2. Reminder letter for influenza vaccination (55)	Influenza, "greater than 45%" vaccinated in both groups (not significant); cancer screening, 1 versus 2 = 16% net change ($p < 0.05$); blood pressure, measured ">90% of groups"
O'Sullivan and Jacobsen (41)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Turner et al. (125)	1987–1988	Randomized trial, greatest suitability, fair	Greenville, North Carolina; resident physician clinic, East Carolina School of Medicine; clients: 60% black; mixed urbanicity; otherwise target population incompletely described	1. Patient-held mini record *plus* provider reminders (177 participants versus 2. Provider reminders (246)	Influenza, 1 versus 2 = 18% ($p < 0.002$); pneumococcal, 1 versus 2 = –2% ($p = 0.34$); significant increase occurred in most other preventive measures

the five studies (six intervention arms) (56, 127, 129, 132, 133) which looked at vaccination coverage as an outcome found –1 percent to 29 percent (median 10 percent) increases in coverage. Baseline coverage ranged from 41 to 83 percent. The other two studies also showed improvements in immunization outcomes but did not present data that could be transformed to a coverage difference (131, 134). Studies that combine reducing out-of-pocket costs with other interventions showed coverage increases from –8 to 47 percent (median 16 percent) (36, 41, 43, 91, 95, 103, 135, 136). Baseline coverage ranged from 17 to 64 percent. These interventions included patient reminders (five), patient education (three), expanded access (two), provider education (two), patient-held medical records (one), interventions in WIC (one), and provider reminders (one). Reducing out of pocket costs appear to be effective in improving vaccination coverage when used alone and in combination with other interventions.

Five studies (133, 139–142) with fair and good execution found that providers reported being more likely to refer children with less public or private insurance coverage to other sites for vaccination. Two of these studies (139, 140) were nationwide cross-sectional surveys of pediatricians and/or family physicians.

Generalizability. Positive effects of reducing out of pocket costs were shown in children (127, 131, 135, 136) and adults (36, 43, 91, 95, 103, 129) in both urban (36, 91, 135) and rural (43, 129) settings, and in low socioeconomic populations (132, 135). Settings in which low cost vaccines were provided included hospitals, clinics, and WIC sites. No studies were identified which evaluated this intervention in adolescents.

Immunization interventions in WIC. Definition. Interventions in WIC involve efforts to encourage the immunization of a low-income target population in a nonmedical setting. At a minimum, immunization-promoting strategies in WIC require assessment of each child's immunization status and referral of underimmunized children to a health-care provider. Other services can include education, provision of vaccinations, and/or incentives to accept vaccinations.

Background. WIC (the Special Supplemental Nutrition Program for Women, Infants, and Children) is a categorical federal grant program administered by the US Department of Agriculture and implemented through state health departments and Indian tribal organizations. WIC provides supplemental foods, health care referrals, and nutrition education for low-income women, infants, and children who are found to be at nutritional risk. WIC programs are required to coordinate and serve as a gateway for other health services, including immunizations.

WIC is the single largest point of access to health-related services for low-income preschool children. Nationwide, WIC serves over 45 percent of the US birth cohort. In some cities, up to 80 percent of low-income infants participate in WIC. In general, participants visit WIC sites every 2–3 months to receive nutritional services and to pick up food vouchers; more comprehensive health status evaluations are conducted every 6–12 months. Voucher restrictions are routinely used to more closely monitor high-risk clients in the WIC program, and require families to return to the WIC site more frequently than would otherwise have been the case, usually monthly. All immunization interventions in WIC involve assessing immunization status and referring for immunizations to the child's medical home; immunizations may also be provided on site. Many WIC programs have used voucher restrictions for children who are behind on immunizations, requiring monthly rather than less frequent visits until the child's immunization status is documented as up-to-date. Immunization interventions in WIC can result in increased vaccination coverage either by increasing attendance in clinical settings through referrals or increasing doses delivered through vaccinating children on site.

Effectiveness. Of the 10 studies reviewed (47, 135, 143–151), four studies with greatest suitability (prospective studies with concurrent comparison groups) and fair execution showed improvements in vaccination coverage ranging from 4–34 percent (median 9 percent) over 6–12 months (47, 135, 143, 145) (table 11). The remaining studies had limited execution. Two studies with greatest suitability and fair execution which compared WIC interventions to no intervention showed improvements in coverage of 34 and 9 percent, respectively, from 6–24 months after the program became operational (135, 145). Baseline coverages were 35 percent and 37 percent, respectively. A third study (with relatively high baseline coverages of 94 percent) compared either escort to an immunization clinic or voucher restrictions in addition to education, assessment, and referral, with education, assessment, and referral alone. The interventions resulted in the vaccination of 86 percent of undervaccinated children in the escort group, 79 percent in the voucher restriction group, and 54 percent of children in the group that received education, assessment, and referral alone (143). Because baseline vaccination coverages were high in all groups, the absolute improvements in coverage attained by the enhanced interventions are small, approximately 4 percent. A final study used WIC interventions as part of a comprehensive multicomponent intervention and showed a 12 percent improvement in coverage attributable to all of the

TABLE 10. Reducing out-of-pocket vaccination costs

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Effects of reducing out-of-pocket vaccination costs alone					
Combs et al. (127)	1993–1994	Before-after study, least suitable, fair	Durham, North Carolina; Duke University Medical Center clinics; clients: infants	1. Free vaccine through continuity clinic (335 participants) versus 2. Prior usual care which involved obtaining hepatitis B vaccinations 2 and 3 at health department (376 participants)	Hepatitis B: three doses by time of third DTP*, 1 versus 2 = 29% net change ($p < 0.001$); any dose during the study period, 1 versus 2 = 14% net change ($p < 0.001$)
Holtmann (56)	See Table 4. Multicomponent [communitywide] strategies that include education				
Ives et al. (129); Lave et al. (130)	1989–1991	Randomized trial, greatest suitability, fair	Pennsylvania; five rural counties hospital/clinics; clients aged 65–79 years; 57% female	1. Free vaccinations from hospital versus 2. Free vaccinations from provider versus 3. Comparison group of usual care (Total study population, 1,989 participants) All groups received examination/vaccination assessment	Influenza, 1 versus 3 = 9% net change ($p < 0.0001$); 2 versus 3 = 15% ($p < 0.0001$)
Lurie et al. (131)	1974–1982	Randomized trial, greatest suitability, fair	Cities in Ohio, Washington, Massachusetts; target population adults and children, aged <62 years; mixed urbanicity; mixed socioeconomic status	1. Insurance coverage with free vaccination versus 2. Insurance coverage with copays (Total study population, 3,823 participants)	Percentage of persons filing claims for DTP/MMR* (children) or influenza/Td* (adults), 1 versus 2 = 10% net change in children (significant); 1 versus 2 = 8% in adults (significant)
Rodewald et al. (132)	1991–1993	Before-after study, least suitable, fair	Upstate New York; clinics and community-wide; clients aged 0–6 years; 48% female; 85% white; low socioeconomic status	1. Insurance plan that provided coverage for vaccines at <222% poverty versus 2. Prior insurance coverage (Total study population, 2,232 participants)	Up-to-date DTP/OPV*/MMR for children 1–5 years, 1 versus 2 = 5% net change ($p < 0.001$) Referral to public health clinics decreased from 0.06 to 0.02 visits/year/child ($p < 0.01$) and use of private providers increased from 0.46 to 0.52 visits/child/year ($p < 0.01$)
Taylor et al. (133)	Early 1990s	Other designs with concurrent comparison groups, greatest suitability, fair	Idaho, Massachusetts, Rhode Island, Vermont, Washington, Colorado, New Jersey, New York, Oregon, South Carolina, Utah; private pediatric offices; clients aged 2 or 3 years	1. State-sponsored universal purchase program (seven providers); versus 2. Usual care (eight providers) (client charts evaluated 857–977)	4 DTP/3 OPV/1 MMR at 2 years, 1 versus 2 = −1% net change ($p = 0.774$) Pediatricians in nonuniversal purchase states reported more likely to refer children elsewhere for immunization 7/8 versus 2/7 ($p = 0.04$)
Zimmerman and Janosky (134)	Not reported	Cross-sectional study, least suitable, fair	Minnesota; clinics/offices of family practitioners and pediatricians; clients aged <7 years, mixed socioeconomic status	1. No insurance coverage versus 2. Medicaid versus 3. Private insurance (37 providers; 507 patient records)	Age of receipt of DTP3 and MMR for children with insurance was closer to recommended age than for children with no insurance; significant for DTP3; not significant for MMR

