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Increasing Coverage of Appropriate Vaccinations:

A Community Guide Systematic Economic Review

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Abstract

Context—Population-level coverage for immunization against many vaccine-preventable diseases remains below optimal rates in the U.S. The Community Preventive Services Task Force recently recommended several interventions to increase vaccination coverage based on systematic reviews of the evaluation literature. The present study provides the economic results from those reviews.

Evidence acquisition—A systematic review was conducted (search period, January 1980 through February 2012) to identify economic evaluations of 12 interventions recommended by the Task Force. Evidence was drawn from included studies; estimates were constructed for the population reach of each strategy, cost of implementation, and cost per additional vaccinated person because of the intervention. Analyses were conducted in 2014.

Evidence synthesis—Reminder systems, whether for clients or providers, were among the lowest-cost strategies to implement and the most cost effective in terms of additional people vaccinated. Strategies involving home visits and combination strategies in community settings were both costly and less cost effective. Strategies based in settings such as schools and managed care organizations that reached the target population achieved additional vaccinations in the middle range of cost effectiveness.

Conclusions—The interventions recommended by the Task Force differed in reach, cost, and cost effectiveness. This systematic review presents the economic information for 12 effective strategies to increase vaccination coverage that can guide implementers in their choice of interventions to fit their local needs, available resources, and budget.

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Context

Vaccines are effective against a range of diseases and have a proven record of averting serious illness and death.^{1,2} Based on proven effectiveness, the Advisory Committee on Immunization Practices has made recommendations for routine and targeted vaccinations since 1964, with current recommendations covering 17 vaccine-preventable diseases.³ The importance of vaccinations is further emphasized in recent economic research that indicates substantial societal savings from childhood⁴ and adult⁵ immunization programs. Despite evidence of effectiveness and economic benefits, vaccination coverage (percentage of target population vaccinated) remains below optimum, and *Healthy People 2020*⁶ makes several recommendations for clinical and community-level interventions to increase coverage.

The present systematic economic review estimated the reach, cost to implement, and the cost effectiveness of 12 interventions found to be effective in increasing population-level coverage of appropriate vaccinations. The review was performed under the guidance of the Community Preventive Services Task Force (Task Force), an independent, nonfederal, unpaid panel of public health and prevention experts that provides evidence-based findings and recommendations about community preventive services, programs, and policies to improve health.

The first set of Task Force recommendations on vaccination intervention strategies was based on a Community Guide review published in 2000 (the 2000 review), covering evidence from papers appearing from 1980 through 1997.⁷ The present review updates the economic evidence from that review with studies published from January 1998 through May 2012. An economic review of immunization information systems, published separately,⁸ is not included in the present review.

Evidence Acquisition

Methods developed for conducting Community Guide systematic economic reviews can be found at www.thecommunityguide.org/about/economics.html. A coordination team (team), comprising vaccination program subject matter experts from various organizations and systematic review experts and health economists from the Community Guide Branch at CDC, conducted the review with oversight from the Task Force. The team developed analytic frameworks, systematically searched for and identified relevant studies, and abstracted information from included studies. Analyses were performed in 2014.

Conceptual Approach

The 12 interventions recommended by the Task Force to increase vaccination coverage were conceptualized in three broad categories for both the effectiveness and economics reviews.

Interventions that enhance access to vaccination services are designed to reduce financial barriers (e.g., by reducing out-of-pocket costs) or reduce the inconvenience of obtaining vaccinations by bringing the services to clients in their homes and other non-medical settings. The four interventions in this category were:

- Home Visits to Increase Vaccination Rates

- Reducing Client Out-of-Pocket Costs for Vaccinations
- Vaccination Programs in Schools and Organized Child Care Centers
- Vaccination Programs in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) Settings

Interventions that increase demand for vaccinations are designed to increase the number of people who actively seek vaccination by educating them and making them aware of their vaccination and risk status, by providing financial or material incentives, or by enacting laws. The four interventions in this category were:

- Client Reminder and Recall Systems
- Client or Family Incentive Rewards
- Vaccination Requirements for Child Care, School, and College Attendance
- Community-Based Interventions Implemented in Combination

Provider- or health system-based interventions target providers with reminders, feedback assessments, education, and other mechanisms designed to reduce missed opportunities to vaccinate receptive patients during periodic visits. The interventions in this category were:

- Provider Reminders
- Provider Assessment and Feedback
- Standing Orders
- Healthcare System-based Interventions Implemented in Combination

Detailed intervention definitions are provided in Appendix Table 1 (available online).

