Interventions to Improve Influenza, Pneumococcal Polysaccharide, and Hepatitis B Vaccination Coverage Among High-Risk Adults

A Systematic Review

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Overview

Influenza, pneumococcal infections, and hepatitis B, three vaccine-preventable diseases, cause significant morbidity and mortality in the United States. Rates of morbidity and mortality are higher among adults with certain medical conditions, occupational exposures, or risk behaviors. Vaccination coverage rates in these target populations remain low and below national health objectives.

Using methods previously developed for the *Guide to Community Preventive Services* for reviews of universally recommended vaccines (those that should be administered to all people in a given age group), we conducted systematic reviews to evaluate the evidence on effectiveness of 11 interventions to improve vaccination coverage in targeted populations (those with risk factors that make them particularly susceptible to a disease). Electronic databases and reference lists of retrieved papers were searched for all relevant citations in the period 1980 to August 2000. More than 2450 citations were screened; of these 35 studies met the quality criteria and became part of the review. Determinations of intervention effectiveness were based primarily on measurements of change in vaccination coverage rates for influenza, pneumococcal polysaccharide, and hepatitis B vaccination.

Reviews identified strong evidence of effectiveness of provider reminder systems, when implemented alone, in increasing targeted vaccination coverage. We found insufficient evidence, however, to determine the effectiveness of all other interventions when implemented alone. Of the 35 qualifying studies, 23 studies evaluated interventions implemented in combination. We found strong evidence of effectiveness in increasing targeted vaccination coverage when interventions to enhance access to vaccination services were combined with provider- or system-based interventions and/or interventions to increase client or community demand for vaccinations.

These reviews form the basis of the recommendations by the Task Force on Community Preventive Services presented elsewhere in this supplement. Evidence reviews and recommendations can assist decision makers in selecting and implementing effective interventions to address gaps in targeted vaccination coverage for influenza, pneumococcal polysaccharide, and hepatitis B vaccines.

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Introduction

Influenza, pneumococcal disease, and hepatitis B—three vaccine-preventable diseases—cause significant morbidity and mortality in the United States. Factors that contribute to infection, illness, and death vary by disease and include medical conditions, occupational exposures, and high-risk behaviors. Despite the availability of effective vaccines, vaccination coverage rates remain low among adults at high risk for infection or complications of infection. Indications for vaccination are provided in Table 1.[1–7]

Influenza

Each year in the United States, influenza causes an estimated 114,000 excess hospitalizations[8] and 36,000 deaths.[9] Morbidity and mortality rates are high among adults aged ≥65, and among younger people who have medical conditions, such as diabetes or lung or heart disease, that place them at risk for complications from the disease.[10–12] In one study, case fatality rates among adults aged 44 to 64 years with two or more risk conditions were estimated at 377/100,000.[13,14] In comparison, case fatality rates for adults ≥65 without other

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Table 1. Indications for influenza, pneumococcal polysaccharide, and hepatitis B vaccines[1–7]

Universal recommendations[a]	Targeted indications[b]
Influenza	
Adults aged ≥50 years	Medical indications: People with heart disease, lung disease, diabetes, renal dysfunction, hemoglobinopathies, immunosuppression, and/or people living in nursing homes and other chronic care facilities.
Children aged 6 to 23 months	Children and adolescents (aged 6 months to 18 years) who are receiving long-term aspirin therapy and, therefore, might be at risk for experiencing Reye syndrome after influenza infection. Occupational indications: Healthcare workers and those who provide key community services. Other indications: People working or living with at-risk people. Household contacts and out-of-home caregivers of children aged 0 to 23 months. Students and other people in institutional settings. Women who will be pregnant during the influenza season. Travelers to areas where influenza activity exists or when traveling among people from areas of the world with current influenza activity. Anyone who wishes to reduce the likelihood of becoming ill with influenza.
Pneumococcal polysaccharide	
Adults aged ≥65 years Note: The heptavalent pneumococcal conjugate vaccine is recommended for all children aged 2 to 23 months (and for certain children aged 24 to 59 months)	Medical indications: People who have chronic illness including cardiac or pulmonary diseases, chronic liver disease, alcoholism, diabetes mellitus, or cerebrospinal fluid leaks. People who have other medical risk factors such as anatomic or functional asplenia, or sickle cell disease. People who are immunocompromised including those with HIV infection, leukemia, lymphoma, Hodgkin's disease, multiple myeloma, generalized malignancy, chronic renal failure, or nephritic syndrome. People receiving immunosuppressive chemotherapy (including corticosteroids). Organ or bone marrow transplant recipients. Candidates for or recipients of cochlear implants. Pregnant women with high-risk conditions should be vaccinated if not done previously. Other indications: People living in special environments or social settings (including Alaska Natives and certain American Indian populations).
Hepatitis B	
Children and adolescents	Medical indications: Hemodialysis patients, patients who receive clotting-factor concentrates. Occupational indications: Healthcare workers and public safety workers who have exposure to blood in the workplace, people training in schools of medicine, dentistry, nursing, laboratory technology, and other allied health professions. Behavioral indications: Injecting drug users, people with more than one sex partner in the previous 6 months, people with recently acquired STDs, all clients in STD clinics, and men who have sex with men. Other indications: Household contacts and sex partners of people with chronic HBV infection, clients and staff of institutions for the developmentally disabled, international travelers who will be in countries with high or intermediate prevalence of chronic HBV infection for >6 months, inmates of correctional facilities.

[a]Universally recommended vaccination means that all people in a given age group should receive the vaccine.
[b]Targeted indications include medical, occupational, behavioral, or other risk factors that increase susceptibility to the disease and identify people who should receive the appropriate vaccine.

risk conditions were estimated at 9/100,000.[14,15] The number of people aged <65 years with at-risk medical conditions for influenza-related complications was recently estimated to be 12 million adults aged 50 to 64, 18 million adults aged 18 to 49, and 8 million children.[16]

Annual vaccination is recommended for people who are at risk (Table 1), especially during the winter months from October through March. Influenza vaccination is effective in preventing hospitalization and death in people with high-risk medical conditions.[17] The vaccine is effective in people infected with HIV.[18] Among elderly people not in nursing homes, the effectiveness of the vaccine varies between 30% and 70% in preventing hospitalization from pneumonia and influenza.[19–21]

Influenza coverage rates among adults aged <65 years with risk conditions remain low, as noted by the Institute of Medicine in its 2002 report.[22] In 2000, vaccination coverage for adults aged 18 to 64 with high-risk conditions was 33%, well below the *Healthy People 2010* goal of 60%.[23] Among high-risk adults aged 50 to 64, coverage rates were only 44%.[8]

Pneumococcal Disease

In the United States, about 3500 people aged ≤65 die every year as a result of pneumococcal disease.[24] Pneumococcal infections cause an estimated 3000 cases of meningitis, 50,000 cases of bacteremia, and 500,000 cases of pneumonia annually.[2] Risk conditions for invasive pneumococcal disease include chronic illness and cardiac and pulmonary diseases.[10,11,25] In one report, case fatality rates among adults aged 18 to 64 with risk conditions was 12.1% compared with a case-fatality rate of 5.4% for adults without risk conditions.[24]

Recommendations for pneumococcal polysaccharide vaccination are provided in Table 1. Efficacy rates for the current 23-valent vaccine in studies of immunocompetent adults range from 65% to 75% in the prevention of pneumococcal bacteremia and meningitis.[26,27] Despite the efficacy of the vaccine, vaccination coverage remains low for younger adults (aged 18 to 64) with risk conditions. National Health Interview Survey (NHIS) data from 2002 indicate that only 19.1% of high-risk adults aged 18 to 64 have ever received the pneumococcal polysaccharide vaccine (NHIS, 2002, unpublished data).

Universal and targeted indications for influenza and pneumococcal polysaccharide vaccination are similar, and combined or coordinated efforts to improve vaccination coverage rates for both are possible. In one study, receipt of both vaccines was associated with a 72% reduction in hospitalization and an 82% reduction in mortality among people with chronic lung disease.[28]

Hepatitis B

An estimated 1.25 million people in the United States are chronically infected with hepatitis B virus (HBV),[29] of whom 5000 die of HBV-related cirrhosis or liver cancer annually.[30–32] Risk conditions for hepatitis B include occupational exposures and risk behaviors such as injection drug use and multiple sex partners. Although reported cases of HBV declined by 76% in the period 1987–1998,[33] the annual number of new infections remains significant, with 73,000 cases estimated in 2003.[32]

Indications and recommendations for hepatitis B vaccination are shown in Table 1. Despite the availability of an effective vaccine, vaccination coverage rates remain low in most populations with targeted indications. In one study, for example, only 9% of men who have sex with men (MSM) had serologic evidence of hepatitis B vaccination in 1998.[34] Among injection drug users attending a sexually transmitted disease clinic in San Diego from 1998 to 2001, vaccination coverage with hepatitis B was only 6%.[35] HBV infection is also an occupational exposure associated with both routine and emergency care delivered by health, rescue, and law enforcement personnel. With the initiation of routine vaccination, the annual number of HBV infections among healthcare workers declined dramatically, from 17,000 in 1983 to 400 in 1995.[36]

Over the last decade, improvements in adult vaccination coverage have been unevenly distributed. Although coverage rates for influenza and pneumococcal polysaccharide vaccines have steadily improved among adults aged ≥65 years, improvements in vaccination coverage in younger adults with risk conditions have been less dramatic and coverage rates remain low.[22] Similarly, significant increases in vaccination coverage for HBV among healthcare workers have not been matched in harder to reach populations that engage in high-risk behaviors. To remedy these gaps, communities, healthcare systems, and providers may consider implementing or adding one or more interventions to improve vaccination coverage among adults at high risk.

As part of the *Guide to Community Preventive Services* (*The Community Guide*), this report provides a systematic review of the evidence on effectiveness of interventions implemented to increase coverage rates for vaccines indicated for adult populations (aged 18 to 64 years) with risk conditions, occupational exposures, or risk behaviors. As a group, we will refer to these as targeted vaccines and to efforts to improve coverage as targeted vaccination interventions. (These same vaccines—influenza, pneumococcal polysaccharide, and hepatitis B—are appropriate for use in the general population. The difference between universally recommended and targeted vaccines is the indicated use, not the vaccines.) Although other vaccines have targeted indications

(e.g., the hepatitis A vaccine is recommended for people with chronic liver disease), this review focused on the evidence on effectiveness of interventions to increase targeted vaccination coverage for influenza, pneumococcal polysaccharide, and hepatitis B. This report is designed to complement the initial set of systematic reviews of interventions to improve vaccination coverage for universally recommended vaccinations in children, adolescents, and adults.[37,38]

Conceptual Approach

We adopted the conceptual approach developed for the *Community Guide* reviews of evidence on interventions to improve vaccination coverage for universally recommended vaccines.[37] The logic framework shown in Figure 1 provides a concise depiction of the strategy and intervention options for increasing vaccination coverage in populations at high risk. The conceptual (strategic) categories for interventions directly relevant to the conduct and conclusions of this review are:

- Interventions to increase client or community demand for vaccines and vaccination services. These efforts provide or disseminate information, advice, or both to clients, to increase and improve their efforts to seek appropriate vaccination.
- Interventions to enhance access to vaccination services. These efforts reduce the barriers clients may encounter in attempting to receive vaccinations.
- Provider- or system-based interventions. These interventions provide information or deliver timely reminders or periodic feedback to healthcare providers with the intent of increasing provider counseling about, and administration of, appropriate vaccinations to clients.

Methods

The general methods for conducting systematic reviews for the *Community Guide* have been described in detail elsewhere.[39] The specific methods used to conduct these systematic reviews, and to organize the evidence on effectiveness into a menu format recommendation from the Task Force, are presented elsewhere in this volume.[40] This section briefly describes pertinent general and specific methods employed in this systematic review.