					Patients of providers who refer patients for immunizations were more likely to have immunization delays
Effects of reducing out-of-pocket vaccination costs in combination with other interventions on coverage					
Etkind et al. (36)	See Table 4. Multicomponent [communitywide] strategies that include education				
Hutchins et al. (135)	1991–1993	Group randomized trial, highly suitable, fair	Chicago, Illinois; WIC* sites; clients aged <5 years; 53–98% black; 1–42% Hispanic; urban; low socioeconomic status	1. Assessment of vaccination status and education, *plus* voucher restriction *plus* referral to on-site clinic, off-site clinic, or on-site nurse; free vaccinations available to all study participants versus 2. Comparison group of usual standard of care for WIC and health care services (Total, 27,596 children in study; 300 aged 13–35 months evaluated in each group)	DTP/OPV/MMR (4:3:1 doses, respectively) at 24 months, 1 versus 2 = 34% net change ($p < 0.05$)
Moran et al. (91)	See Table 5. Patient reminder/recall systems				
Nexoe et al. (95)	See Table 5. Patient reminder/recall systems				
Ohmit et al. (43)	See Table 4. Multicomponent [communitywide] strategies that include education				
O'Sullivan and Jacobsen (41)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Satterthwaite (103)	See Table 5. Patient reminder/recall systems				
Szilagyi et al. (136)	1994	Prospective cohort study, greatest suitability, fair	New York City (Manhattan and the Bronx); two emergency departments; clients aged birth–6.9 years; urban; 52–53% male; low socioeconomic status	1. Patients screened in emergency department and offered vaccination *plus* vaccinations provided at no cost (484 participants) versus 2. Prior usual care	Up-to-date with DTP/OPV/MMR/Hib*/HepB*, 1 versus 2 = 11% net change ($p < 0.001$) at 1 day and 2% (not significant) after 6 months in Manhattan; 1 versus 2 = 8% ($p < 0.05$) at 1 day and –9% (not significant) at 6 months in the Bronx
Effects of reducing out-of-pocket vaccination costs on vaccine availability and referral					
Arnold and Schlenker (141)	1990	Cross-sectional survey, least suitable, fair	Milwaukee, Wisconsin; pediatric clinics; clients: children, otherwise not well described	1. Traditional private insurance versus 2. Managed care versus 3. Medicaid versus 4. No insurance coverage (202 physicians)	DTP/OPV/MMR/Hib vaccination less likely to be provided to uninsured patients ($p < 0.01$) No differences in vaccine provision between managed care or traditional private insurance
Mainous and Hueston (142); Hueston et al. (128)	1993	Other designs with concurrent comparison groups (matched cross-sectional survey of physicians), greatest suitability, good	Washington, Oregon, North Dakota, South Dakota, New Hampshire, Delaware; family practice clinics; clients not described	1. Practitioners in states which provide free vaccines for Medicaid patients versus 2. Practitioners in states which do not provide free vaccines for Medicaid patients (553 providers)	Practices in free vaccine states were more likely to offer immunization to Medicaid patients, 1 versus 2 = 17% (reported statistically significant); largest differences in rural practices and small communities

Table continues

TABLE 10. Continued

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Ruch-Ross and O'Connor (140)	1992	Cross-sectional survey, least suitable, fair	US nationwide; pediatricians; 87% metropolitan, 12% non-metropolitan, 1% rural	1. State programs that provide free vaccines versus 2. Usual care in comparison states (1,246 of 1,600 pediatricians responded to survey)	Presence and type of state program providing free vaccines was significantly associated with likelihood that children would be referred. Odds of referral if state provides some vaccines free of charge 3.7, odds of referral if state provides no free vaccines 6.7; relative to states providing all vaccines free. Costs of vaccination were leading reported cause of referrals
Zimmerman et al. (139)	1995	Other designs with concurrent comparison groups (matched cross-sectional survey), greatest suitability, good	United States; pediatrician and family practice offices; 86% urban	1. Free vaccines for specific child populations versus 2. Usual care (1,236 of 2,100 physicians surveyed)	Practices with free vaccine reported to refer less often. Referral rates for patients who were uninsured and unable to pay was 90% in states not providing free vaccines versus 44% in states providing free vaccines ($p < 0.001$)

* DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; HepB, hepatitis B vaccine; Hib, *Haemophilus influenza* type B vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine; Td, tetanus-diphtheria vaccine; WIC, Women, Infants, and Children.

strategies combined (47). Immunization interventions in WIC appear to improve vaccination coverage when used by itself or in combination with other interventions.

Generalizability. Positive effects of interventions in WIC settings have been shown in urban areas among disadvantaged, predominantly minority, children. The studies we reviewed did not include non-urban areas or non-minority populations.

Home visits. Definition. Home visits to promote immunizations involve providing face-to-face services to clients in their homes; services can include education, assessment of need for vaccinations, referral for vaccinations, and provision of vaccinations. Additionally, home visiting interventions can involve telephone or mail reminders.

Background. In the United States, home visiting interventions are usually targeted towards subpopulations that are difficult to reach, such as persons living in public housing communities or persons living in rural areas.

Effectiveness. Of 15 studies reviewed (50, 51, 98, 152–163), seven had good or fair execution (50, 98, 153, 158, 159, 162, 163) (table 12); the remainder had limited execution. Four of the studies (153, 158, 162, 163) evaluated home visits with or without reminder and mail contact between visits, two (50, 159) evaluated a complex multicomponent strategy, one part of which included home visits, and one study (98) evaluated the association between provider reported practice policies (including home visiting) and immunization rates. These seven studies showed changes in vaccination coverages ranging from –1 percent to 49 percent (median 10 percent). All studies utilized immunization record screening as part of the strategy. Home visits appears to improve vaccination coverage when used by itself or in combination with other interventions (coverage range: –1 to 10 percent (median 5 percent); coverage range: 2 to 20 percent (median 13 percent), respectively).

Generalizability. Positive effects of this intervention were shown in children (50, 158, 159, 162, 163) in predominantly low socioeconomic urban populations (158, 159, 162) and in adults (98). Home visits have not been studied among adolescents, or to increase the delivery of hepatitis B or pneumococcal vaccine.

Immunization interventions in child care. Definition. Interventions in child care involve efforts to encourage the immunization of a target population of children less than 5 years of age. These interventions require assessment of each child's immunization status at entry into child care, at a point during the child's enrollment, or at periodic intervals during the child's enrollment in child care. Other services can

TABLE 11. Vaccination interventions in WIC* settings

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Effects of intervention in WIC settings alone					
Birkhead et al. (143)	1991	Group randomized trial, greatest suitability, fair	New York City; WIC sites; clients aged 12–59 months, median age 14 months; urban; 56% Hispanic, 39% black, low socioeconomic status	1. Assessment of vaccination status, education, and referral to provider *plus* voucher restriction (178 participants) versus 2. Assessment and referral *plus* escort to pediatric clinic (377) versus 3. Comparison group of assessment and referral (281)	MMR*, 1 versus 3 = 4% net change ($p < 0.01$); 2 versus 3 = 4% ($p < 0.01$) after 6 months; 86% of children vaccinated at start of study
Effects of interventions in WIC settings with other interventions					
Golden (145)	1993–1995	Nonrandomized trial, greatest suitability, fair	Los Angeles, California; WIC sites; clients aged ≤16 months; 93% Hispanic, 6% black; low socioeconomic status; urban	1. Assessment of vaccination status, education, and referral to provider *plus* on-site free vaccinations versus 2. Assessment and referral *plus* voucher restriction versus 3. Assessment and referral *plus* on-site free vaccinations *plus* voucher restriction versus 4. Assessment and referral versus 5. Comparison group of usual care (Total study population, 2,457 *participants pre*)	DTP*/OPV*/MMR (4:3:1 doses, respectively), coverage at 16 months, 1–4 combined versus 5 = 9% net change ($p < 0.01$); in general, no major differences between various intervention combinations
Hutchins et al. (135)	See Table 10. Reducing out-of-pocket vaccination costs				
Waterman et al. (47)	See Table 4. Multicomponent [communitywide] strategies that include education				

* DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine; WIC, Women, Infants, and Children.