Inclusion Criteria

Studies were included if they:

- met the definition of one or more of the 12 interventions;
- were published in English;
- were conducted in a high-income country⁹; and
- estimated or modeled intervention cost or cost per additional person vaccinated (APV).

The economic concepts related to intervention outcomes in this review are described below, along with how the concepts are measured and constructed from variables usually reported in studies. The three primary outcomes of interest are reach, cost, and cost effectiveness.

Reach of intervention—The intervention’s reach is defined as the number of people in the target population, or, in the case of trials, in the group that received the intervention:

$$\text{Reach} = N,$$

where

N=number of people in target population or intervention group

Cost of intervention—The implementation and operation of vaccination programs use staff time, equipment, supplies, materials, facilities, utilities, and other resources. The cost of intervention is the cost of resources used to implement and operate it:

Intervention cost = (quantity of materials×unit cost of materials) + (quantity of labor×unit cost of labor)

Effectiveness of intervention—The primary effectiveness of the intervention is the number of additional people vaccinated because of the intervention. It is the incremental percentage increase in coverage owing to the intervention multiplied by the target population:

$$APV = N \times \text{incremental percentage coverage (owing to intervention),}$$

where

APV=additional people vaccinated; and

N=Number of people in target population

Cost effectiveness—The primary effect of the intervention is the number of APV. Cost effectiveness is defined as the economic cost incurred by the intervention to achieve a unit increase in a health outcome. The cost effectiveness of each intervention is the intervention cost per APV:

$$\text{Cost effectiveness} = \text{intervention cost}/APV$$

This review focuses on the economics of strategies to increase coverage of Advisory Committee on Immunization Practices–recommended vaccines. The cost of vaccines is excluded except for the specific intervention to improve coverage through reduced patient out-of-pocket costs. This approach is taken to ensure that intervention costs are not unduly affected by differences in vaccine prices. For example, when comparing the resource use of

identical strategies to increase coverage of the human papillomavirus and the measles, mumps, and rubella vaccines, inclusion of the relevant vaccine prices will incorrectly indicate different resource use for implementing the same intervention strategies. However, it is to be noted that the uptake for different vaccines may still vary due to vaccine-specific attributes that are non-economic.¹⁰

Considerable variability is expected in estimates from reviews of public health interventions. Hence, an important objective of Community Guide economic review methods is to try to explain, or at least identify, sources of variability. Estimates are converted to per person per year (PPPY) terms to account for intervention scale and duration. Monetary values are converted to a common base year in U.S. dollars to account for inflation and denomination in foreign currencies. All monetary values in the present review are in 2013 U.S. dollars. The medians and interquartile intervals are presented, where there are more than three estimates, so that the focus is on typical results rather than outliers when unexplained variation remains.

All analysis was performed in Microsoft Excel 2013.

Review Approach

The Task Force considered the evidence for each intervention and issued individual statements of finding for them, with no formal assessment of comparative effectiveness or cost effectiveness across strategies. The approach of the present review is to describe the results from the intervention by intervention analysis of economic data and from analysis of the data pooled together from all interventions to determine how reach, cost, and cost effectiveness varied across type of intervention and type of vaccine, as well as setting and baseline rate of coverage.

Types of interventions—The three primary outcomes of reach, cost, and cost effectiveness are postulated to vary by type of intervention. In creating the categorical variable for type of intervention, strategies are combined where they: were implemented in similar settings, targeted change in the same care behavior for providers, and targeted change in client behavior through financial or material incentives. Hence, strategies based in schools and child care settings are combined, as were provider reminders and provider assessments and feedback, as well as client and family incentives and reduced out-of-pocket costs.

Settings—Reach, cost, and cost effectiveness are expected to vary based on the setting in which the intervention takes place, with setting defined as the organization or social unit where the resources were expended. Studies that evaluated interventions related to vaccination requirements for school and college attendance and reduced out-of-pocket cost had ill-defined settings, and were excluded from the setting-based analysis.