A systematic review development team (made up of *Community Guide* researchers and methodologists, Task Force members, and other subject matter specialists) was recruited to provide oversight and subject matter expertise. As noted above, the conceptual approach

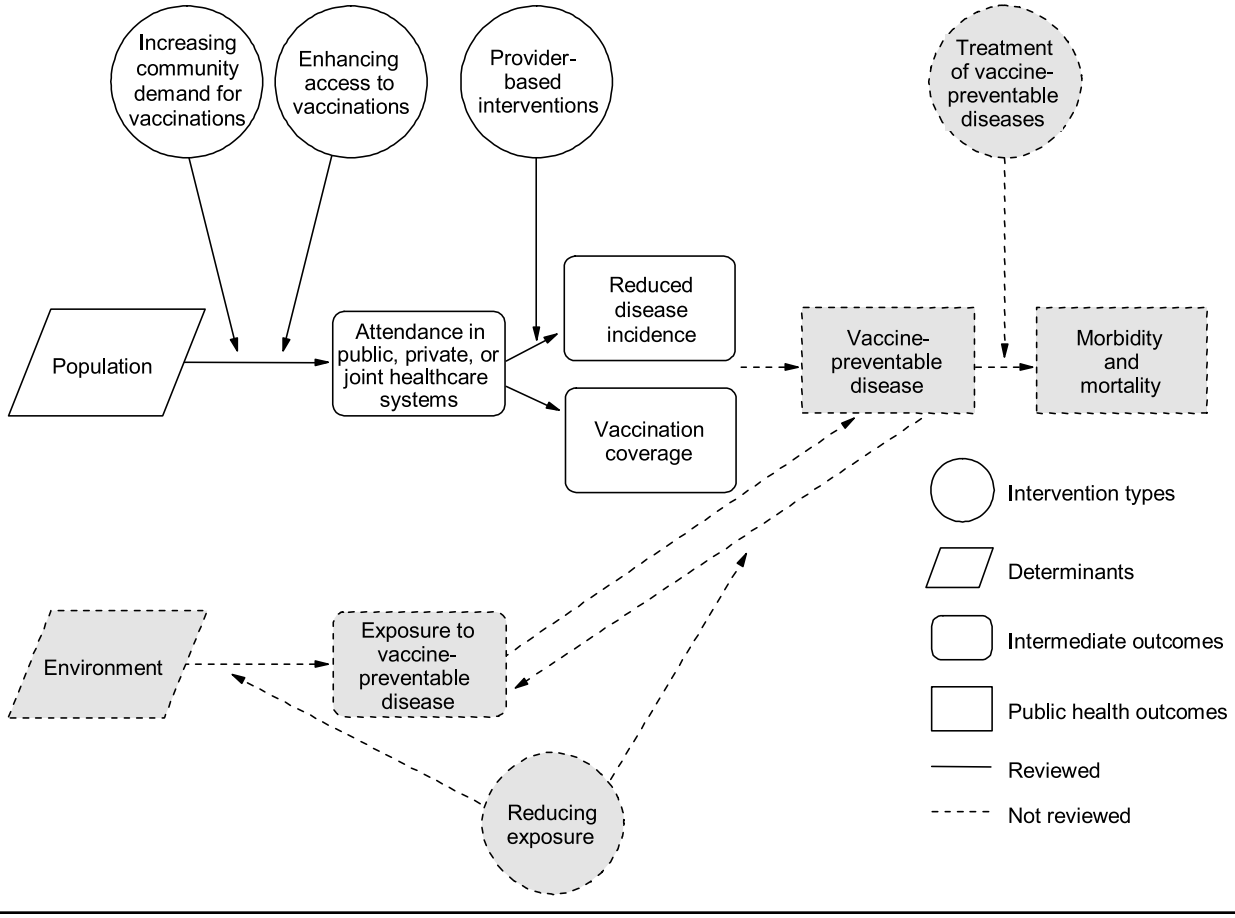

Figure 1. Logic framework depicting the conceptual approach used in these reviews. Adapted from: Briss PA, et al.[37]

and the interventions selected for review were adopted from the preceding systematic review of interventions to increase coverage for universally recommended vaccines.[37] The team searched for published studies in 12 electronic databases and in reference lists from retrieved papers. Studies were included if (1) they were published between 1980 and August 2001 as a journal article in English; (2) they evaluated an intervention to deliver influenza, pneumococcal polysaccharide, or hepatitis B vaccinations in a population at risk, or included information on risk populations (subsets) as part of a larger vaccination effort; and (3) outcome measurements included changes in vaccination coverage.

Two reviewers abstracted identified studies,[41] and differences in assessment of study design and quality of execution were resolved by consensus of the team. The primary outcome measures used to evaluate intervention effectiveness were changes in vaccination coverage in the at-risk study population (or subset). Results including a median effect measurement and the range are summarized in the text of the review (below) and are displayed graphically where appropriate.

Evidence on effectiveness is presented below in two sections. In the first section, we review the evidence on effectiveness for each intervention when implemented alone. In the second section, we review the evidence on effectiveness for interventions when implemented in combination. For our review of multicomponent interventions, we developed additional methods for organizing, evaluating, and displaying the evidence on effectiveness. These methods are described in detail in the accompanying article.[40] In short, studies of multicomponent interventions were reorganized into combinations across categories of vaccination demand and delivery. Results were summarized and evaluated according to the evidence on effectiveness within each category combination. Category combinations with evidence of effectiveness were then presented in a menu format identifying effective combinations and specific interventions within each category. The menu format provides a new option for presenting conclusions on effectiveness regarding evidence from multicomponent studies.

Results Part 1: Reviews of Evidence for Interventions to Increase Targeted Vaccine Coverage When Implemented Alone

Interventions to Increase Community or Client Demand for Vaccinations

Interventions to increase demand for vaccination services provide information, advice, or both to individual clients or to at-risk community members. Information and advice delivered to individuals at risk may increase or improve their demand for and receipt of vaccinations. In this category, we reviewed the following single-component interventions: clinic-based client education, client reminder systems, community-wide education, client or family incentives, and vaccination requirements. We found insufficient evidence to determine whether any of these interventions alone increases targeted vaccine coverage.

Clinic-based client education when implemented alone. Clinic-based education interventions provide information to clients served in specific medical or public health clinic settings. Information can help clients identify their risk status, indications for specific vaccines, and the potential benefits of vaccination. Education can also reduce or remove barriers by changing negative attitudes and beliefs about vaccination. Education efforts used a variety of formats, including letters, newsletters, brochures, and posters.

Effectiveness. We identified two studies evaluating the effectiveness of client education when implemented alone.[42,43] Details of the two qualifying studies are provided in the Appendix and at www.thecommunityguide.org/vaccine. Both studies evaluated the implementation of brochures. One study[42] evaluated two versions of health information given to healthcare providers and observed increases of 2 and 10 percentage points, respectively, in the proportion screened or vaccinated for hepatitis B. The second study evaluated the impact on subsequent receipt of pneumococcal vaccination of an educational handout given to patients at triage.[43] Vaccination rates among patients with at-risk medical conditions improved by 16.1 percentage points compared with patients who were not provided the information at triage.

Conclusion. According to *Community Guide* rules,[39] available studies provided insufficient evidence to determine the effectiveness of clinic-based client education when implemented alone in increasing targeted vaccination coverage in adult populations at high risk. Evidence was insufficient because we found only two studies, with fair quality of execution, that evaluated this intervention when implemented alone. The evidence on effectiveness of clinic-based client education when combined with additional interventions is reviewed below (see Results Part 2).

Client reminder systems when implemented alone. Client reminder systems provide information or advice directly to individual clients to inform or encourage them to obtain an appropriate vaccination. Examples of client reminders include letters or postcards sent from a provider office, healthcare system, or insurance carrier. Frequently, the content of client reminders over-

laps with client education interventions. In this review, we categorized interventions as client reminders if the intervention (1) identified and notified individual clients at high risk and (2) included an individual recommendation about vaccination from the client's healthcare provider or system.

Effectiveness. We identified one study evaluating the effectiveness of client reminder systems when implemented alone.[44] Details of the qualifying study are provided in the Appendix and at www.thecommunityguide.org/vaccine. In this study, patients identified at high risk for influenza received a postcard with a personal message signed by their physician. At follow-up, self-reported vaccination for influenza improved by 3.7 percentage points compared with patients who did not receive a postcard reminder.

Conclusion. According to *Community Guide* rules,[39] the evidence was insufficient to determine the effectiveness of client reminder systems when implemented alone in increasing targeted vaccination coverage of high-risk adults because only one study, with fair quality of execution, was identified. The evidence on effectiveness of client reminder systems when combined with additional interventions is reviewed below (see Results Part 2).

Community-wide education when implemented alone. Community-wide education interventions provide information to most or all of a target population in a geographic area, sometimes including vaccination providers. Educational messages can be delivered by various methods (e.g., mail, radio, newspapers, television, or posters). Community-wide education is intended to increase or improve the availability of information about vaccinations and increase knowledge, thereby changing behavior. It can result in increasing vaccination coverage by increasing acceptance and demand for vaccination among clients.[37]

Effectiveness. Our search identified no studies of community-wide education when implemented alone.

Conclusion. According to *Community Guide* rules,[39] evidence was insufficient to determine the effectiveness of community-wide education when implemented alone in increasing targeted vaccination coverage of high-risk adults, because we identified no studies of this intervention. In addition, we identified no studies of community-wide education when combined with additional interventions.

Client or family incentives when implemented alone. Client or family incentives seek to motivate people to accept vaccinations by providing either rewards or penalties. These interventions are based on the assumption that clients will be motivated to seek vaccinations if they receive rewards (e.g., money or discount coupons for retailers) or to avoid penalties (e.g., being excluded from participating in a program).[45]

Effectiveness. We identified one study evaluating the effectiveness of client incentives when implemented alone.[45] Details of the qualifying study are provided in the Appendix and at www.thecommunityguide.org/vaccine. This study evaluated the implementation of monetary incentives ($10.00) to increase hepatitis B vaccination coverage among recruited injection drug users and observed an improvement over baseline of 35 percentage points.

Conclusion. According to *Community Guide* rules,[39] evidence was insufficient to determine the effectiveness of client incentives when implemented alone in increasing targeted vaccination coverage among adults at high risk because only one study, with fair quality of execution, qualified for this review. In addition, we identified no studies that evaluated client or family incentives when combined with additional interventions.

Vaccination requirements when implemented alone. Vaccination requirements are laws or policies requiring vaccinations, other documentation of immunity, or documentation of declining to receive a vaccination as a condition of attendance, participation, or employment. Although some hospitals may have policies requiring their staff to be vaccinated against influenza, no state or federal laws in the United States require vaccination of high-risk adults with influenza, pneumococcal polysaccharide, or hepatitis B vaccines. Current Occupational Safety and Health Administration standards mandate that employers offer the hepatitis B vaccination series, at no cost, to any employee whose work is reasonably anticipated to include exposure to blood or other potentially infectious materials.[46] Employees can opt to sign a form declining the vaccination.

Effectiveness. Our search identified one study evaluating vaccination requirements for high-risk people, including healthcare workers and drug users, in the Czech Republic.[47] The study did not qualify for our review due to limited quality of execution.

Conclusion. According to *Community Guide* rules,[39] evidence was insufficient to determine the effectiveness of vaccination requirements alone in increasing vaccination coverage among high-risk adults because the single identified study did not qualify for review.

Interventions to Enhance Access to Vaccination Services

Interventions that enhance access to vaccination services are designed to reduce the cost or to increase the convenience of obtaining vaccinations. The two interventions we reviewed were reducing out-of-pocket costs

to the client and expanding access in healthcare settings. We found insufficient evidence to determine whether either intervention, by itself, is effective in increasing targeted vaccination coverage.

Reducing client out-of-pocket costs when implemented alone. Reducing out-of-pocket costs to individuals for vaccines or their administration can be implemented by paying for the vaccine or its administration, providing insurance coverage, or reducing co-payments for vaccinations at the point of services.[37] Reducing client out-of-pocket costs can result in increases in vaccination coverage either by improving availability of vaccinations or increasing demand for vaccinations.

Effectiveness. Our search identified no studies evaluating the effectiveness of reducing client out-of-pocket costs when implemented alone.

Conclusion. According to *Community Guide* rules,[39] evidence was insufficient to determine the effectiveness of reducing client out-of-pocket costs alone in increasing targeted vaccination coverage of high-risk adults because no studies were identified in this review. The evidence on reducing client out-of-pocket costs when combined with additional interventions is reviewed below (see Results Part 2).