TABLE 12. Home visits

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
			Effects of home visits alone		
Black et al. (153)	1990–1992	Randomized trial, greatest suitability, fair	Ontario, Canada; clients ≥65 years; "public health patients"; 66% with ≥1 chronic health problem	1. Home visit by public health nurse promoting influenza vaccination and identifying strategies to overcome barriers versus 2. Comparison group with "safety education" (Study group total, 359 participants)	Influenza, 1 versus 2 = −1% net change (not significant); 42% of intervention group reported talking with nurse about influenza versus 18% of control group
Nicholson et al. (98)	1984	Cross-sectional study, least suitable, fair	Trent, United Kingdom; general practitioners; clients aged ≥65 years; otherwise, not well-described	1. Practice policies including any of following: home-bound patients to be vaccinated at home, patient reminders, or special vaccination clinics versus 2 Lack of policies (Study group total, 127 general practitioners surveyed)	Influenza, 1 versus 2 = 10% net change ($p < 0.05$) for home vaccination Influenza, 1 versus 2 = 7% net change ($p < 0.05$) for regular or special immunization clinics
			Effects of home visits alone and in combination with other interventions		
Bond et al. (163)	1996	Randomized trial, greatest suitability, fair	Australia; communitywide; clients aged 9 or 16 months identified from Australian Childhood Immunization Registry	1. Letter, telephone, and home contact including administration of vaccine versus 2. Usual care (Total study population 2,194; 204 and 202 not-up-to-date randomized to interventionand control)	4 DTP*/OPV*/Hib* at 9 months or 1 MMR* at 16 months, 1 versus 2 = 1%
Browngoehl et al. (50)	See Table 4. Multicomponent strategies that included education [in clinical settings]				
Rodewald et al. (158)	1994–1995	Randomized trial, greatest suitability, intervention 1 good, intervention 2 fair	Rochester, New York; homes and provider offices, rural health center, hospital-based clinics; clients aged 0–12 months; urban/rural; 36–39% black; 6–10% Hispanic; low/middle socioeconomic status	1. Lay community services provider made phone, mail, or home contact (630 participants) versus 2. Provider education *plus* feedback *plus* reminders (744) versus 3. Both 1 and 2 (648) versus 4. Usual care (719) Only 12% of group 1 received ≥1 home visit; only 16% of group 2 received provider reminder	DTP/OPV/MMR/Hib (4:3:1:4 doses, respectively), 1 versus 4 = 20% net change ($p < 0.001$); 2 versus 4 = 1% ($p = 0.54$); no interaction between 1 and 2; other health outcomes (health visits and anemia and lead screenings) significantly increased in group 1 but not in group 2
Rosenberg et al. (159)	1992–1993	Before-after study, least suitable, fair	New York City; public health clinics, homes, streets; clients aged <5 years; 54% aged <2 years; urban; 40% Hispanic, 40% black; low socioeconomic status	1. Local community-based organization performed outreach (e.g., making informal presentations where people congregate or making door to door visits) *plus* disseminated information *plus* screened vaccination history *plus* provided vaccination appointment *plus* reminders/follow-up (2,676 participants versus 2. Prior usual care	Evaluation subsample found DTP/OPV/MMR coverage in 1 versus 2 = 49% net change ($p < 0.05$)

Wood et al. (162)	1994	Randomized trial, greatest suitability, good	Los Angeles (10 ZIP codes); homes and clinics; clients aged <15 months; 90% urban; 100% black, low socioeconomic status	1. Case management with home visits and telephone contact prior to age 6 weeks and before each vaccination appointment, *plus* health passport versus 2. Health passport only (Study group total, 419 participants)	DTP/OPV/Hib (3:2:3 doses, respectively) at 12 months, 1 versus 2 = 13% net change (p = 0.01)

* DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; Hib, *Haemophilus influenzae* type b vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine;.

include education and notification of parents, referral of underimmunized children to a health-care provider, and, possibly, provision of vaccinations on site.

Background. Children in child-care centers are at increased risk for communicable diseases (164). In 1995, more than 31 percent of preschool-age children were cared for in child-care homes or centers (draft report of the Children's Health Working Group, March 1998). Interventions in child care can result in increased attendance in clinical settings through referrals or possibly by directly increasing coverage through delivering vaccinations on site.

Effectiveness. The single study reviewed (165) had a least suitable design and limited execution. The one limited study did not allow an estimation of effectiveness.

School-based vaccination programs. Definition. These interventions involve the use of school-based programs to administer vaccines to school-aged individuals.

Background. The outreach activities usually include immunization-related education of students, parents, and teachers and other school staff, individual and/or peer incentives to motivate participation, acquiring written consents from parents, and administering vaccines to participating students. The programs are often collaborations between schools, local health departments, private hospitals, and community clinics.

School-based programs provide a unique opportunity for reaching adolescents with vaccinations and other preventive services since over 99 percent of the 11 and 12 year olds in the United States attend school (166). School-based immunization programs could track each student's vaccination status, identify those who have missed doses, and ensure vaccine series completion (e.g., with hepatitis B vaccine) among most students.

Effectiveness. Of the four studies reviewed (37, 73, 100, 167), a single study had fair execution and a least suitable design. The results showed post-coverage with three doses of hepatitis B of 66 percent (167) (table 13), but there was no baseline. This study evaluated a school-based hepatitis B program for adolescents; the study utilized multiple components including teacher education, classroom lessons, written patient education materials, and peer and individual incentives to encourage children to bring in their consent forms. Results showed significant improvements in patient knowledge about hepatitis B vaccine; schools utilizing peer incentives showed significantly higher rates of return of consent forms. The limitations of the study in design and conduct make it difficult to estimate effectiveness for this intervention.

Expanding access in health-care settings. Definition. These interventions increase the availability of vaccinations in medical or public health clinical settings

TABLE 13. Schools

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Unti et al. (167)	1992–1995	Multiple designs; moderately suitable, least suitable, fair	San Francisco, California; schools; seventh grade students	1. Teacher orientation *plus* classroom lessons *plus* school assembly *plus* patient education materials *plus* student vaccination during school hours *plus* peer and individual incentives (4,928 students)	Hepatitis B (3 doses), coverage post 66%, cannot calculate net change because no comparison; 71% of target population consented; 93% of those who consented received 3 doses hepatitis B vaccine; knowledge regarding vaccination increased significantly; peer incentives increased return of consent forms

in which vaccinations are offered by 1) reducing the distance from the clinic to the population, 2) increasing or changing hours during which vaccination services are provided, 3) delivering vaccinations in clinical settings in which they were previously not provided (emergency rooms, inpatient units, subspecialty clinics), or 4) reducing administrative barriers within clinics to obtaining vaccinations services (e.g., developing a drop-in clinic).

Background. Surveys of parental attitudes and behaviors have identified inconvenience of obtaining vaccines as an important barrier toward improving vaccination rates in children (126). This factor may be especially important for disadvantaged low income families, many of whom have large families and/or little financial support for child care or transportation.

Effectiveness. Of 25 studies (24, 26, 28, 33, 35, 38, 39, 44, 47, 51, 58, 60, 75, 80, 86, 91, 96–98, 121, 136, 168–170), 16 with fair execution (35, 39, 44, 47, 50, 57, 58, 80, 86, 91, 97, 98, 112, 136, 168, 170) (table 14) showed a median coverage difference of 10 percent (range: –8 percent to 35 percent). Most of the studies (35, 44, 47, 50, 57, 58, 80, 86, 91, 97, 112, 136) evaluated expanding access in combination with other interventions; these studies showed a median coverage difference of 13 percent (range: –8 to 35 percent), baseline coverage 7 percent to 68 percent. Eight of the studies included patient reminders as part of the multicomponent intervention. Other interventions included patient education (five), provider education (four), reducing cost of vaccines (three), standing orders (three), and patient incentives, WIC, and home visiting (one each). Expanded access consisted of drop-in clinics (six), increased hours on nights and weekends (three), vaccination in the emergency department (two), dedicated immunization clinics, special appointments, vaccination stations, and transportation assistance (one). The two studies (98, 170) which evaluated expanded access by itself showed a median coverage difference of 5 percent (range: 3 to 7 percent). One study (170) was conducted in an emergency department and showed a nonsignificant coverage difference of 3 percent after 12 months study duration, baseline 72 percent. The other study (98) which evaluated the association between provider reported practice policies (including special vaccination clinics) and immunization rates found a coverage difference of 7 percent, baseline: 19 percent. Expanded access appears to improve vaccination coverage when used in combination with other interventions, but the small number of studies, variability in results, and limitations in study designs and executions make it difficult to estimate effectiveness of this intervention by itself.