Expanding access in health care settings when implemented alone. Expanding access increases the availability of vaccines in medical or public health clinic settings in which vaccinations are offered by (1) reducing the distance from the setting to the population; (2) increasing or changing hours during which vaccination services are provided; (3) delivering vaccinations in clinical settings where they were previously not provided (e.g., emergency departments, inpatient units, or subspecialty clinics); or (4) reducing administrative barriers to obtaining vaccination services within clinics (e.g., developing a "drop-in" clinic or an "express lane" vaccination service).[37]

Inconvenient hours and locations, as well as burdensome administrative requirements, are important barriers to obtaining vaccinations. These barriers are particularly significant among patients who do not have regular clinic visits, have transportation problems, or have difficulties making clinical appointments during the months when the vaccine is available.

Effectiveness. We found no studies evaluating the effectiveness of expanding access in healthcare settings when implemented alone.

Conclusion. According to *Community Guide* rules,[39] evidence was insufficient to determine the effectiveness of expanding access in healthcare settings when implemented alone in increasing targeted vaccination coverage of high-risk adults because we identified no studies in this review. The evidence on expanded access in healthcare settings when combined with additional interventions is reviewed below (see Results Part 2).

Provider- or System-Based Interventions

Provider- or system-based interventions are implemented primarily through healthcare systems with the goal of reducing missed opportunities for vaccination. We reviewed provider reminder systems, provider education, provider assessment and feedback, and standing orders.

Provider reminder systems when implemented alone. Provider reminder interventions inform vaccine providers that individual clients are due for specific vaccinations. Techniques by which reminders are delivered vary, and include the use of notations in clients' charts, attached chart prompts or stickers, or standardized checklists generated by the clinical staff or drawn from computer databases and registries. Reminders can be directed at the primary healthcare provider or to one or more members of the clinic staff.

Provider reminder systems make information about the client's immunization status available to providers either manually or through a computerized system. All the reminder systems described in the studies identified in this review delivered information to the provider at the time of the scheduled appointment.

Effectiveness. Our search identified seven studies of the effectiveness of provider reminder systems in increasing targeted vaccination coverage.[48–54] These studies focused on influenza and pneumococcal polysaccharide vaccines. Details of the seven qualifying studies are provided in the Appendix and at www.thecommunityguide.org/vaccine. The provider reminder systems evaluated in the qualifying studies included attachments to the patient chart generated by computer programs[48,49,51,52] or by clinic staff.[50,53] One study evaluated a reminder questionnaire designed as a letter from a colleague.[51] Two studies reported measurements of changes in influenza vaccine coverage.[49,50] One study reported measurements of changes in pneumococcal polysaccharide vaccine coverage.[53] Four studies provided measurements of changes in coverage for both influenza and pneumococcal polysaccharide vaccinations.[48,51,52,54] Figure 2 shows the results of studies reporting changes in vaccination coverage. The nine study arms in the seven qualifying studies showed a median improvement in vaccination coverage of 17.9 percentage points (range, −1 to 72). Overall, the data provide strong evidence of the effectiveness of provider reminder systems when implemented alone.

Applicability. The seven qualifying studies evaluated the effectiveness of provider reminder systems on resident and faculty physicians[48,49,51–53] and on nurses.[50,52] The client populations in the qualifying studies were patients with chronic illnesses. All studies were implemented and evaluated in academic healthcare settings, including hos-

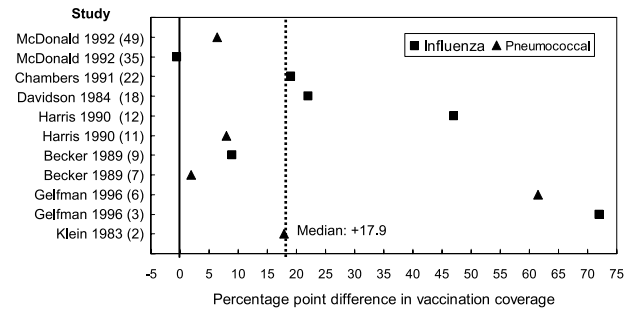

Figure 2. Percentage point change in vaccination coverage attributable to provider reminders when implemented alone, from the studies included in this review. Number in parentheses is baseline coverage.

pitals and clinics. None of the studies identified in this review evaluated outcomes of hepatitis B vaccination coverage in high-risk populations or settings.

Other positive or negative effects. Three studies evaluated provider reminder systems that included prompts for the delivery of additional preventive services or clinical care practices, including fecal occult blood exam, Pap smear, mammography, dental exam, tetanus vaccine, cancer screening, or measurements of serum cholesterol.[48,50,52] No harms of provider reminder systems were reported in the identified studies.

Economic efficiency. No studies were identified that met the requirements for inclusion in a *Community Guide* review.[55,56]

Barriers to intervention implementation. Potential barriers to the implementation of provider reminder systems include concerns among some providers about the efficacy[52,53] and safety[51] of pneumococcal polysaccharide vaccination. Clients may also refuse to be vaccinated.[49,51] Cost is another potential burden in implementing reminder systems.[49]

Conclusion. According to *Community Guide* rules,[39] strong evidence shows that provider reminder systems, when used alone, are effective in improving targeted vaccination coverage among high-risk adults. The evidence on provider reminders when combined with additional interventions is reviewed below (see Results Part 2).

Provider education when implemented alone. Provider education involves giving providers information about vaccinations to increase their knowledge or change their attitudes. Receipt of such information might result in fewer missed vaccination opportunities, and, consequently, a greater proportion of eligible patients receiving indicated vaccinations. Techniques by which information is delivered can include written materials, videos, lectures, continuing medical education programs, or computerized software.

Effectiveness. Our review identified no studies of provider education interventions when implemented alone.

Conclusion. According to *Community Guide* rules,[39] evidence was insufficient to determine the effectiveness of provider education when implemented alone in increasing targeted vaccination coverage of high-risk adults because no studies were identified in this review. The evidence on provider education when combined with additional interventions is reviewed below (see Results Part 2).

Standing orders when implemented alone. Requirements for physical examinations prior to vaccination and lack of personnel to administer vaccines are two administrative barriers that may contribute to missed opportunities to vaccinate. Standing orders authorize healthcare personnel (e.g., nurses or pharmacists) to prescribe or deliver vaccinations to clients by protocol without direct physician involvement at the time of the interaction. Empowering nonphysician personnel to deliver vaccinations might reduce barriers to vaccination and missed opportunities, resulting in improved vaccination delivery.[37]

Effectiveness. Our search identified no studies providing measurements of the effectiveness of standing orders when implemented alone.

Conclusion. According to *Community Guide* rules,[39] evidence was insufficient to determine the effectiveness of standing orders when implemented alone in increasing targeted vaccination coverage of high-risk adults because no studies were identified in this review. The evidence on standing orders when combined with additional interventions is reviewed below (see Results Part 2).

Provider assessment and feedback when implemented alone. Provider assessment and feedback involve both retrospective evaluation of provider performance in delivering one or more vaccinations to client populations and giving this information to providers. Assessment and feedback can result in improvements in vaccination coverage either by changing provider knowledge, attitudes, and behaviors, or by stimulating use of additional changes in the vaccination delivery system (e.g., reminders or standing orders).[37]

Effectiveness. We identified one study that evaluated the effectiveness of provider assessment and feedback when implemented alone.[57] Details of this qualifying study are provided in the Appendix and at www.thecommunityguide.org/vaccine. The study examined the impact of annual chart reviews and feedback to resident physicians on coverage for influenza and pneumococcal polysaccharide vaccines and found that vaccination coverage among at-risk patients improved by 32 percentage points for influenza vaccine and 18 percentage points for pneumococcal polysaccharide vaccine.

Table 2. Intervention combinations evaluated in studies qualifying for review of multicomponent strategies to increase targeted vaccination coverage (n = 26 study arms from 23 studies)

	Interventions to increase demand			Provider- or system-based interventions				Interventions to enhance access	
Study (year)[ref]	Client education	Client reminders	Client incentives	Standing orders	Provider reminders	Provider feedback	Provider education	Expanded access in healthcare settings	Reducing out-of-pocket costs
Baker (1998)[58]	X	X						X	
Barton (1990)[59]		X			X	X			
Becker (1989)[48]		X			X				
Brimberry (1988)[61]		X						X	
Carter (1986)[62]	X	X						X	
Coyne (2000)[65]	X					X	X		
Fedson (1996)[68]				X				X	X
Harbarth (1998)[73]	X	X						X	X
Hogg (1998)[75]	X				X				X
(two arms)		X			X				X
Jans (2000)[76]						X	X		
Klein (1986)[78]	X			X			X	X	
Landis (1995)[80]				X					X
Larson (1982)[44]	X	X							
Moran (1996)[83]	X	X						X	X
(three arms)		X	X					X	X
	X	X	X					X	X
Nichol (1990)[84]	X	X		X	X			X	
Nichol (1998)[85]	X			X				X	
Overhage (1996)[87]					X			X	
Sellors (1997)[90]		X							X
Spaulding (1991)[93]		X						X	X
Thomas (1993)[95]	X							X	X
Turner (1990)[97]		X			X				
van Essen (1997)[98]	X					X	X		
Yassi (1993)[101]	X	X						X	X
Totals (arms)	14	16	2	5	7	4	4	15	12

Conclusion. According to *Community Guide* rules,[39] evidence was insufficient to determine the effectiveness of provider assessment and feedback interventions when implemented alone in increasing targeted vaccination coverage among high-risk patients because only one study, with fair quality of execution, qualified for review. The evidence on effectiveness of provider assessment and feedback when combined with additional interventions is reviewed below (see Results Part 2).

Results Part 2. Reviews of Evidence for Interventions to Increase Vaccine Coverage When Implemented in Combination

Most of the available evidence on effectiveness identified in this review of interventions to increase targeted vaccines coverage comes from studies that evaluated interventions implemented in combination (multicomponent interventions). The paucity of evidence on the effectiveness of interventions when implemented alone (see Results Part 1) and the variety of intervention combinations evaluated complicate assessment of the effectiveness of this multicomponent body of evidence. A full description of the methods used in the following evaluation of effectiveness, and in constructing a menu format as part of the Task Force recommendation, is provided elsewhere in this supplement,[40] and a brief description is included at the end of the Methods section of this article.

Effectiveness

Our systematic review identified a total of 47 studies evaluating interventions to increase vaccination coverage among at-risk populations when implemented in combination (multicomponent).[44,47,48,58–101] Two papers provided additional information on studies already included in the review.[102,103] Twenty-four studies were excluded due to limited quality of execution[60,63,66,74,77,81,82,88,89,96] or least suitable study design.[47,64,67,69–72,79,86,91,92,94,99,100] Details of the 23 qualifying studies[44,48,58,59,61,62,65,68,73,75,76,78,80,83–85,87,90,93,95,97,98,101] are provided in the Appendix and at www.thecommunityguide.org/vaccine.