Generalizability. Positive effects of expanding access have been shown among adults, adolescents,

TABLE 14. Expanding access in health-care settings

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (*statistical significance*)
			Effects of expanding access in health-care settings alone		
Nicholson et al. (98)	See Table 12. Home visits				
Rodewald et al. (170)	1990–1991	Randomized trial, greatest suitability, fair	Rochester, New York; emergency departments, primary care sites; clients aged 6–36 months; mean 18 months; urban; 55–59% female; 43–48% black; low socioeconomic status	1. Provider reminders by mail (610 participants) versus 2 Vaccination offered on-site at emergency departments (611) versus 3. Comparison group of usual care (614) All children enrolled through emergency departments	Up-to-date with DTP*/OPV*/MMR*/Hib*, 1 versus 3 = no significant difference; 2 versus 3 = 8% net change (p = 0.002) at 1 month, but 2 versus 3 = 3% (p = 0.2) at 12 months
			Effects of expanding access in health-care settings in combination with other investigations		
Browngoehl et al. (50)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Elster et al. (35)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Hutchison and Shannon (80)	See Table 5. Patient reminder/recall systems				
Karuza et al. (57)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Lukasik and Pratt (58)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
MacDonald and Roder (39)	See Table 4. Multicomponent [communitywide] strategies that include education				
Margolis et al. (86)	See Table 5. Patient reminder/recall systems				
Moran et al. (91)	See Table 5. Patient reminder/recall systems				
Nichol et al. (97)	See Table 5. Patient reminder/recall systems				
Nichol (168)	1990	Prospective cohort study, greatest suitability, fair	Minneapolis, Minnesota Veterans Administration Hospital; clients aged ≥65 years	1. Standing orders and vaccination stations among inpatients versus 2. Standing orders and provider reminders and walk-in "flu-shot" clinics and educational mailings among outpatients	Prior to intervention inpatient coverage <25% and outpatient coverage >60%; addition of policy for in-patients brought inpatient coverage to 79% which did not differ significantly from outpatient levels
Pierce et al. (44)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Szilagyi et al. (136)	See Table 10. Reducing out-of-pocket vaccination costs				
Waterman et al. (47)	See Table 4. Multicomponent [communitywide] strategies that include education				
Yokley et al. (112)	See Table 5. Patient reminder/recall systems				

* DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; Hib, *Haemophilus influenzae* type b vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine.

and children in a variety of settings (managed care (86), community clinic (75), Veterans Administration hospitals (97), academic medical centers (35), public health clinics (44)) and for most antigens. Expanded access has not been studied for pneumococcal vaccine. Neither of the two available studies in emergency departments showed results that were substantially or significantly different from zero.

Legal/regulatory interventions

School, child care, and college entry requirements. Definition. School, child care, and college entry requirements are laws or policies requiring vaccinations (or other documentation of immunity) as a condition of school, child care, and college entry or attendance.

Background. Enactment and enforcement of state immunization laws in the 1970s–1980s led to over 95 percent of school-age children now being appropriately immunized with the recommended doses of vaccine. Vaccination requirements for child care attendance and college attendance are more recent and vary greatly among states.

Effectiveness. Of 10 studies (171–181), nine had fair execution and one was limited (181) (table 15). School, child care, and college requirements were found to reduce disease rates and disease outbreaks in six of six studies (171, 173, 175, 177, 179, 180). Three nationwide studies (175, 179, 180) (cross-sectional and before-after studies) found that states with vaccination requirements for school-aged children had lower measles and mumps incidence, and that areas with low incidence were more likely to enforce school laws with exclusion from school.

The three studies which looked at vaccination coverage as the outcome found a median coverage difference of 15 percent (range: 5–35 percent). The first study (172), conducted in Ontario, Canada, found that immunization requirements for all school attendees 5–17 years of age produced coverage differences of on average 5 percent (range: 3–9 percent by antigen) in comparison to before the law was implemented. Baseline coverage in this population was relatively high at 87 percent. The second study (176) was a time series which measured immunization coverage of school-aged children over a 7-year period (1979–1986) following enactment of school laws in California in 1977; over this time period, immunization coverage of children aged 5–6 years increased approximately 15 percent from a baseline coverage of 75 percent. The third study (173), conducted in New Jersey, found that children <7 years of age covered by a school law to be vaccinated against mumps had higher "documented immunity" or vaccination coverage compared with children not covered by the law (96 percent versus 61 percent, respectively).

One study (174) which evaluated the effect of a school law for rubella found an initial improvement in rubella immunity that was not sustained several years later.

School, child care, and college requirements appear effective in reducing disease rates or disease outbreaks and/or improving vaccination coverage.

Generalizability. Positive effects of child care, school, and college entry requirements have been shown among children and young adults. This intervention appears to be effective nationwide, regardless of varying race/ethnicity and socioeconomic status. This intervention has not been studied for hepatitis B vaccine.

Provider-based interventions

Provider-based strategies include interventions that are implemented primarily in health-care settings and systems. These interventions include provider education, provider recall/reminder, provider feedback, and standing orders.

Provider reminder/recall. Definition. This intervention provides reminders to providers that immunizations are due or late for individual clients. Techniques by which reminders are delivered (in patient charts, by computer, by mail, other) and content of the reminders may vary. Interventions that incorporate both reminders and standing orders are classified as standing orders.

Background. Information on the client's immunization status is either made available manually or through a computerized system; this information is then conveyed to the provider before, during, or after a scheduled clinic visit.

Effectiveness. Of 60 studies (27, 31, 34, 38, 40, 45, 46, 48, 52, 57–59, 64, 65, 74, 76, 87, 88, 93, 99, 101, 102, 105, 121, 123, 137, 138, 154, 158, 170, 182–219), 29 (36 intervention arms) with good or fair execution and greatest or moderate design suitability (46, 57–59, 64, 65, 74, 88, 99, 158, 170, 185, 186, 189, 190, 192, 194–200, 204, 213, 215–217, 219) showed a median coverage difference of 17 percent (range: 1 to 67 percent) (table 16). Baseline coverages ranged from 4 to 89 percent. The available studies evaluated provider reminder/recall by itself (median coverage difference 17 percent, range: 1 to 67 percent) and as a multicomponent intervention (median coverage difference 14 percent, range: 1 to 36 percent). Interventions in combination with provider reminders included patient education (eight), provider feedback (seven), patient reminders (seven), provider education (three), improved access (one), and standing orders (one). Most strategies to remind providers involved placing provider reminders, flow charts, or health maintenance checklists on the patients chart at the time of the clinic visit.

Provider reminder/recall systems appear effective in improving vaccination coverage when used by themselves or in combination with other interventions.

Generalizability. Positive effects of provider reminder/recall have been shown in adults and children, in a wide range of settings, and with MMR, DTP, OPV, Hib, influenza, pneumococcal vaccine, and Td. One study (196) found a positive effect among adolescents. Provider reminder/recall works by itself or as part of a multicomponent intervention. We did not identify studies of this intervention to increase the use of hepatitis B vaccine.

Provider assesment and feedback. Definition. Provider assesment and feedback involves giving retrospective information to immunization providers about their performance in delivering one or more vaccines to a client population. Feedback may or may not also involve other interventions such as benchmarking (that is, comparing performance to a goal or standard) and giving incentives to providers who perform well.

Background. Evaluation of feedback is timely. Information systems are improving and increasingly common; most vaccines are delivered in the private sector; and quality assurance approaches such as Healthplan Employer Data and Information Set (HEDIS) are increasingly used. Feedback can result in improvements in vaccination coverage either by changing provider knowledge, attitudes, and behavior, or by stimulating changes in the vaccine delivery system (reminders, standing orders), or some combination.

Effectiveness. Of 27 studies reviewed (24, 52, 57, 64, 69, 81, 93, 108, 109, 121, 158, 184, 187, 195, 196, 200, 202, 205, 212, 214, 217, 220–229), 14 with good or fair execution (57, 64, 69, 81, 158, 187, 195, 196, 200, 217, 220, 225–227) showed increases in vaccination coverage ranging from 1 to 43 percent (median 16 percent) (table 17). Five studies (69, 81, 217, 225, 226) which looked at provider feedback by itself found a median coverage increase of 16 percent (range: 9–41 percent); baseline coverage: 4–56 percent. Four of these studies (69, 217, 225, 226) used provider feedback alone. A fifth study (81) looked at provider feedback with incentives compared with provider feedback alone (10–20 percent increase in payment per vaccine delivered if over 70 percent of clinic population vaccinated) and found a 17 percent coverage difference with the addition of incentives (baseline: 56 percent). One study (226) found that feedback to individual physicians as compared with the Chief of Service physician produced an 18 percent greater increase in coverage.

The studies (57, 64, 69, 158, 187, 195, 196, 200, 217) which looked at provider feedback as part of a multicomponent strategy, found a median coverage difference of 17 percent (range: 1–43 percent). These different interventions included provider reminders (eight), provider education (four), patient reminders (three), patient education (three), standing orders (one), and expanded access (one).

These studies show that provider feedback appears effective in improving vaccination coverage by itself and in combination with other interventions. Several studies have demonstrated that improvements in coverage can be maintained or further improved over several years of follow-up (187, 225, 226).

Generalizability. Positive effects of feedback have been shown in a range of settings (private practice, managed care, public and community health centers, and academic settings), for a range of providers (resident and staff physicians, nonphysician providers, internal medicine, family medicine, general practice), for both adults and children, and for most universally-recommended antigens (MMR, DTP, OPV, Hib, influenza, pneumococcal, TD). Feedback has not been studied to increase the delivery of hepatitis B vaccine.

Standing orders. Definition. Standing orders involve interventions in which nonphysician immunization personnel vaccinate client populations with one or more antigens by protocol without direct physician involvement at the time of the interaction. Settings in which this occurs may vary, e.g. clinics, hospitals, nursing homes. Dedicated immunization clinics often operate under standing orders and we do not consider standing orders in that context to be an intervention.

Background. Requirements for physical examinations and lack of personnel to administer vaccines are two important administrative barriers that may contribute to missed opportunities to vaccinate. Empowering nonphysician personnel to deliver vaccinations without physician involvement at the time of the visit could reduce barriers to immunization and missed opportunities and improve vaccine delivery.

Effectiveness. Of 16 studies (38, 52, 55, 57, 86, 96, 97, 138, 168, 190, 211, 230–237), 11 had greatest or moderately suitable designs and good or fair execution (55, 57, 86, 97, 168, 190, 230, 232–235) (table 18). The available studies evaluated standing orders by themselves, a feedback intervention after which standing orders were implemented in some cases, or multicomponent institutional interventions including standing orders. Studies in which standing orders were used by themselves among adults showed a median coverage difference of 51 percent (range: 30–81 percent) (190, 232, 233, 235). Studies in which standing orders were used as part of a multicomponent strategy in adults showed a median coverage difference of 16 percent

TABLE 15. School, child care, and college entry requirements

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
			Effects of school entry laws on disease rates		
CDC* (180)	1979–1980	Cross-sectional study, least suitable, fair	United States nationwide; target population not described	1. "Comprehensive" laws requiring documentation of immunity for entry into all grades (35 states) versus 2. School entry laws requiring immunity only at entry into kindergarten or first grade (14 states)	Of 15 states with high incidence of measles, nine had only school entry laws; of 37 states with low incidence of measles, 11 had only school entry laws ($p < 0.05$)
Chaiken et al. (173)	1983	Cross-sectional study, least suitable, fair	New Jersey; children aged 5–19 years, grades K–12	1. Law requiring students aged <7 years to be vaccinated against mumps versus 2. Comparison group of usual care (Total study population, 3,250 participants)	96% of children covered by law versus 61% not covered had "documented immunity"; 25% of children not covered by law had mumps versus 3% of children covered by law (significant)
Robbins et al. (175)	1977–1978	Cross-sectional study, least suitable, fair	United States nationwide; children aged <18 years	1. Presence, type, and enforcement of state school vaccination laws versus 2. Comparison group of usual care (54 vaccination project areas)	Areas with low versus high incidence more likely to have laws requiring measles vaccinations for all children, 46% versus 0% ($p < 0.025$); more likely to enforce exclusion from school, 77% versus 0% ($p < 0.001$)
van Loon et al. (179)	1995	Before-after study, least suitable, fair	United States nationwide; children aged 5–19 years, grades K–12	1. Partial law requiring certain students to receive mumps vaccination versus 2. Comprehensive law requiring all students to receive mumps vaccination versus 3. Comparison group of usual care (50 states)	Mumps incidence cases/100,000, 1 = 5.4%; 2 = 3.8%; 3 = 9.4% (statistical significance not reported)
			Effects of school laws on immunity		
Nelson et al. (174); Schum et al. (178)	1979–1987	Time series, moderate suitability, fair	Milwaukee, Wisconsin; clinics; clients aged 9–15 years; 75–82% black; urban; low socioeconomic status	1. Enactment and enforcement of school law in 1980–1981 requiring vaccination versus 2. Prior usual care (1979–1981, number = 481 participants, 1985–1987, number = 341)	Rubella susceptibility, declined from 22% in 1979 to 5% in 1981 ($p < 0.001$); rubella susceptibility, increased from 4% in 1985 to 25% in 1987 (significant)
			Effects of school laws on vaccination coverage		
Carlson and Lewis (172)	1983–1984	Before-after study, least suitable, fair	Ontario, Canada; children aged 5–17 years, grades K–12	1. Law requiring school attendees aged <18 years to be vaccinated against diphtheria, tetanus, poliomyelitis, measles, and rubella versus 2. Comparison group of usual care (Size of target population not reported)	Single-antigen measles, tetanus, diphtheria, rubella, poliomyelitis, mumps coverage, average 5%, range 3–9% (statistical significance not reported); effects larger in high school students, 1 versus 2 = 35% net change

Chaiken et al. (173)		See above this table in section Effects of school entry laws on disease rates			
Scheiber and Halfon (176)	1979–1987	Time series study, moderate suitability, fair	California; children aged 5–6 years	1. School entry vaccination laws enacted in 1977 and enforced in 1986 versus 2. Prior usual care (Size of target population not shown)	DTP*/OPV*/MMR* (4:3:2 doses, respectively), 15% net change (statistical significance not reported)
Effects of child care center entry laws on disease rates					
Schulte et al. (177)	1987–1991	Before-after study, least suitable, fair	New York State; child care centers; children aged <5 years	1. State requirement for *Haemophilus influenzae* type b vaccinations in child care centers enacted in 1990 but never enforced versus 2. Comparison group of prior care (Study population not reported)	1 versus 2: *Haemophilus influenzae* type b incidence cases/100,000 in New York State, 30 versus 3; in child care centers 31 versus 9 (statistical testing not reported); rate of decline of incidence in child care centers was greater than rate of decline in all New York State children ($p < 0.002$)
Effects of college entry requirements on disease outbreaks					
Baughman et al. (171)	1988–1991	Retrospective cohort study, moderate suitability, fair	United States nationwide; 2- and 4-year colleges, target population college students; students not otherwise described	1. Prematriculation vaccination requirement by state law versus 2. Prematriculation vaccination requirement by regent's policy or no requirement (880 colleges)	1 versus 2: in multivariate analysis relative risk of outbreak = 0.3, confidence interval: 0.1, 0.84

* CDC, Centers for Disease Control and Prevention; DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine.

(range: 6–26 percent) (55, 57, 86, 97, 168). These interventions included expanded access (four), patient reminders (three), patient education (two), provider education (two), provider reminders (one), and provider feedback (one). Baseline coverages in eight adult studies ranged from 2 to 66 percent, with a median coverage difference of 28 percent with a range of 6 to 81 percent; most studies last <1 year but one showed continuing improvements over 5 years (96). A single study in children (230) showed modest declines in missed opportunities to vaccinate at non-well child visits, but this did not translate into an overall improvement in vaccine delivery. Standing orders appear effective in improving vaccination coverage in adults whether used by themselves or together with other interventions.

Generalizability. Positive effects of standing orders have been shown among adults in a range of settings (private practices (57), community hospitals (190), other hospitals (233), managed care organizations (57, 86), academic clinical organizations (55, 57, 96, 97, 168, 230, 232–234), nursing home (235)) with influenza and pneumococcal vaccines, and whether standing orders are used by themselves or combined with other interventions. Standing orders have not been studied among adolescents for hepatitis B vaccine or Td. The data do not allow us to assess the effectiveness of standing orders among children due to availability of a single study and no effect of the intervention on vaccination coverage in that study.

Provider education. Definition. Provider education involves providing information about immunizations to immunization providers. Techniques by which information is delivered may include written materials, videos, lectures, continuing medical education (CME) credits, computerized software, or other. Interventions that provide information but also use other enabling factors or reinforcing factors (i.e., reminders or feedback) are reviewed elsewhere.

Background. Provider education is based on the assumption that provider knowledge about vaccination will affect physician behavior in a positive way. Provider education can motivate providers to educate patients so parents are more aware of and demand vaccination; provider education can also motivate providers to implement other interventions such as reminder recall systems or standing orders.