The intervention combinations evaluated in each of the qualifying studies are presented in Table 2. Overall,

Table 3. Combinations of intervention categories and differences in targeted vaccination coverage observed in qualifying studies

Study (year)[ref]	Interventions to increase client or community demand	Provider- or system-based interventions	Interventions to enhance access	Interventions across all categories	Percentage point difference in vaccination coverage (vaccine)	Median change (percentage points)
Studies evaluating interventions combined within a single category: community demand						
Larson (1982)[44]	2			2	+13.6 (I)	+13.6
Studies evaluating interventions combined within a single category: provider- or system-based						
Jans (2000)[76]		2		2	+11 (I)	+11
Studies evaluating interventions combined across two conceptual categories: community demand + provider- or system-based						
Barton (1990)[59]	1	2		3	+28.9 (I)	
Becker (1989)[48]	1	1		2	+16.1 (I)	
					+0.8(P)	+3.7 (range: −2
Coyne (2000)[65]	1	2		3	+3.7 (HB)	to +28.9)
Turner (1990)[97]	1	1		2	+18 (I)	
					−2 (P)	
van Essen (1997)[98]	1	2		3	+1.1 (I)	
Studies evaluating interventions combined across two conceptual categories: community demand + enhanced access						
Baker (1998)[58]	2		1	3	+3.1 (I)	
Brimberry (1988)[61]	1		1	2	+5.5 (I)	
Carter (1986)[62]	2		1	3	+13 (I)	
Harbarth (1998)[73]	2		2	4	+10 (I)	
Moran (1996)[83]	2		2	4	+14 (I)	+14 (range: +3.1
(three arms)	2		2	4	+14 (I)	to +46)
	3		2	5	+17 (I)	
Sellors (1997)[90]	1		1	2	+23 (HB)	
Spaulding (1991)[93]	1		2	3	+16.1 (I)	
Thomas (1993)[95]	1		2	3	+46 (I)	
Yassi (1993)[101]	2		2	4	+19.6 (HB)	
Studies evaluating interventions combined across two conceptual categories: provider- or system-based + enhanced access						
Fedson (1996)[68]		1	2	3	+31 (I)	
Landis (1995)[80]		1	1	2	+27.8 (P)	+27.8 (range: −0.5
Overhage (1996)[87]		1	1	2	−0.5 (P)	to +31)
Studies evaluating interventions combined across all three conceptual categories						
Nichol (1990)[84]	2	2	1	5	+28.4 (I)	
Nichol (1998)[85]	1	1	1	3	+17.2 (I)	
					+32.1 (P)	+22.8 (range: −5.9
Hogg (1998)[75]	1	1	1	3	−5.9 (I)	to +67)
(two arms)	1	1	1	3	+2.6 (I)	
Klein (1986)[78]	1	2	1	4	+67 (P)	

HB, hepatitis B; I, influenza; P, pneumococcal polysaccharide.

the 23 qualifying studies provided 26 study arms evaluating 22 different combinations of interventions. Seven study arms in seven studies[48,58,62,73,83,97,101] evaluated one of three specific intervention combinations: two studies evaluated a combination of client reminders and provider reminders[48,97]; two studies implemented a combination of client education, client reminders, and expanded access in a healthcare setting[58,62]; and three studies implemented a combination of client education, client reminders, expanded access, and reduced client out-of-pocket costs.[73,83,101] The remaining 19 study arms evaluated unique combinations of interventions.

We conducted additional analyses to examine the combinations of interventions described in the qualifying studies. We consolidated individual interventions into categories of vaccination delivery (e.g., interventions to increase client demand) and performed stratified analyses on these categories. In Table 3, categories subsume the specific interventions, and the qualifying studies are reorganized into similar combinations across categories. Of the qualifying studies, 21 of 23 (24 of 26 study arms) evaluated the effectiveness of interventions combined across two or three conceptual categories.

Figure 3 presents the results from the 26 multicomponent study arms organized into combinations within a category (two categories: increasing community or client demand; provider- or system-based interventions) or across categories (four combinations: increased community or client demand plus provider- or system-based interventions; increased demand plus enhanced access; provider- or system-based interventions plus enhanced access; increased

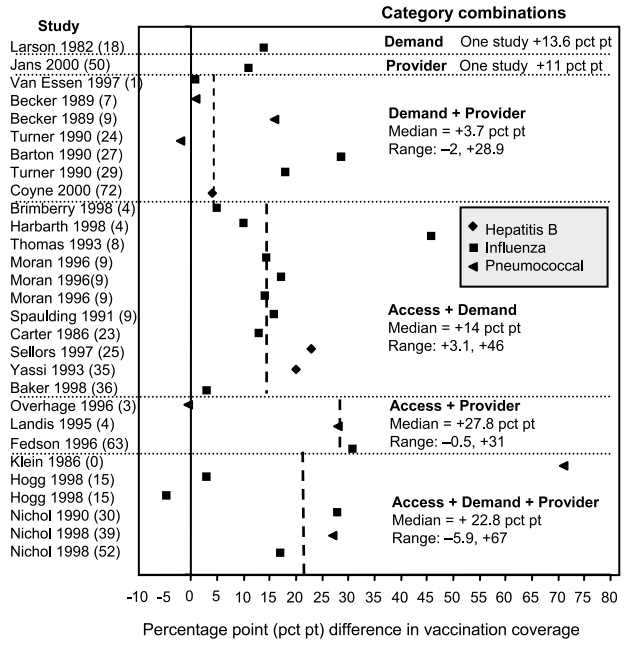

Figure 3. Percentage point change in vaccination coverage attributable to interventions implemented in combination in the studies included in this review. Number in parentheses is baseline coverage.

demand, provider- or system-based interventions, and enhanced access).

Only two qualifying studies evaluated interventions combined within a single conceptual category.[44,76] One study[44] evaluated the combination of client education and client reminders to increase client demand for influenza vaccination. At follow-up, vaccination coverage had improved by 13.6 percentage points. The second study[76] evaluated two provider- or system-based interventions: provider education and provider assessment and feedback. At follow-up, influenza vaccination coverage had improved by 11 percentage points.

An intervention to increase client demand was combined with one or two provider- or system-based interventions in five studies.[48,59,65,97,98] These five studies provided seven measurements of changes in vaccination. The median change in vaccination coverage reported in these studies was an increase of 3.7 percentage points (range, −2 to +28.9 percentage points).

Nine studies evaluated one or two interventions to increase client demand when combined with one or two interventions to enhance access to vaccination services,[58,61,62,73,83,90,93,95,101] providing nine measurements of changes in vaccination coverage. The median change was an improvement of 14 percentage points (range, 3.1 to 46 percentage points).

Three studies evaluated one or two provider- or system-based interventions when combined with one or two interventions to enhance access to vaccination services.[68,80,87] Two studies observed improvements in vaccination coverage of 31 and 27.8 percentage points.[68,80] The remaining study observed a minimal change in coverage (−0.5 percentage points) for the pneumococcal polysaccharide vaccine.[87]

Finally, four studies evaluated combinations of interventions to increase vaccination coverage drawn from all three categories.[75,78,84,85] These four studies provided six measurements of changes in vaccination coverage. The median change was an improvement of 22.8 percentage points (range, −5.9 to +67).

The effectiveness of combinations that included one or more interventions to enhance access to vaccination services with one or more interventions from one or both of the other two categories was evaluated in a total of 19 study arms from 16 qualifying studies.[58,61,62,68,73,75,78,80,83–85,87,90,93,95,101] Within this subset of combined interventions, vaccination coverage improved by a median of 16.5 percentage points (range, −5.9 to +67). Overall, we found strong evidence of the effectiveness of the combination of interventions shown in Table 4 in increasing targeted vaccine coverage.

Applicability

These findings should be applicable to a range of clients, providers, and healthcare settings. Studies examined client populations including outpatients,[58,83] inpatients,[78,80,87] and healthcare workers.[73,95,101] The evaluated provider populations included nurses[84,85,101]

Table 4. Combinations of interventions demonstrating strong evidence of effectiveness in increasing targeted vaccine coverage

Combinations of interventions across categories			Evidence on effectiveness	Results
Enhancing access	Provider- or system-based	Increasing demand	Number of studies (arms)	Median change
One or more of these interventions[a]	Plus one or more of these interventions[b]	And/or one or more of these interventions[c]	16 (19)	+16.5 percentage points (range, −5.9 to +67)

[a]Interventions to enhance access include expanded access and reducing out-of-pocket costs.
[b]Provider- or system-based interventions include standing orders, provider reminders, and provider feedback.
[c]Interventions to increase client or community demand include client education and client reminders.

and faculty physicians.[62,73,83,101] The healthcare settings evaluated were academic programs,[62,73,83,101] outpatient clinics,[58,83,101] hospitals,[62,73,84,85] long-term care facilities,[95] and the workplace.[73,101]

Other Positive or Negative Effects

We identified no additional effects specific to the combination of interventions in this review. Positive or negative effects of single-component interventions may remain relevant when the interventions are implemented in combination.

Economic Efficiency

No studies were found that met the requirements for inclusion in a *Community Guide* review.[55,56]

Barriers to Intervention Implementation

Barriers to the implementation of single-component interventions are likely to remain relevant to combined efforts. Additional barriers, such as lack of infrastructure, may be encountered in efforts to coordinate these interventions.

Conclusions

According to *Community Guide* rules,[39] the available qualifying studies provide evidence that interventions combined across categories are effective in increasing vaccination coverage in adult populations at high risk. We found strong evidence of effectiveness in studies evaluating interventions to enhance access to vaccination services (expanding access in healthcare settings, reducing client out-of-pocket costs) combined with provider- or system-based interventions (provider reminders, provider assessment and feedback, standing orders) and/or interventions to increase client demand for vaccination services (client education, client reminders) (Table 4).

Available studies provided insufficient evidence to determine the effectiveness of combinations that did not include one or more interventions to enhance access to vaccination services (specifically, combinations across the two categories of interventions to increase client demand and provider- or system-based interventions). Evidence was considered insufficient because the small number of qualifying studies reported inconsistent effects on vaccination coverage in populations at high risk.

The available studies also provided insufficient evidence to determine the effectiveness of either client incentives or community-wide education as options for interventions to increase demand for vaccination. Evidence was considered insufficient because of the small number of qualifying studies. These single-component interventions, therefore, do not appear among the choices in the menu format (see Table 4).

Finally, the available studies provided insufficient evidence to determine the effectiveness of provider education as an option for combinations of provider- or system-based interventions. Evidence was considered insufficient because the small number of qualifying studies reported results that were inconsistent and small in magnitude when compared with other intervention combinations.

Results Part 3. Research Issues

Effectiveness

The qualifying studies identified in this review provide strong evidence of the effectiveness of provider reminder systems when implemented alone in improving targeted vaccination coverage among adults at high risk. Strong evidence of effectiveness was also identified in multicomponent programs directed at clients and providers, when these programs included one or more interventions to enhance access to vaccination combined with one or more interventions to increase demand, one or more provider- or system-based interventions, or both. However, significant gaps remain in our evaluation of intervention effectiveness.

Further consideration and research into the effectiveness of single-component interventions should address the questions of whether these interventions (other than provider reminder systems, for which effectiveness was established) are consistently effective in improving targeted vaccine coverage.

The conclusions about effectiveness of interventions when implemented in combination represent an initial effort to evaluate a complicated body of evidence. Although this summary confirms one aspect of the evidence on effectiveness (interventions combined across conceptual approaches to vaccination delivery), important research questions remain about the effectiveness of specific intervention combinations.

Are combinations of interventions to increase client and community demand for vaccination effective?

Are combinations of provider- or system-based interventions to increase targeted vaccination coverage effective?

Are combinations of interventions to enhance access to vaccination services effective?

Are interventions combined across strategic categories of vaccination effective because they are synergistic?

What specific combinations of interventions are most effective in improving targeted vaccination coverage? Do effective combinations differ by target population or setting? Do effective combinations differ by vaccine?

Designated staff empowered by standing orders were used in three of the qualifying studies[68,78,80] to direct vaccination efforts for healthcare workers or hospital inpatients. The available evidence suggests that designated staff may be an effective intervention in these and other settings (e.g., long-term care facilities). Additional research would expand the body of evidence on effectiveness.

Eight study arms from seven studies evaluated the effectiveness of the same intervention(s) (five single-component arms and three combination arms) in improving coverage rates for both influenza and pneumococcal polysaccharide vaccines.[48,51,52,54,57,85,97] With similar indications and populations at risk, these vaccines offer the potential for coordinated, targeted efforts within a community or healthcare system. Although the evidence is already sufficient to conclude on the effectiveness of provider reminder systems, research questions remain about the effectiveness of other interventions or combinations of interventions in improving vaccination coverage for both vaccines in the same population.

Applicability

Overwhelmingly, the evidence identified in this review is derived from interventions implemented and evaluated in healthcare systems. The evidence on effectiveness should be applicable in most healthcare settings and adult patient populations. A number of important research questions about specific high-risk populations and settings should still be addressed.

Can these intervention combinations be implemented as effectively in smaller healthcare settings, such as clinics and private practices?

What interventions and combinations of interventions are effective in increasing hepatitis B coverage among people at high risk because of behaviors (e.g., injection drug users, multiple sex partners)? This review identified only two qualifying studies of interventions directed at populations with risk behaviors[45,90] that provided insufficient evidence to determine the effectiveness of interventions or intervention combinations in improving hepatitis B vaccination coverage in these populations. Evaluations of the effectiveness of expanded access in non-healthcare settings, reduced client out-of-pocket costs, standing orders (designated vaccination staff), client education, and client incentives are areas for further research.

Are interventions to increase hepatitis B vaccination coverage among healthcare workers equally effective in other populations who are at risk of hepatitis B infection? Evidence from studies conducted in healthcare settings may not translate to the community-based requirements of a vaccination effort directed at people with risk behaviors. Challenges, including low perceptions of risk, limited access to health care, and poor adherence to follow-up, may be significant.

Other Positive or Negative Effects

The studies identified in this review provided little information about other positive or negative effects of targeted vaccination efforts. No significant research issues were identified.

Economic Efficiency

We did not identify any studies providing economic information or evaluations of targeted vaccination interventions. Basic economic research needs to be conducted to investigate the following questions:

What is the cost of implementing a single-component intervention?

What is the cost of implementing multicomponent interventions?

Are multicomponent interventions more cost-effective than single-component interventions?

What are the costs per additional person vaccinated, in single- or multi-component interventions?

What is the cost-benefit or cost-utility of these interventions?

Barriers to Implementation

Several studies identified in this review discussed barriers to vaccination. These included refusals to be vaccinated[78] as well as fear of side effects[73] and needles.[95] Although these represent obstacles to the vaccination of individual clients, and are not specific to interventions, vaccination coverage rates may respond to efforts that address client concerns.

Are client education efforts effective in increasing client requests for vaccination (or reducing client refusals to be vaccinated)?

Barriers specific to the implementation of interventions include the administrative burdens and infrastructure requirements of targeted vaccination efforts. Do registries facilitate the adoption of interventions and intervention combinations focused on high-risk adult populations?

What impact would providing insurance coverage have on the administration and receipt of hepatitis B vaccine among people with risk behaviors?

How frequent are missed opportunities to administer each of these vaccines, and what factors contribute to these missed opportunities?

Discussion

This report introduces a new qualitative technique for the organization and assessment of evidence on effectiveness of interventions. These methods provide a useful framework for evaluating a complicated body of evidence, and attempt to incorporate evidence on effectiveness both for specific interventions and for less

specific combinations across conceptual categories (strategies). The qualitative techniques developed and implemented here are potentially adaptable to other systematic reviews conducted for the *Guide to Community Preventive Services*.

The information and conclusions about targeted vaccine strategies complement and expand the initial *Community Guide* review of interventions to increase vaccine coverage for universally recommended vaccines.[37,38] Taken together, the initial and current reports provide an increasingly complete assessment of intervention options available to programs and planners seeking to improve vaccination coverage rates in communities and healthcare systems.

In 2000, concerned about the low influenza vaccination rates among people aged 50 to 64 with risk conditions, the Advisory Committee on Immunization Practices expanded their universal recommendation for annual influenza vaccination to include all adults in this age group.[104] Program planners dedicated to increasing influenza vaccination coverage within this "new" population should consider recommendations from either or both applicable Task Force reviews. For initial efforts, program planners may find that the recommendations in the original, universal review[37,38] provide a number of effective and flexible intervention options. Planners attempting to enhance initial program efforts may find the information on intervention combinations recommended in this targeted review helpful.

Several limitations should be noted about the conclusions of this review.

(1) The available evidence on effectiveness was not stratified by targeted vaccine or by targeted indications (e.g., medical, occupational, behavioral, other). As noted below, few studies evaluated the effectiveness of interventions to increase targeted hepatitis B vaccine coverage, especially among people with high-risk behaviors. In our review, we opted to organize the available information according to the intervention or combinations of interventions implemented and evaluated. Within this format, further stratification by vaccine or by targeted indication resulted in insufficient evidence to support more specific conclusions on effectiveness. We recognize the value of these stratified evaluations, however, and expect that additional studies will enable future reviews to illuminate any differences.
(2) The conceptual categories adopted for this review consolidate the evidence on effectiveness (or ineffectiveness) of the specific interventions within that category. This method for organizing the evidence obscures some information about the contribution of any specific intervention to a combined effort.
(3) The category-based conclusions on effectiveness support a significantly greater number of specific intervention combinations than were demonstrated in the qualifying studies.

Significant gaps in the available evidence on effectiveness remain, and provide an important agenda for further research. One critical gap is the paucity of economic evaluations of population-based interventions to improve vaccination coverage. We did not identify any economic evaluations of the targeted vaccination interventions in this review.

In contrast to the evidence on effectiveness of universally recommended vaccines, the published evidence about efforts to increase targeted vaccine coverage includes few studies of interventions when implemented alone. The available studies of interventions combined across conceptual categories broadly support the current conclusions, but provide limited information to compare and contrast potential combinations of interventions.

The evidence on effectiveness identified in this review is divided among three vaccines, a number of targeted populations with different indications for vaccination, and a variety of community and healthcare settings. The evidence is limited for many of these combinations (vaccine + target group + setting) when considered individually. Nevertheless, the review conclusions presented here should be considered as broadly applicable, except as noted below. Much of the evidence identified in this review evaluated intervention efforts implemented within a healthcare system, either to improve coverage among healthcare workers or among patients with medical indications. The results summarized in this review suggest that vaccination coverage can be improved in both populations with the application of provider reminder systems alone or with the appropriate combination of interventions. For example, combinations of interventions were effective in increasing coverage for influenza among healthcare workers, and similar combinations of interventions were also effective in increasing coverage for influenza or pneumococcal polysaccharide vaccines among patients with medical indications. Differences in the vaccines, in the target groups (such as baseline knowledge and motivations to be vaccinated), and in the settings (hospitals, outpatient clinics, and practictioners' offices) remain important factors that may require tailoring of the content and conduct of the interventions selected to address specific gaps in vaccination coverage.

Few studies identified in this review evaluated the effectiveness of interventions to increase coverage for hepatitis B vaccine, and most of these studies evaluated interventions to increase coverage rates among healthcare workers. Significant gaps remain in the evidence on the implementation, evaluation, and effectiveness of community-based efforts to increase coverage among people at high risk for hepatitis B infection. A number

of community-based hepatitis B vaccination programs are currently under way, and may provide additional evidence on the effectiveness of this approach.[105]

The evidence reviewed here, along with the accompanying evidence-based recommendations from the Task Force on Community Preventive Services,[106] provide a point-in-time assessment of effectiveness of interventions and strategies to improve targeted vaccines coverage rates in at-risk populations. These reports provide evidence to help decision makers and program planners select and implement interventions to reduce morbidity and mortality from vaccine-preventable diseases.

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References

1. Centers for Disease Control and Prevention. Hepatitis B virus: a comprehensive strategy for eliminating transmission in the United States through universal childhood vaccination. Recommendations of the Immunization Practices Advisory Committee (ACIP). MMWR Recomm Rep 1991;40(RR-13):1–19.
2. Centers for Disease Control and Prevention. Prevention of pneumococcal disease: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 1997;40(RR-08):1–24.
3. Centers for Disease Control and Prevention. Preventing pneumococcal disease among infants and young children: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2000;49(RR-09):1–38.
4. Centers for Disease Control and Prevention. Pneumococcal vaccination for cochlear implant candidates and recipients: updated recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Morb Mortal Wkly Rep 2003;52:739–40.
5. Centers for Disease Control and Prevention. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2004;53(RR-06):1–40.
6. Centers for Disease Control and Prevention. Recommended childhood and adolescent immunization schedule—United States, July–December 2004. MMWR Morb Mortal Wkly Rep 2004;53:Q1–Q3.
7. Immunization Action Coalition. Summary of recommendations for adult immunization. Adapted from the Advisory Committee on Immunization Practices (ACIP) by the Immunization Action Coalition. Available at: www.immunize.org/catg.d/p2011b.htm. Accessed April 22, 2004.
8. Bridges CB, Fukuda K, Uyeki T, Cox N, Singleton J. Prevention and control of influenza. Recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2002;51(RR-03):1–31.
9. Thompson WW, Shay DK, Weintraub E, et al. Mortality associated with influenza and respiratory syncytial virus in the United States. JAMA 2003;289:179–86.
10. Barker W, Mullooly J. Impact of epidemic type A influenza in a defined adult population. Am J Epidemiol 1980;112:798–811.
11. Barker W. Excess pneumonia and influenza associated hospitalization during influenza epidemics in the United States, 1970–78. Am J Public Health 1986;76:761–5.
12. Glezen WP, Couch R. Interpandemic influenza in the Houston area, 1974–76. N Engl J Med 1978;298:587–92.
13. Zimmerman R, Ahwesh E. Adult vaccination, part 2: vaccines for persons at risk. Teaching Immunization for Medical Education (TIME) Project. J Fam Pract 2000;49(suppl 9):S51–63.
14. Barker WH, Mullooly JP. Pneumonia and influenza deaths during epidemics. Implications for prevention. Arch Intern Med 1982;142:85–9.
15. Zimmerman RK. Adult vaccination, part 1: vaccines indicated by age. Teaching Immunization for Medical Education (TIME) Project. J Fam Pract 2000;49(suppl 9):S41–50.
16. Fukuda KJ, O'Mara D, Singleton J. Drug shortages, part 4: how the delayed distribution of influenza vaccine created shortages in 2000 and 2001. Pharm Ther 2002;27:235–42.
17. Hak E, Nordin J, Wei F, et al. Influence of high risk medical conditions on the effectiveness of infleunza vaccination among elderly members of 3 large managed care organizations. Clin Infect Dis 2002;35:370–7.
18. Fine AD, Bridges CB, DeGuzman AM, et al. Influenza A among patients with human immunodeficiency virus: an outbreak of infection at a residential facility in New York City. Clin Infect Dis 2001;32:1784–91.
19. Mullooly JP, Bennett MD, Hornbrook MC, et al. Influenza vaccination programs for elderly persons: cost-effectiveness in a health maintenance organization. Ann Intern Med 1994;121:947–52.
20. Nordin J, Mullooly J, Poblete S, et al. Influenza vaccine effectiveness in preventing hospitalizations and deaths in persons 65 years or older in Minnesota, New York and Oregon: data from 3 health plans. J Infect Dis 2001;184:665–70.
21. Patriarca PA, Weber JA, Parker RA, et al. Risk factors for outbreaks of influenza in nursing homes: a case control study. Am J Epidemiol 1986;124:114–9.
22. Institute of Medicine. Calling the shots: immunization finance policies and practices. Washington DC: National Academy Press, 2002.
23. U.S. Department of Health and Human Services. Healthy people 2010. 2nd ed. Washington DC: U.S. Government Printing Office, 2000.
24. Robinson KA, Baughman W, Rothrock G, et al. Epidemiology of invasive Streptococcus pneumoniae infections in the United States, 1995–1998. JAMA 2001;285:1729–35.
25. Glezen WP. Serious morbidity and mortality associated with influenza epidemics. Epidemiol Rev 1982;4:25–44.
26. Butler J, Breiman RF, Campbell JF, Lipman HB, Broome CV, Facklam RR. Pneumococcal polysaccharide vaccine efficacy: an evaluation of current recommendations. JAMA 1993;270:1826–31.
27. Shapiro E, Berg A, Austrian R, et al. The protective efficacy of polyvalent pneumococcal polysaccharide vaccine. N Engl J Med 1991;325:1453–60.
28. Nichol K, Baken L, Wuorenma J, Nelson A. The health and economic benefits associated with pneumococcal vaccination of elderly persons with chronic lung disease. Arch Intern Med 1999;159:2437–42.
29. Jiles R, Daniels D, Yusuf H, McCauley M, Chu S. Undervaccination with hepatitis B vaccine: missed opportunities or choice? Am J Prev Med 2001;20(suppl 4):75–83.
30. Bloom BS, Hillman AL, Fendrick AM, Schwartz JS. A reappraisal of hepatitis B virus vaccination strategies using cost-effectiveness analysis. Ann Intern Med 1993;118:298–306.
31. Margolis HS, Coleman PJ, Brown RE, Mast EE, Sheingold SH, Arevalo JA. Prevention of hepatitis B virus transmission by immunization. An economic analysis of current recommendations. JAMA 1995;274:1201–8.
32. National Center for Infectious Diseases, Centers for Disease Control and Prevention. Disease burden from Hepatitis A, B, and C in the United States. Available at: www.cdc.gov/ncidod/diseases/hepatitis/resource/dz_burden02.htm. Accessed October 18, 2004.