Effectiveness. Of six studies (190, 209, 210, 238–241), four had fair or good execution (190, 239–241) (table 19). The two available studies which looked at vaccination coverage as an outcome-evaluated provider education by itself (239) or used provider education as the comparison group in a study primarily looking at other interventions (190); both studies were conducted in adults. The study which evaluated

TABLE 16. Provider reminder/recall

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
			Effects of provider reminder/recall alone		
Chambers et al. (185)	1987	Group randomized trial (by physician); greatest suitability, fair	Philadelphia, Pennsylvania; Thomas Jefferson University Family Practice Center; providers: family medicine residents and faculty; clients: adults, 68% aged ≥65 years; urban; 74% female; 56% black; low socioeconomic status	1. Physician reminders for all patients versus 2. Physician reminders for half of all eligible patients versus 3. Comparison group of never reminded (Total 30 physicians; 635 patients)	Influenza, 1 versus 3 = 21% net change (statistical significance not shown)
Cheney and Ramsdell (186)	1982–1983	Group randomized trial, greatest suitability, fair	San Diego, California; University of California at San Diego internal medicine house staff-training program; providers: residents; clients: adults, 55% aged >60 years; urban; 66% female	1. Health maintenance checklists incorporated into medical record versus 2. Comparison group of usual care (Total study group 75 providers; 200 charts audited)	Influenza, 1 versus 2 = 30% net change ($p < 0.01$); pneumococcal, 1 versus 2 = 16% ($p < 0.02$); Td, 1 versus 2 = 6% ($p < 0.05$); performance in nine preventive services, 1 versus 2 = 0.13 ($p < 0.002$)
Cohen et al. (189)	1980	Group randomized trial, greatest suitability, fair	Cleveland, Ohio; clinic/hospital; clients: adults, otherwise target population not well described	1. Physician reminders (checklists) on charts *plus* physician education versus 2. Comparison group of usual care (Numbers of patients not described)	Influenza, 1 versus 2 = 32% net change ($p < 0.001$); pneumococcal, 1 versus 2 = 37% ($p < 0.001$); physician attitudes but not knowledge increased posttest ($p < 0.05$)
Crouse et al. (190)	1992	Prospective cohort study, greatest suitability, fair	Northern Minnesota; community hospitals; clients: inpatients; adults; otherwise, not well described	1. Standing orders versus 2. Physician reminders in charts versus 3. Comparison group of physician education (Total two hospitals in each group; patient numbers not given)	Influenza, 2 versus 3 = 7% net change (not significant); 1 versus 2 = 23% ($p < 0.002$); 1 versus 3 = 30% (significance not shown)
Gelfman et al. (192)	1983–1984	Time series study, moderate suitability, fair	Richmond, Virginia; internal medicine training program, clients: adults; urban; otherwise, not well described	1 Physician reminders on chart for influenza and pneumococcal versus 2 Prior usual care versus 3. Post intervention (158 charts evaluated for influenza and 300 pneumococcal)	Influenza, 1 versus 2 = 72% net change ($p < 0.001$); pneumococcal, 1 versus 2 = 61% $p < 0.001$); pneumococcal, 2 versus 3 = 1% ($p > 0.5$)
Hahn and Berger (194)	1983–1984	Retrospective cohort study, moderate suitability, fair	Midsized midwestern city, provider: family physician in multispecialty group practice; clients: adults; urban, 43–48% female, predominantly white; middle socioeconomic status	1. Health maintenance flow sheet on chart versus 2. Comparison group of usual care (Total, 1,862 patients seen during study period; random sample of 250 charts reviewed)	Td,* 1 versus 2 = 55% net change ($p < 0.001$); significant increases occurred in most other preventive measures
Harris et al. (197); Davidson et al. (191)	1979–1984	Time series study, moderate suitability, fair	North Carolina; university-based general medicine clinic; providers: internal medicine residents and faculty; clients aged >50 years, mean 64–65 years, 100% female; 50–60% nonwhite	1. Nurse-initiated health maintenance checklist and computer-generated reminders on chart (150 participants) versus 2. Prior usual care (150)	Influenza, 1 versus 2 = 47% ($p < 0.001$, analysis of variance); pneumococcal, 1 versus 2 = 8% (not significant)

Hutchison (198)	1985–1986	Nonrandomized trial, greatest suitability, fair	Hamilton-Burlington, Ontario, Canada; family practice; health service organization; providers: "experienced family physicians" and nurse practitioners; clients aged ≥65 years; urban; 27–33% with high-risk conditions	1. Provider reminder message on computer encounter form on chart (593 participants) versus 2. Comparison group of usual care (618)	Influenza, 1 versus 2 = 16% net change; significant increase in intervention group but not in comparison; no difference between patients at high risk versus those not at high risk
Klein and Adachi (199)	1980–1981	Randomized trial, greatest suitability, fair	Bronx, New York; North Central Bronx Hospital; clients: urban; inpatients; adults; mean age 61 years, 64% female; 27–33% with high-risk conditions	1. Provider reminders on chart versus 2. Comparison group of usual care (600 total participants)	Pneumococcal, 1 versus 2 = 8% net change ($p < 0.05$); 18% net change year 2 ($p < 0.001$)
McDonald et al. (203, 204)	1978–1980	Group randomized trial (by practice team), greatest suitability, fair	Indianapolis, Indiana; academic general internal medicine training program; providers: staff and resident physicians, nurses and nurse practitioners; clients: adults; 60% aged >50 years; urban; 65% female; 65% black	1. Computerized reminders on chart versus 2. Comparison group of usual care (Total 12,467 patient visits)	Influenza, 1 versus 2 = 25% net change ($p < 0.0001$); pneumococcal, 1 versus 2 = 40% ($p < 0.0001$); significant improvements in all 13 other preventive services
McDowell et al. (87, 88); Rosser et al. (101, 102)	1983–1985	Group randomized trial (by family), greatest suitability, fair	Ottawa, Ontario, Canada; University of Ottawa Family Medicine Center at Civic Hospital; providers: staff and resident physicians, nurses; clients aged ≥65 years	1. Computer generated provider reminder (218 participants) versus 2. Patient reminder by telephone (226) versus 3. Patient reminder by letter (231) versus 4. Comparison group of randomized controls (230)	Influenza, 1 versus 4 = 13% net change ($p < 0.005$); 2 versus 4 = 26% ($p < 0.005$); 3 versus 4 = 26% ($p < 0.005$); Td, 1 versus 4 = 20% (confidence interval: 17%, 22%); 2 versus 4 = 21% (confidence interval: 18%, 24%); 3 versus 4 = 27% (confidence interval: 25%, 31%)
Rodewald et al. (170)	See Table 14. Expanding access in health-care settings				
Schreiner et al. (213)	1980–1988	Other designs with concurrent comparison groups, greatest suitability, fair	Galveston, Texas; general internal medicine house staff clinics of University of Texas; clients: adults, mean ages 56–57 years; urban; 71–73% female; 49–54% black; 35–39% Hispanic	1. Provider reminders on chart (baseline 900 participants; during 180, post 180) versus 2 Concurrent comparison group of usual care (baseline 168; during 168, post 168)	Pneumococcal, 1 versus 2 = 11% net change; group 1 coverage during intervention significantly differs from coverage pre and post
Szilagyi et al. (215)	1991–1993	Randomized clinical trial, greatest suitability, fair	Rochester, New York; pediatric clinic at teaching hospital and neighborhood health center; providers: attending pediatricians, residents, nurses, nurse practitioners; clients mean ages 7–13 months; urban; 52–53% male; 70% black, low socioeconomic status	1. Provider reminders on chart versus 2. Comparison group of usual care (Total population 1,988 participants before randomization) Both groups had policy change encouraging simultaneous administration of vaccinations, and neighborhood health center changed policy to allow any adult to provide consent	Up-to-date with DTP*/OPV*/MMR*/Hib*, 1 versus 2 = 3% net change at clinic ($p = 0.3$) and −2% at neighborhood health center ($p = 0.5$); significant changes occurred if analyzed subset for whom reminder card actually used
Tape et al. (216)	1986–1987	Nonrandomized trial (by physician clinic day), greatest suitability, fair	Omaha, Nebraska; general internal medicine at University of Nebraska Hospital; providers: faculty and residents; clients: adults; urban; otherwise, target population not described	1. Computerized provider reminders at visit versus 2. Health-care maintenance flow sheet in chart (Total population, 892 participants before randomization)	Performance of hemoccult, proctoscopy,influenza vaccination increased significantly; performance of mammogram, Td vaccination increased (not significant); performance of Pap smears did not increase