33. Goldstein ST, Alter MJ, Williams IT, et al. Incidence and risk factors for acute hepatitis B in the United States, 1982–1998: implications for vaccination programs. J Infect Dis 2002;185:713–9.
34. MacKellar DA, Valleroy LA, Secura GM, et al. Two decades after vaccine license: hepatitis B immunization and infection among young men who have sex with men. Am J Public Health 2001;91:965–71.
35. Centers for Disease Control and Prevention. Hepatitis B vaccination among high-risk adolescents and adults—San Diego, California, 1998–2001. MMWR Morb Mortal Wkly Rep 2002;51:618–21.
36. Mahoney FJ, Stewart K, Hu H, Coleman P, Alter MJ. Progress towards elimination of hepatitis B virus transmission among health care workers in the United States. Arch Intern Med 1997;157:2601–5.
37. Briss PA, Rodewald LE, Hinman AR, et al. Reviews of evidence regarding interventions to improve vaccination coverage in children, adolescents, and adults. Am J Prev Med 2000;18(suppl 1):97–140.
38. Task Force on Community Preventive Services. Recommendations regarding interventions to improve vaccination coverage in children, adolescents, and adults. Am J Prev Med 2000;18(suppl 1):92–6.
39. Briss PA, Zaza S, Pappaioanou M, et al. Developing an evidence-based Guide to Community Preventive Services—methods. Am J Prev Med 2000;18(suppl 1):35–43.
40. Ndiaye SM, Hopkins DP, Smith SJ, Hinman AR, Briss PA. Task Force on Community Preventive Services. Methods for conducting systematic reviews of targeted vaccination strategies for the Guide to Community Preventive Services. Am J Prev Med 2005;28(suppl 3):238–47.
41. Zaza S, Wright-de Aguero L, Briss PA, et al. Data collection instrument and procedure for systematic reviews in the Guide to Community Preventive Services. Am J Prev Med 2000;18(suppl 1):44–74.
42. Clancy CM, Cebul RD, Williams SV. Guiding individual decisions: a randomized, controlled trial of decision analysis. Am J Med 1988;84:283–8.
43. Jacobson TA, Thomas DM, Morton FJ, Offutt G, Shevlin J, Ray S. Use of a low-literacy patient education tool to enhance pneumococcal vaccination rates. A randomized controlled trial. JAMA 1999;282:646–50.
44. Larson EB, Bergman J, Heidrich F, Alvin BL, Schneeweiss R. Do postcard reminders improve influenza compliance? A prospective trial of different postcard "cues". Med Care 1982;20:639–48.
45. Trubatch B, Paschane D, Fisher D, Cagle H, Fenaughty K, Schlicting E. Economic incentives: vaccination compliance among drug users. Presentation at 126th annual meeting and exposition of the American Public Health Association, Washington DC, November 15–19, 1998 (poster session).
46. Department of Labor, Occupational Safety and Health Administration. Occupational exposure to bloodborne pathogens: final rule. Federal Register 1991;56(29 CFR Part 1910.1030):64004–182.
47. Helcl J, Cástková J, Benes C, Novotna L, Sepkowitz KA, DeHovitz JA. Control of occupational hepatitis B among healthcare workers in the Czech Republic, 1982 to 1995. Infect Control Hosp Epidemiol 2000;21:343–6.
48. Becker DM, Gomez EB, Kaiser DL, Yoshihasi A, Hodge RH. Improving preventive care at a medical clinic: how can the patient help? Am J Prev Med 1989;5:353–9.
49. Chambers CV, Balaban DJ, Carlson BL, Grasberger DM. The effect of microcomputer-generated reminders on influenza vaccination rates in a university-based family practice center. J Am Board Fam Pract 1991;4:19–26.
50. Davidson RA, Fletcher SW, Retchin S, Duh S. A nurse-initiated reminder system for the periodic health examination. Implementation and evaluation. Arch Intern Med 1984;144:2167–70.
51. Gelfman DM, Witherspoon JM, Buchsbaum DG, Centor RM. Short-term results of an immunization compliance program. Virginia Medical 1986; 113:532–4.
52. Harris RP, O'Malley MS, Fletcher SW, Knight BP. Prompting physicians for preventive procedures: a five-year study of manual and computer reminders. Am J Prev Med 1990;6:145–52.
53. Klein RS, Adachi N. Pneumococcal vaccine in the hospital. Improved use and implications for high-risk patients. Arch Intern Med 1983; 143:1878–81.
54. McDonald CJ, Hui SL, Tierney WM. Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. MD Comput 1992;9:304–12.
55. Carande-Kulis VG, Maciosek MV, Briss PA, et al. Methods for systematic reviews of economic evaluations for the Guide to Community Preventive Services. Am J Prev Med 2000;18(suppl 1):75–91.
56. Economic evaluation abstraction form, version 3.0. Available at: www.thecommunityguide.org/methods/econ-abs-form.pdf. Accessed September 9, 2003.
57. Kern DE, Harris WL, Boekeloo BO, Barker LR, Hogeland P. Use of an outpatient medical record audit to achieve educational objectives: changes in residents' performances over six years. J Gen Intern Med 1990;5:218–24.
58. Baker AM, McCarthy B, Gurley VF, Yood MU. Influenza immunization in a managed care organization. J Gen Intern Med 1998;13:469–75.
59. Barton MB, Schoenbaum SC. Improving influenza vaccination performance in an HMO setting: the use of computer-generated reminders and peer comparison feedback. Am J Public Health 1990;80:534–66.
60. Berry BB, Murthy VS. Exceeding the Healthy People 2000 goal for influenza vaccination through a collaborative effort at eight primary care clinics. Wisconsin Med J 1996;95:705–10.
61. Brimberry R. Vaccination of high-risk patients for influenza: a comparison of telephone and mail reminders. J Fam Pract 1988;26:397–400.
62. Carter WB, Beach LR, Inui TS. The flu shot study: using multiattribute utility theory to design a vaccination intervention. Organ Behav Hum Decis Process 1986;38:378–91.
63. Chodroff CH. Cancer screening and immunization quality assurance using a personal computer. QRB Qual Rev Bull 1990;16:279–87.
64. Clancy CM, Gelfman D, Poses RM. A strategy to improve the utilization of pneumococcal vaccine. J Gen Intern Med 1992;7:14–8.
65. Coyne DW, Taylor LF, Yelton S, Long C, Preston SD. Network 12 hepatitis B vaccination quality improvement program: an educational program directed at physicians, staff, and patients. Adv Ren Replace Ther 2000;7(4 suppl 1):S71–5.
66. Crouse BJ, Nichol K, Peterson DC, Grimm MB. Hospital-based strategies for improving influenza vaccination rates. J Fam Pract 1994;38:258–61.
67. Davidson M, Chamblee C, Campbell HG, et al. Pneumococcal vaccination in a remote population of high-risk Alaska Natives. Public Health Rep 1993;108:439–46.
68. Fedson DS. Influenza vaccination of medical residents at the University of Virginia: 1986 to 1994. Infect Control Hosp Epidemiol 1996;17:431–3.
69. Girasek DC. Increasing hospital staff compliance with influenza immunization recommendations. Am J Public Health 1990;80:1272–3.
70. Grob PJ, Ridao M, Wagner S, Pelzer JO. An account of a pilot hepatitis B vaccination programme for high-risk individuals in Zurich. J Infect 1983;7(suppl 1):85–92.
71. Hak E, Hermens RP, Hoes AW, Verheij TJ, Kuyvenhoven MM, van Essen GA. Effectiveness of a coordinated nationwide programme to improve influenza immunisation rates in The Netherlands. Scand J Prim Health Care 2000;18:237–41.
72. Haley N, Roy E, Béanger L, Crago A. A hepatitis B vaccination outreach project for street youth in Montreal. Can J Hum Sex 1998;7:331–8.
73. Harbarth S, Siegrist C, Schira J, Wunderli W, Pittet D. Influenza immunization: improving compliance of healthcare workers. Infect Control Hosp Epidemiol 1998;19:337–42.
74. Hoey JR, McCallum HP, LePage EM. Expanding the nurse's role to improve preventive service in an outpatient clinic. CMAJ 1982;127:27–8.
75. Hogg WE, Bass M, Calonge N, Crouch H, Satenstein G. Randomized controlled study of customized preventive medicine reminder letters in a community practice. Can Fam Physician 1998;44:81–8.
76. Jans MP, Schellevis FG, Van Hensbergen W, Van Eijk JT. Improving general practice care of patients with asthma or chronic obstructive pulmonary disease: evaluation of a quality system. Eff Clin Pract 2000;3:16–24.
77. Klachko DM, Wright DL, Gardner DW. Effect of a microcomputer-based registry on adult immunizations. J Fam Pract 1989;29:169–72.
78. Klein RS, Adachi N. An effective hospital-based pneumococcal immunization program. Arch Intern Med 1986;146:327–9.
79. Kleschen MZ, Holbrook J, Rothbaum AK, Stringer RA, McInerney MJ, Helgerson SD. Improving the pneumococcal immunization rate for patients with diabetes in a managed care population: a simple intervention with a rapid effect. Jt Comm J Qual Improv 2000;26:538–46.
80. Landis S, Scarbrough ML. Using a vaccine manager to enhance in-hospital vaccine administration. J Fam Pract 1995;41:364–9.
81. Manian FA. Improving hepatitis B vaccination rates among surgeons. Infect Control Hosp Epidemiol 1994;15:581.
82. Margolis HS, Handsfield HH, Jacobs RJ, Gangi JE. Evaluation of office-based intervention to improve prevention counseling for patients at risk for sexually acquired hepatitis B virus infection. Am J Obstet Gynecol 2000;182 (1 part 1):1–6.

83. Moran WP, Nelson K, Wofford JL, Velez R, Case LD. Increasing influenza immunization among high-risk patients: education or financial incentive? Am J Med 1996;101:612–20.
84. Nichol KL, Korn JE, Margolis KL, Poland GA, Petzel RA, Lofgren RP. Achieving the national health objective for influenza immunization: success of an institution-wide vaccination program. Am J Med 1990;89:156–60.
85. Nichol KL. Ten-year durability and success of an organized program to increase influenza and pneumococcal vaccination rates among high-risk adults. Am J Med 1998;105:385–92.
86. Ohrt CK, McKinney P. Achieving compliance with influenza immunization of medical house staff and students. JAMA 1992;267:1377–80.
87. Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. Arch Intern Med 1996;156:1551–6.
88. Ratner ER, Fedson DS. Influenza and pneumococcal immunization in medical clinics, 1978–1980. Arch Intern Med 1983;143:2066–9.
89. Rodney WM, Chopivsky P, Quan M. Adult immunization: the medical record design as a facilitator for physician compliance. J Med Educ 1983;58:576–80.
90. Sellors J, Pickard L, Mahony JB, et al. Understanding and enhancing compliance with the second dose of hepatitis B vaccine: a cohort analysis and a randomized controlled trial. CMAJ 1997;157:143–8.
91. Shannon CS. Community hospitals can increase staff influenza vaccination rates. Am J Public Health 1993;83:1174.
92. Slobodkin D, Zielske PG, Kitlas JL, McDermott MF, Miller S, Rydman R. Demonstration of the feasibility of emergency department immunization against influenza and pneumococcus. Ann Intern Med 1998;32:537–43.
93. Spaulding SA, Kugler JP. Influenza immunization: the impact of notifying patients of high-risk status. J Fam Pract 1991;33:495–8.
94. Spruill WJ, Cooper JW, Taylor WJ. Pharmacist-coordinated pneumonia and influenza vaccination program. Am J Hosp Pharm 1982;39:1904–6.
95. Thomas DR, Winsted B, Koontz C. Improving neglected influenza vaccination among healthcare workers in long-term care. J Am Geriatr Soc 1993;41:928–30.
96. Tobacman JK. Increased use of pneumococcal vaccination in a medicine clinic following initiation of a quality assessment monitor. Infect Control Hosp Epidemiol 1992;13:144–6.
97. Turner RC, Waivers LE, O'Brien K. The effect of patient-carried reminder cards on the performance of health maintenance measures. Arch Intern Med 1990;150:645–7.
98. van Essen GA, Kuyvenhoven MM, de Melker RA. Implementing the Dutch College of General Practitioners' guidelines for influenza vaccination: an intervention study. Br J Gen Pract 1997;47:25–9.
99. Williams DM, Daugherty LM, Aycock DG, Lindley CM, Harris MJ. Effectiveness of improved targeting efforts for influenza immunization in anambulatory care setting. Hosp Pharm 1987;22:462–4.
100. Wuorenma J, Nichol K, Vonsternberg T. Implementing a mass influenza vaccination program. Nurs Manage 1994;25:81–2, 84–5, 88.
101. Yassi A, Khokhar JB, Marceniuk M, McGill ML. Hepatitis B vaccination for health care workers: evaluation of acceptance rate and program strategy at a large tertiary care hospital. Can J Infect Control 1993;8:94–7.
102. Nichol KL. Long-term success with the national health objective for influenza vaccination: an institution-wide model. J Gen Intern Med 1992;7:595–600.
103. Scarbrough ML, Landis SE. A pilot study for the development of a hospital-based immunization program. Clin Nurse Spec 1997;11:70–5.
104. Centers for Disease Control and Prevention. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2000;49(RR-03):1–38.
105. Immunization Action Coalition. Model programs for hepatitis A, B, and C prevention for adults and adolescents at risk. Available at: www.hepprograms.org. Accessed April 23, 2004.
106. Task Force on Community Preventive Services. Recommendations to improve targeted vaccination coverage among high-risk adults. Am J Prev Med 2005;28(suppl 3):231–7.

Appendix. Qualifying studies of effectiveness of interventions to increase targeted vaccine coverage

Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented alone (single-component interventions)							
Becker (1989)[48] (1986–1987) Greatest: Individual randomized trial Fair Academic medical clinic	Location: Virginia Components: Provider reminders (single-component arm) Comparison: Usual care	Patients with chronic conditions n = 1050	(1) Influenza vaccination rate (2) Pneumococcal polysaccharide vaccination rate	8.9% 6.9%	I 17.8% I2 8.8%	+8.9 pct points +1.9 pct points	12 months
Chambers (1991)[49] (1987) Greatest: Individual randomized trial Fair Family practice program	Location: Philadelphia, PA Components: Provider reminders (chart prompts) -All patients -One-half of patients Comparison: Usual care	Providers randomized to intervention arms n = 32 Patients of providers n=864 eligible n=686 (79%) evaluated	(1) Influenza vaccination rate during study period	22%	Always reminded 41% Sometimes reminded 38%	+19 pct points $p<0.001$	2 months
Clancy (1988)[42] (1983–1984) Greatest: Group randomized trial Fair University hospital	Location: University of Pennsylvania Components: Client education (2 arms) Info only: information only Info + IDA: information plus individualized decision analysis Comparison: Usual care	All faculty and resident physicians N=1280 Information only: n=264 Information + individualized decision analysis: n=753 Comparison: n=263	(1) Percentage of study providers screened or vaccinated for hepatitis B	13%	Info only 15% Info + IDA 23%	+2 pct points +10 pct points	12 months

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results				
			Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented alone (single-component interventions)							
Davidson (1984)[50] (1979–1981) Moderate: Retrospective cohort; also cross-sectional comparisons Fair Academic outpatient clinics	Location: North Carolina Memorial Hospital Components: Provider reminders (chart reminder slip) Comparison: Usual care	Healthcare providers Patients with chronic illnesses Cross-sectional sample n=150 Historical cohort n=170 n=205	(1) Influenza vaccination rates at study points	Cross-sectional 18%	Cross-sectional 40%	+22 pct points $p <$ 0.001	12 months
Gelfman (1986)[51] (1983–1984) Moderate: Time series Fair Academic medicine clinic	Location: Medical College of Virginia Components: Provider reminders (chart prompt letter) Before and after	Patients with chronic illnesses n=381 over 3 study periods	(1) Influenza vaccination rates (2) Pneumococcal polysaccharide vaccination rates	2.9% 5.5%	75% 67%	+72 pct points $p<0.001$ +61.5 pct points $p<0.001$	7 months
Harris (1990)[52] (1979–1984) Moderate: Retrospective cohort Fair Academic outpatient clinic	Location: North Carolina Memorial Hospital Components: Provider reminders (chart prompts) Post 1: Nurse initiated Post 2: Computer generated Comparison: Before–after (retrospective assessment)	Random sample of female patients >50 years of age visiting clinic ≥2 times in the preceeding 12 months Pre: n=50 Post 1: n=150 Post 2: n=150	(1) Influenza vaccination rates during study period (2) Pneumococcal polysaccharide vaccination rates during study period	12% 11%	Post 1 43% Post 2 59% Post 1 18% Post 2 19%	+31 pct points +47 pct points $p<0.001$ +7 pct points +8 pct points Not significant	5 years

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results				
			Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented alone (single-component interventions)							
Jacobson (1999)[43] (1998) Greatest: Individual randomized trial Fair Medical center outpatient clinics	Location: Atlanta GA; Grady Health System Components: Client education (educational sheet attached to patient's chart and given to patient at triage) Comparison: Usual care (nutrition information sheet)	Patients with chart documented high-risk conditions *n*=1830 total *n*=922 eligible *n*=433 randomized Intervention: *n*=221 Comparison: *n*=212	(1) Patient receipt of pneumococcal vaccination	3.8%	19.9%	+16.1 pct points $p<0.001$ Multivariate analysis RR=5.28 95% CI (2.8–9.93)	2 months
Kern (1990)[57] (1981–1987) Moderate: Time series Fair University teaching hospital	Location: Maryland Components: Provider assessment and feedback (annual feedback to residents based on chart audits) Comparison: Before–after	Resident physicians *n*=139 Patients of resident physicians during the study year with chronic conditions *n*=not reported	(1) Influenza vaccination rate (2) Pneumococcal vaccination rate	24% 25%	56% 43%	+32 pct points +18 pct points	6 years
Klein (1983)[53] (1980–1981) Greatest: Individual randomized trial Fair Academic medical centers	Location: New York City Components: Provider reminders (chart prompts) Comparison: Usual care	Patients at risk for pneumococcal infection identified by admission lists over 2 years Randomly assigned to study arms Year 1 / Year 2 Inter 100 / 100 Comp 100 / 100 Cohort 150 / 150	(1) Pneumococcal polysaccharide vaccination of eligible patients	2.1%	20%	+17.9 pct points $p<0.001$	15 months

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented alone (single-component interventions)							
Larson (1982)[44] (1978–1979) Greatest: Individual randomized trial Fair Academic family medical center	Location: Seattle, WA Components: Client reminders (mailed postcards with a personal message signed by patient's provider) Comparison: Usual care	High-risk patients of the study clinic *n*=395 identified *n*=307 available *n*=283 (92%) at analysis Study arms Personal message: *n*=61 Health belief model: *n*=70 Neutral content: *n*=68 Comparison: *n*=84	(1) Influenza vaccination rate (self-reported) Personal message Health belief model Neutral	1977–1978 pre I 51.1% C 34.0% I 51.6% C 34.0% I 34.5% C 34.0%	1978–1979 post I 41.0% C 20.2% I 51.4% C 20.2% I 25.0% C 34.0%	 +3.7 pct points +13.6 pct points +4.3 pct points	 12 months
McDonald (1992)[54] (1978–1981) Greatest: Individual randomized trial Fair School of medicine clinic	Location: University of Indiana Components: Provider reminders (patient list and identification of eligible preventive clinical actions) Comparison: Usual care	Healthcare providers during 3 study periods 1978–1979: Inter 61, Comp 54 1979–1980: Inter 61, Comp 54 1980–1981: Inter 61, Comp 54	(1) Influenza vaccination rates for patients with chronic conditions (2) Pneumococcal polysaccharide vaccination rates for patients with chronic conditions	Influenza 1978–1979 I 35.3% C 17.4% Pneumococcal polysaccharide 1978–1979 I 49.2% C 15.5%	Influenza 1979–1980: I 30.7%, C 18.9%; 1980–1981: I 42.9%, C 25.5% Pneumococcal polysaccharide 1979–1980: I 60.3%, C 20.8%; 1980–1981: I 64.9%, C 24.8%	Influenza −0.5 pct points Pneumococcal polysaccharide +6.4 pct points	3 years

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Trubatch (1998)[45] (Not reported) Greatest: Individual nonrandomized trial Fair Local health clinics	Location: Anchorage, Alaska Components: client incentive ($10.00) Comparison: Usual care	Recruited patients from ongoing study of injection drug users Intervention: n=75 Comparison: n=144	(1) Proportion of study patients who received the first dose of hepatitis B vaccine	8%	43%	+35 pct points $p<0.001$ Logistic regression analysis OR=8.43 95% CI (3.95–18.0)	Not reported
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Baker (1998)[58] (1995) Greatest: Individual randomized trial Fair Medical group clinic	Location: Michigan Components: Client education (posters, postcard, telephone information service) + Client reminder (postcard; letter) + Expanded access (walk-in clinic) Comparison: Expanded access in healthcare settings + Client education	High-risk patients in medical group n=24,743 Subset: Patients at high risk <65 years n=10,573	(1) Influenza vaccination rate during study period				2 months
			Personalized postcard	C 35.8%	I 38.9%	+3.1 pct points 95% CI (0.91–6.4)	
			Generic postcard	C 35.8%	I 37.5%	+1.7 pct points	
			Tailored letter	C 35.8%	I 38.9%	+3.1 pct points	

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Barton (1990)[59] (1984–1987) Moderate: Retrospective cohort Fair HMO clinics	Location: Massachusetts Components: Client reminders (postcard) + Provider reminders (chart flag) + Provider feedback (in year 3) Comparison: (1) Client reminders (2) Before–after	Random sample of clinic patients *n*=647 High-risk patients <65 years, *n*=198 Analyses conducted on a subset of diabetic patients aged 40–65 years Inter *n*=143 Comp *n*=111	(1) Influenza vaccination rate over the study period (subset: diabetic patients aged 40–65 years)	27.0%	55.9%	+28 pct points 95% CI (16–40)	3 years
			(2) Influenza vaccination rates over the study period (high-risk patients aged <65 years)	38%	55%	+17 pct points	3 years
Becker (1989)[48] (1986–1987) Greatest: Individual randomized trial Fair Academic medical clinic	Location: Virginia Components: (multi-arm) Client reminders + Provider reminders (chart memo) Comparison: Usual care	Patients with chronic conditions *n*=1050	(1) Influenza vaccination rate	C 8.9%	I 25%	+16.1 pct points	12 months
			(2) Pneumococcal polysaccharide vaccination rate	C 6.9%	I 7.7%	+0.8 pct points	
Brimberry (1988)[61] (1984–1985) Greatest: Individual randomized trial Fair Academic family practice	Location: Little Rock, Arkansas Components: Client reminders (mail or telephone) + Expanded access (no appointment needed) Comparison: Usual care	High-risk patients *n*=832 (45 vaccinated) *n*=787 eligible Mail reminder: *n*=267 Telephone: *n*=258 Usual care: *n*=262	(1) Influenza vaccination rate	C 3.8%	I Mail 9.7% I Telephone 9.3%	+5.9 pct points $p<0.02$ +5.5 pct points $p<0.02$	5 months

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Carter (1986)[62] (Not reported) Greatest: Individual randomized trial Fair VA medical center	Location: Seattle, WA Components: Client education (brochures sent by mail) + Client reminders (letters) + Expanded Access (special clinic and 2 week period) Comparison: Client reminders + Expanded access	High-risk patients who were not vaccinated in the year prior to study *n*=284 randomized *n*=235 (83%) at f/u I=114 C=121	(1) Influenza vaccination (self-reported receipt)	23%	36%	+13 pct points $p<0.025$	Not reported
Coyne (2000)[65] (1998–1999) Moderate: Time series Fair Hemodialysis network	Location: Iowa, Missouri, Kansas, Nebraska Components: Client education (posters and brochures) + Provider education (posters and brochures) + Provider feedback (to the center) Comparison: Before–after	Chronic hemodialysis patients Baseline: *n*=5555 (74.5% of patients) Second follow-up: *n*=6602 (77.1% of patients) Subset of units (*n*=138) provided baseline + f/u results	(1) Hepatitis B vaccination rate: subset of units with pre–post measures	72.4%	76.1%	+3.7 pct points NS	19 months