Table continues

TABLE 16. Continued

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Weingarten et al. (219)	1985–1987	Nonrandomized trial; greatest suitability, fair	Israel; community health center; provider: one family practitioner; clients: adults; low socioeconomic status	1. Protocol for adult health maintenance displayed on desk-top computer (112 participants) versus 2. Comparison group of usual care (93)	Td, 1 versus 2 = 26% net change ($p < 0.001$); significant increases in most other preventive care
Effects of provider reminder/recall in combination with other interventions					
Barton and Schoenbaum (64)	See Table 5. Patient reminder/recall systems				
Frame et al. (74)	See Table 5. Patient reminder/recall systems				
Harper et al. (195)	1993–1994	Nonrandomized trial, greatest suitability, fair	St. Paul, Minnesota; family practice residency clinic (intervention); community health center (control); clients: children aged 24–35 months; urban; 54–56% male; 86–93% white; low socioeconomic status	1. Physician reminder on chart *plus* patient education *plus* feedback on performance (280 participants) versus 2. Comparison group of usual care (239)	DTP/OPV/MMR (4:3:1 doses, respectively), at age 24–35 months, 1 versus 2 = 12% net change ($p < 0.02$)
Harper and Murray (196)	1990–1991	Nonrandomized trial, greatest suitability, fair	St. Paul, Minnesota; family practice residency clinic (intervention); community health center (control); clients aged 11–18 years; urban; 55–59% female, 87–90% white; low socio-economic status	1 Provider reminders on chart after assessment by front desk *plus* feedback to front desk (733 participants pre, 737 post) versus 2. Comparison group of usual care (599 pre, 812 post)	Net change in percent of client visits where client was up to date for MMR was 24%
Karuza et al. (57)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Korn et al. (200)	1984–1985	Time series study, moderate suitability, fair	Minneapolis, St. Paul, Minnesota; internal medicine resident's clinic at a hospital; clients: adults; mean age 52–56 years; urban/suburban; 35–42% male	1. Instructional seminars *plus* biweekly provider feedback *plus* provider reminders (202 participants) versus 2. Prior usual care (199)	Influenza, 1 versus 2 = –3% net change (not significant); pneumococcal, 1 versus 2 = 15% ($p < 0.01$)
Lukasik and Pratt (58)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Paunio et al. (59)	See Table 4. Multicomponent [communitywide] strategies that include education				
Rodewald et al. (158)	See Table 12. Home visits				
Effects of provider reminder/recall alone and in combination					
Becker et al. (65)	See Table 5. Patient reminder/recall systems				
Ornstein et al. (99)	See Table 5. Patient reminder/recall systems				

Tierney et al. (217)	1983–1984	Randomized trial, greatest suitability, fair	Indianapolis, Indiana, university-based clinic; providers; residents; clients: adults; urban; otherwise, not well described	1. Provider reminders on chart versus 2. Monthly feedback versus 3. Both 4. Comparison group received reminders regarding other preventive care (135 resident physicians; total, 1,750 patients)	Pneumococcal, 1 versus 4 = 30% net change; 2 versus 4 = 14%; 3 versus 4 = 28% (no statistical tests reported); pattern for other preventive care similar
Turner et al. (46)	See *Table 4. Multicomponent strategies that include education [in clinical settings]*				

* DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; Hib, *Haemophilus influenzae* type b vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine; Td, tetanus-diphtheria vaccine.

provider education by itself included attaching a health assessment fact sheet to the chart and found a median coverage difference of 5 percent; baseline coverage was 19 percent. The other study found net changes in coverage of –30 percent and –7 percent compared with provider reminders and standing orders, respectively.

Two studies evaluated the effectiveness of provider education on knowledge and attitudes (240, 241); both showed improvements in provider knowledge and attitudes after provision of provider education through 1) dissemination of national guidelines for hepatitis B and 2) implementation of an innovative problem-based learning protocol in medical schools. One study (239) which used a provider-oriented health assessment fact sheet on the chart did not show any improvement in knowledge.

The small number of studies, limitations in design and conduct, and variability in results does not allow us to assess the effects of provider education alone in changing provider attitude or vaccination coverage. However, provider education is a part of several effective multicomponent interventions including provider reminders, feedback, and multicomponent education.

DISCUSSION

The summaries in this review article are an important part of the information upon which the Task Force will base its recommendations for strategies to improve immunization coverage levels in US communities.

The summaries presented are unique in the use of expert consultants to identify and categorize interventions, the use of a logic framework to describe the context of the interventions, and the breadth of interventions considered. Reviews of individual interventions to raise immunization coverage (242, 243) are being conducted, and three reviews of a range of interventions to raise coverage (19, 244, 245) have been published. The summaries of individual interventions are being done using the methods of the Cochrane collaboration (246) which has a more restricted set of inclusion criteria and a greater reliance on statistical summary measures than does this review.

Interventions were assessed in the context of a logic framework that describes the relations of population and environmental determinants of coverage and disease, the systems in which immunizations are delivered, and disease and health outcomes. The use of a logic framework helped categorize interventions and allowed consideration of the outcomes that interventions were trying to influence and the confidence with which it can be stated that those outcomes are actually being changed.

TABLE 17. Assessment and feedback for vaccination providers

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Effects of giving feedback to vaccination providers alone					
Carey et al. (220)	1987, 1989	Before-after study, least suitable, fair	North Carolina; state supported clinics, community health centers, National Health Service Corps sites; rural; clients: adults, low socioeconomic status	1. Chart audits and feedback versus 2. Prior usual care (37 practices, 40 physicians)	Vaccine offering: influenza, 1 versus 2 = −11% net change Other prevention practices showed improvements
Kern et al. (225)	1981–1987	Before-after study, least suitable, fair	Baltimore, Maryland; university teaching hospital; providers: internal medicine residents; clients: adults, 56% female; "working class"	1 Chart audits and feedback versus 2. Prior usual care (139 medical residents)	Td*, pneumococcal, influenza, 1 versus 2 = 8%, 18%, 32% (significance not reported)
Kouides et al. (81)	1990–1991	Nonrandomized trial, greatest suitability, fair	Monroe County, New York; private physician offices; providers: predominantly internal medicine; clients aged ≥65 years; urban/suburban; middle/high socio-economic status	1. Provider feedback *plus* provider incentives versus 2. Provider feedback (Total 135 physician practices)	Influenza, 1 versus 2 = 17% net change ($p < 0.001$) (9% adjusted measure); rates in practices using patient reminders were lower than in practices not using reminders (i.e., postcards), 54%
LeBaron et al. (226); Dini et al. (222)	1988–1994	Time series study, moderate suitability, fair	Georgia; public immunization clinics; clients aged 21–23 months; mixed urbanicity	1. Annual provider audit and feed-back to clinic staff (136,004 participants) versus 2. Prior usual care Clinics used variety of interventions in response to feedback; certain clinics used award plaques for good performance	DTP*/OPV*/MMR* (4:3:1 doses, respectively), 1 versus 2 = 41% net change (statistical significance not reported)
Lynch (227)	1991–1992	Cross-sectional study, least suitable, fair	Scotland; general practice clinics; clients aged 0–24 months, otherwise population not well described	1. Provider feedback *plus* incentives for "high" target coverage versus 2. Provider feedback *plus* incentives for "low" target coverage versus 3. Provider feedback *plus* no incen-tives for "below" target coverage (Total 208 practices)	Up-to-date with DTP/OPV/MMR: previous bonuses had significant effects on coverage levels by ordinary least squares regression and on likelihood of achieving high targets by logistic regression
Effects of giving feedback to vaccination providers in combination with other interventions					
Barton and Schoenbaum (64)	See Table 5. Patient reminder/recall systems				
Chodroff (187)	1986–1989	Before-after study, least suitable, fair	York, Pennsylvania; internal medicine outpatient clinics at York Hospital; providers: internal medicine residents; clients: mean age 49–51 years, 55–58% male	1. Provider feedback *plus* provider reminders *plus* provider education versus 2. Prior usual care (Random sample 400 charts pre; all 1,612 clients post)	Td, pneumococcal, influenza, 1 versus 2 = 43%, 38%, 49% net changes (significance not reported)
Harper et al. (195)	See Table 16. Provider reminder/recall				
Harper and Murray (196)	See Table 16. Provider reminder/recall				
Karuza et al. (57)	See Table 4. Multicomponent strategies that include education [in clinical settings)				
Korn et al. (200)	See Table 16. Provider reminder/recall				

Rodewald et al. (158)	See Table 12. Home visits
Effects of giving feedback to vaccination providers alone and in combination with other interventions	
Buffington et al. (69)	See Table 5. Patient reminder/recall systems
Tierney et al. (217)	See Table 16. Provider reminder/recall

* DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; MMR, measles, mumps, rubella vaccine; OPV, oral poliomyelitis vaccine; Td, tetanus-diphtheria vaccine.

This review used vaccination coverage as the primary measure of intervention effectiveness because the linkage between the intermediate outcome (vaccination) and the ultimate outcome (reduction of disease, morbidity, and mortality) is very strong (20). The current extremely low levels of vaccine preventable disease among preschool children make vaccination levels more sensitive and feasible-to-measure indicators of intervention impact than disease levels.

We chose the *net percent point difference* in immunization coverage levels as the primary outcome rather than the *relative* percentage change in coverage because percent point differences translate directly into numbers of individuals in a population protected from vaccine-preventable disease.

This review identifies a number of interventions for which considerable evidence is available indicating effectiveness and other interventions for which available evidence is sparse. Among interventions to increase community demand for immunizations, patient reminder/recall systems and multicomponent strategies including education seemed to show evidence of impact, whereas a group of single-component interventions (clinic-based education, communitywide education, patient or family incentives, and patient-held medical records) had either little evidence or only weakly supportive evidence.

A number of interventions to enhance access to immunization services were supported by the evidence—reducing out-of-pocket costs, immunization interventions in WIC settings, home visits, and expanding access in health care settings as part of multicomponent interventions. Immunizations in child-care facilities and schools had too few studies to make a determination of impact and expanding access in health-care settings as a single-component intervention had less firm support.

Legislative strategies, including immunization requirements for child care, elementary school, and college entry had supportive evidence. Strongly supported were several provider-based interventions; including provider reminder/recall systems, provider feedback, and standing orders; provider education interventions had less support.

The data taken together suggest some directions for additional research. Many areas with sparse available data could benefit from additional effectiveness studies. Other areas (e.g., patient and provider reminders) are well-supported by available evidence and might benefit more from additional work on overcoming barriers to implementation and enhancing adoption than from additional effectiveness studies. Even these clearly effective interventions have not been universally adopted (247–249).

TABLE 18. Standing orders

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
			Effects of standing orders alone		
Christy et al. (230)	1990–1991	Nonrandomized trial, greatest suitability, fair	Rochester, New York: pediatric resident clinic; clients aged 2–60 months; urban; predominantly low socioeconomic status	1. Nurse-guided assessment and algorithm *plus* standing orders (875 participants) versus usual care in 2 and 3 2. Concurrent controls (1,226) and 3. Historical controls (713)	DTP* (4 doses), 1 versus 2 = –4% net change; 1 versus 3 = 4%; MMR* > 92% coverage in all groups
Crouse et al. (190)	See Table 16. Provider reminder/recall				
Hoey et al. (232)	1980	Nonrandomized trial, greatest suitability, fair	Montreal, Quebec, Canada; teaching hospital-based polyclinic; clients not described	1. Standing orders (435 participants) versus 2. Usual practice (348)	Influenza, 1 versus 2 = 33% net change (significance not shown)
Klein and Adachi (233)	1984	Nonrandomized trial, greatest suitability, fair	Bronx, New York; teaching hospital; clients: median ages, 56–63 years; 57–59% male	1. Standing orders (90 participants) versus 2. Usual practice (97)	Pneumococcal, 1 versus 2 = 69% net change ($p < 0.001$)
Margolis et al. (234)	1986	Retrospective cohort study, moderate suitability, fair	Minneapolis, Minnesota; general medicine specialty clinic; clients aged ≥65 years	1. Standing orders (97 participants) versus 2. Concurrent comparison (106) and historical comparison (73)	Influenza, 1 versus 2 = 52% net change ($p < 0.001$); 1 versus 3 = 53% ($p < 0.001$); outcomes in vaccines offering, coverage not reported
Morton et al. (235)	Not reported	Nonrandomized trial, greatest suitability, fair	Location not reported; long term care facilities; clients not described	1. Standing orders versus 2. Usual care (Total 172 clients)	Pneumococcal, 1 versus 2 = 81% (significant)
			Effects of standing orders in combination with other interventions		
Herman et al. (55)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Karuza et al. (57)	See Table 4. Multicomponent strategies that include education [in clinical settings]				
Margolis et al. (86)	See Table 5. Patient reminder/recall systems				
Nichol et al. (97)	See Table 5. Patient reminder/recall systems				
Nichol (168)	See Table 14. Expanding access in health-care settings				

* DTP, diphtheria toxoid, tetanus toxoid, pertussis vaccine; MMR, measles, mumps, rubella vaccine.

The differences in effect sizes provide some guidance about which interventions might be expected to produce the largest gains in coverage, but these estimates should be interpreted with considerable caution. First, effect sizes could reflect differences in effectiveness or other differences between studies (e.g., target population or baseline coverage). Second, even if the effects were assumed to be comparable, there is not an agreed upon threshold for distinguishing "large" effects. Third, some interventions may be directly comparable (e.g., provider reminders versus provider feedback versus standing orders) but others clearly are not (school laws for childhood immunizations and standing orders in adults are very different in terms of populations targeted, implementers, and numerous other issues) and are probably not usefully compared. Fourth, the distributions of effects shown by these reviews should not be interpreted as point estimates that can be directly compared because of limitations both in the available data (numbers of studies are often small, reporting was variable) and in the methods (statistical summary measures such as confidence intervals are not provided). Finally, the summary of effectiveness data in this paper does not take into account cost-effectiveness and other implementation questions that will be important to users of this information.

Limitations

The scope was limited to studies conducted in developed countries because many interventions successfully applied in developing countries, such as periodic mass campaigns, are almost certain to have different characteristics, outcomes, and consequences if used in the United States.

The limitations of the literature relate to publication bias and to an uneven distribution of studies across interventions. Publication bias (250, 251) could result in finding relatively fewer studies with small or null effects than studies with larger or significant effects thus 1) falsely elevating the median effect sizes among effective interventions and 2) failing to identify sufficient studies to form firm conclusions about interventions that may be ineffective. We took steps to minimize publication bias including polling experts about the availability of unpublished information and using it where it was found. However, few studies that otherwise met inclusion criteria were identified in this manner.

Potential limitations of the methods include decisions made in grouping studies into interventions and in conducting the structured review process. To evaluate the effectiveness of population-based interventions, it was necessary to group interventions and outcomes that are alike enough into a single intervention category to represent a single "body of evidence" of effectiveness for that intervention category. Our groupings might have obscured important differences between interventions; for example, all reminder systems are not alike: some use telephone autodialers; some use postcards; some work from an immunization registry.

Single-component interventions allowed us to evaluate effectiveness because we could reasonably conclude that any effect observed was likely caused by the single intervention. Public health professionals who learn that these interventions are successful can expect to replicate the results if they carry out similar interventions. This is also true for some multicomponent interventions if the interventions carried out include the same package of activities as those reviewed here.

Uses for the summaries

The main contribution of these structured summaries is to synthesize within a conceptual framework the best evidence on effectiveness available on interventions to improve coverage levels for routinely recommended vaccinations. Those desiring to improve performance of vaccination programs can use this base of evidence in conjunction with the recommendations of the Task Force for Community Preventive Services to inform and guide their efforts.

Health services research on methods to raise and sustain immunization coverage levels can also be guided by these summaries. Gaps in knowledge can be identified using a combination of the summaries and the logic framework. For effective interventions, the research agenda can progress from measuring effectiveness to improving cost-effectiveness and enhancing implementation. For example, reminder/recall interventions are clearly effective, but only a few studies measuring cost-effectiveness and no studies determining methods to improve the use of reminder/recall systems in various provider settings exist.

Research funders might benefit from progression of research agendas and from synthesizing research agendas across disciplines. For example, research to improve immunization coverage levels should inform other research to improve the use of other clinical preventive services.

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TABLE 19. Provider education

Study (reference no.)	Study period	Design, category, and execution	Study location, setting type, and population description	Interventions studied and comparisons (no. of participants)	Outcomes evaluated and effect net change in coverage unless otherwise noted (statistical significance)
Effects of provider education on vaccination coverage					
Cowan et al. (239)	1985	Group randomized trial, greatest suitability, fair	Illinois; internal medicine resident clinic, University of Illinois; clients: adults, mean ages 57–60 years	1. Generic health assessment fact sheet attached to patient's chart (62 participants, 16 physicians) versus 2. Comparison group of usual care (45, 13 physicians)	Pneumococcal, 1 versus 2 = 10% net change (not significant); influenza, 1 versus 2 = −1%; no significant difference in physician knowledge or attitudes
Crouse et al. (190)	See Table 16. Provider reminder/recall				
Effects of provider education on knowledge and attitudes					
Freed et al. (240)	1992	Before-after study, least suitable, fair	North Carolina; clinics/offices; study population: pediatricians; 73% male, 38% in managed care settings; family practitioners, 83% male, 26% in managed care settings	1. National Guidelines for Universal Hepatitis B and attendant dissemination efforts (591 physicians) versus 2. Comparison group of prior usual care (478 physicians)	Agreement with universal hepatitis B recommendations, rose from 32% to 62% among pediatricians and 17% to 32% among family practitioners
Zimmerman et al. (241)	Not reported	Before-after study, least suitable, good	United States; medical schools and residency programs; study population: residents in family practice and pediatrics; medical students	1. Problem-based learning and multistation clinical teaching versus 2. Comparison group of prior provider education (20 medical schools; 996 medical students; 126 residents)	Significant improvement in knowledge for all 11 topics with median change of 2.6 items on 10-item list

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