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results				
			Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Fedson (1996)[68] (1986–1994) Moderate: Time series Fair Academic general medicine clinic	Location: University of Virginia Health Sciences Center Components: Standing orders (designated staff) + Expanded access (vaccination carts) + Reduced client out-of-pocket costs (free vaccinations) Comparison: Before–after	Vaccination program for healthcare providers (medical residents) *n*=Not reported	(1)Influenza vaccination coverage among medical residents 1993: No designated staff person 1994: Designated staff	1993 63%	1994 94%	+31 pct points	1 year
Harbarth (1998)[73] (1995–1997) Greatest: Other design with concurrent comparison group Fair Academic employee health clinic (healthcare workers)	Location: Switzerland; Geneva Components: Client education (conferences, newsletter, posters) + Client reminders (mail, letters) + Expanded access (on-site vaccinations) + Reduced out-of-pocket costs (free vaccinations) Comparison (subset): Client education + Client reminders + Rreduced out-of-pocket costs	Vaccination program for healthcare workers in 3 high-risk departments Inter Comp Pre 1076 4356 Post 1092 4422 Comparison: Other departments	(1) Influenza vaccination coverage High-risk departments (intervention) Other departments (comparison) Both groups received some interventions	High risk 13% Other 9%	37% 23%	+10 pct points $p<0.001$	12 months

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results				
			Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Hogg (1998)[75] (1990–1991) Greatest: Group randomized trial Fair Private rural medical center	Location: Canada; Quebec province Components: 2 arms Client education (mailed letter; general preventive information) Client reminders (mailed, patient specific reminder) + Provider reminders (computerized) + Reduced client out-of-pocket costs (free vaccination) Comparison: Provider reminders + Reduced out-of-pocket costs	Randomly selected families n=719 families Client education + provider reminders + reduced out-of-pocket costs: n=252 Client reminders + provider reminders + reduced out-of-pocket costs: n=204 Provider reminders + reduced out-of-pocket costs: n=263	(1) Influenza vaccination of eligible family members	Provider reminders + reduced costs 15%	+Client education 9.1% +Client reminders 17.6%	−5.9 pct points +2.6 pct points	7 months
Jans (2000)[76] (1993, 1994) Greatest: Other design with concurrent comparison Fair General medicine clinics	Location: The Netherlands Components: Provider education (guidelines, meetings) + Provider feedback (personal feedback about patient care provided at educational meetings) Comparison: Usual care	Recruited general medicine practices Inter: n=14 practices Comp: n=5 practices Recruited patients with asthma or COPD Inter: 455 427 (94%) f/u Comp: 152 146 (96%) f/u	(1) Mean percentage of study patients receiving influenza vaccine	50%	61%	+11 pct points p>0.2 NS	12 months

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Klein (1986)[78] (1984) Greatest: Individual nonrandomized trial Fair Academic medical centers	Location: New York City Components: Client education (posters) + Standing orders (designated staff) + Provider education (posters in hospital) + Expanded access (hospital inpatients) Comparison: Client + Provider education (posters) + Expanded access	Hospitalized inpatients on two medical wards during study period Intervention n=136 patients total n=101 (74%) high risk Comparison n=122 patients total n=99 (81%) high risk	(1) Pneumococcal polysaccharide vaccination status at discharge	I 9% C 2%	I 78% C 4%	+67 pct points $p<0.001$	6 months
Landis (1995)[80] (1993) Greatest: Group nonrandomized trial Fair Regional hospital	Location: Asheville NC Components: Standing orders (designated staff) + Reduced client out-of-pocket costs (free vaccination) Comparison: Enhanced usual care (client education)	Hospital inpatients admitted to one of six nursing care units: n=1252 patients Note: Program included universal and targeted vaccinations	(1) Percentage of patients receiving pneumococcal vaccine	4.1%	31.8%	+27.7 pct points $p<0.001$	4 months

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results				
			Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Larson (1982)[44] (1978–1979) Greatest: Individual randomized trial Fair Academic family medical center	Location: Seattle WA Components: Multicomponent arm (based on content) Client education + Client reminders (mailed postcards with content based on health belief model) Comparison: Usual care	High risk patients of study clinic *n*=395 identified *n*=307 available *n*=283 (92%) at analysis Three intevention arms Health belief model: *n*=70 Personal message: *n*=61 Neutral content: *n*=68 Control: *n*=84	(1) Influenza vaccination rate (self-reported) Health belief model	1977–1978 pre I 51.6% C 34.0%	1978–1979 post I 51.4% C 20.2%	+13.6 pct points $p<0.001$ Note: Minimal change in intervention arm, but significant decrease in comparison arm	12 months
Moran (1996)[83] (1991–1992) Greatest: Individual randomized trial Good Community health center	Location: Massachusetts Components: Client education (brochure) + Client reminders (mail) + Client incentive (lottery contest) + Expanded access (walk-in clinic) + Reduced out-of-pocket costs (free vaccine) Comparison: Expanded access + Reduced out-of-pocket costs	High-risk patients of urban community health center *n*=816 identified *n*=797 (97%) random Brochure *n*=198 Incentive *n*=198 Brochure + Incentive: *n*=198 Usual care (access + reduced costs): *n*=202 Note: Results for subset of patients aged <65 years reported here	(1) Influenza vaccination rate Client reminders + client education + access + reduced costs Client reminders + client incentive + access + reduced costs Client reminders + client education + client incentive + access + reduced costs	C 9% C 9% C 9%	I 23% I 26% I 26%	+14 pct points +14 pct points +17 pct points	6 months

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results				
			Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Nichol (1990)[84] (1987) Greatest: Group nonrandomized trial Fair VA medical center	Location: Minneapolis MN Components: Client education (mailed letter) + Client reminders (clinic appt notice) + Provider reminders (stamp) + Standing orders (nurses) + Expanded access (walk-in clinic; lobby) Comparison: Client education + Expanded access	Randomly selected outpatients Intervention VA: n=500 n=267 (70.6%) patients responded + high-risk indications Comparison VA: n=1500 n=697 (69.9%) patients responded + high-risk indications	(1) Influenza vaccination (patient self-reported receipt)	29.9%	58.3%	+28.4 pct points $p<0.000001$	2 months
Nichol (1998)[85] (1987–1997) Moderate: Time series Fair VA medical center	Location: Minneapolis MN Components: Client education (annual mailed info.) + Standing orders (nurse) + Expanded access (walk-in clinics) Note: Previous paper (Nichol, 1990) also described client and provider reminders Comparison: Before–after	VA patients (inpatient program was added to outpatient program over study period) Annual patient surveys n=500/year Response rates 77% to 81% Note: Results from high-risk subset + age <65 years reported here	(1) Percentage of patients self-reporting receipt of influenza vaccination	1987–1988 52.2%	1996–1997 69.4%	+17.2 pct points	10 years
			(2) Percentage of patients self-reporting receipt of pneumococcal vaccination	1994–1995 19.5%	1996–1997 51.6%	+32.1 pct points	3 years

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Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Overhage (1996)[87] (1992–1993) Greatest: Individual randomized trial Fair Academic medical center	Location: Indianapolis, Indiana University Components: Provider reminders (computer notification; daily reports) + Expanded access (inpatient vaccinations) Comparison: Usual care	Providers of hospitalized patients n=78 physicians on 24 teams (12 I, 12 C)	(1) Percentage of hospitalized patients receiving pneumococcal vaccination	2.6%	2.1%	−0.5 pct points p=0.69	6 months
Sellors (1997)[90] (1992–1993) Greatest: Individual randomized trial Fair STD clinic	Location: Canada; Hamilton, Ontario Components: Client reminders (telephone) + Reduced client out-of-pocket costs (free in Canadian healthcare system) Comparison: Client reminders (appointment letters at 3 months sent by mail) + Reduced client out-of-pocket costs	Consecutive, self-referred patients of study STD clinic n=385 n=256 (66.5%) HBsAG negative at baseline Random assignment of patients who failed to present for second dose Inter: n=67 Comp: n=69	(1) Proportion of initially noncompliant patients who received second dose of hepatitis B vaccine	25%	48%	+23 pct points p=0.008	10 months

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Appendix *(continued)*

Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
Spaulding (1991)[93] (1983–1984) Greatest: Individual randomized trial Fair Army medical center	Location: Washington State Components: Client reminders (postcard) + Enhanced access (walk-in clinic) + Reduced client out-of-pocket costs (free) Comparison: Enhanced access + Reduced client out-of-pocket costs	Patients identified as high-risk n=1068 Intervention: n=519 Comparison: n=549	(1) Percentage of patients receiving influenza vaccination during study period	9.1%	25.2%	+16.1 pct points $p<0.001$	6 months
Thomas (1993)[95] (1990–1992) Moderate: Time series Fair Life-care community	Location: Winston-Salem NC Components: Client education (reviewed CDC guidelines with staff) + Expanded access (vaccination fair) + Reduced client out-of-pocket costs (free) Comparison: Before-after	Healthcare workers in study facility n=195	(1) Percentage of healthcare workers receiving influenza vaccination	1990 8%	1992 54%	+46 pct points	2 years
Turner (1990)[97] (1987–1988) Greatest: Group randomized trial Fair Academic medical center	Location: Greenville NC Components: Client reminders (preventive services card) + Provider reminders (chart prompts) Comparison: Provider reminders (chart prompt)	Resident physicians Intervention: n=12 Comparison: n=12 Patients of study providers n=423 enrolled Inter: n=177 Comp: n=246	(1) Provider delivered influenza vaccination as prompted (2) Provider delivered pneumococcal vaccination as prompted	29% 24%	47% 22%	+18 pct points $p < 0.002$ −2 pct points p=0.34	9 months

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Appendix *(continued)*

Author (year)[ref] (Study period) Design suitability: design Quality of execution Evaluation setting	Intervention and comparison elements	Study population description Sample size	Results: Effect measure	Reported baseline	Reported effect	Value used in summary	Follow-up time
Studies evaluating interventions to increase targeted vaccine coverage when implemented in combination (multicomponent interventions)							
van Essen (1997)[98] (1992–1993) Greatest: Other design with a concurrent comparison group Fair GPs in community	Location: The Netherlands: Amersfoot and Arnhem Components: Client education (guideline dissemination) + Provider education (guideline meetings of GPs) + Provider feedback (data on vaccine prescriptions filled) Comparison: Usual care	GPs in study communities Intervention: Amersfoot n=82 practices/118 GPs Comparison: Arnhem n=97 practices/124 GPs	(1) Estimates of patient influenza vaccination rate calculated from influenza vaccine prescriptions and patient population	1992 I 7.7% C 8.5%	1993 I 9.3% C 9.0%	Mean number of influenza vaccines per 100 insured patients +1.1 95% CI (0.6–1.6) (+1.1 pct points)	12 months
Yassi (1993)[101] (1988 and 1990) Greatest: Other design with a concurrent comparison group Fair Academic medical center	Location: Canada; Winnipeg, Manitoba Components: Client education (posters, handouts, video) + Client reminders (letters for follow-up doses) + Expand access (on-site clinics) + Reduced client out-of-pocket costs (free to healthcare workers in high-risk areas) Comparison: Usual care	Healthcare workers employed in areas designated as high risk 1988: n=1203 1990: n=1107	(1) Hepatitis B vaccination rate	1988 I 41.1% C 42.4%	1990 I 54.7% C 36.4%	+19.6 pct points	12 months

C or Comp, comparison group; CDC, Centers for Disease Control and Prevention; CI, confidence interval; COPD, chronic obstructive pulmonary disease; f/u, follow-up; GP, general practitioner; I or Inter, intervention group; NS, not significant; OR, odds ratio; pct points, percentage points (absolute difference); RR, relative risk; STD, sexually transmitted disease; VA, Veterans Affairs medical center.