Vaccine—Cost effectiveness drawn from different studies is postulated to vary by the types of vaccine(s) promoted in the interventions. These may be multiple vaccines in a series, multiple doses of a single vaccine, or a single dose of one or more vaccines, and the resource used is expected to be greater for multiple vaccines such as the childhood series than for

single dose vaccines such as that for influenza. Further, patients may be more receptive to interventions promoting certain vaccines than others, and this difference would be reflected in cost per APV.

Baseline coverage—Baseline rates of vaccination coverage are postulated to explain observed cost effectiveness, the expectation being that it would require fewer resources to achieve a percentage increment in coverage starting from rates that are low rather than from rates close to 100%. Categories of baseline rates from low to high were constructed from quartiles of estimates reported in the studies, with rates in the first quartile classified as low, those in the second and third quartiles classified as medium, and those in the fourth quartile classified as high.

Search Strategy and Yield

Twenty-four economic studies from the 2000 review (search period, January 1980 to December 1997) were included. Newer evaluation studies of the 12 intervention strategies were identified through a search of the literature published from January 1997 through February 2012. Detailed search strategy and criteria are shown in Appendix Table 2. More than 49,000 candidate studies were identified from the update search, of which 61 economic papers met the inclusion criteria (Figure 1). Hence, this review includes 84 studies: 60 studies^{11,71} (two^{61,62} papers were counted as one study) from the recent search and 24 studies^{72,95} from the 2000 review.⁷

Evidence Synthesis

Results for 12 Intervention Strategies Considered by the Task Force

The results from the economic reviews of the 12 recommended intervention strategies are summarized in Appendix Table 3, Appendix Chart 1, and Table 1. Appendix Table 3 shows the number of studies contributing to the economic evidence for each strategy, the period of study publication, the vaccines involved, and the geographic distribution across countries. Table 1 shows the reach of each intervention strategy, the cost to implement the strategy, and the cost to vaccinate an additional person using the strategy. Most studies were U.S.-based. The number of studies that reported both economic outcomes and effectiveness outcomes were almost threefold greater in the 1998–2012 period compared with 1980–1997, signaling the growing importance of the economic perspective in public health. Interventions to increase coverage of early childhood vaccines were researched most often, followed by influenza, hepatitis B, and pneumococcal vaccines. Many of the hepatitis B studies were catch-up vaccinations for adolescents and adults, especially among at-risk and new immigrant populations. Vaccines administered during adolescent years, such as human papillomavirus and meningococcal conjugate vaccine, were the least studied from the economic perspective. Client reminders and standing orders were among the least resource-intensive strategies to implement and home visits and client and family incentives were among the most resource intensive. Strategies involving population-wide vaccination policies and laws and those brought to non-medical settings frequented by a target population had among the greatest reach. Client reminders, standing orders, and those based in school settings were among the most cost-effective strategies.

Reach, Cost, and Cost Effectiveness by Intervention Strategies

Table 2 and Appendix Chart 2 present summary statistics for reach, cost per person, and cost per APV in nine types of intervention strategies. Requiring vaccinations for school attendance did not have adequate cost and cost-effectiveness data to be included in the analysis.

Interventions with the greatest reach, measured as the size of the intervention group, were those implemented in health systems such as health plans, hospitals, and health centers and within non-medical organizations such as schools. Cost PPPY was highest for client incentives and reducing client out-of-pocket costs, followed by home visits and combined community-based interventions. Reminder systems, whether for providers or patients, were least expensive to implement. Interventions that target populations in particular settings (e.g., schools, WIC) fell in the middle of the cost PPPY distribution. Combined interventions in community settings require more economic resources to implement than those in health systems; in the former, activities occur in dispersed community populations, whereas the target populations for the latter are well identified in patient panels or at the point of care.

The cost per APV followed roughly the same distribution as cost PPPY. They were among the highest for combinations that included home visits and manual tracking and outreach, for home visits alone, and for client incentives and interventions that reduce out-of-pocket cost, and lowest for those implementing client reminder systems and for combined interventions in health systems. Provider reminder and provider assessment and feedback systems are an exception, ranking second in terms of fewest resources to implement but fourth in highest cost per vaccinated person. A partial explanation may be the multiple events necessary to reach a successful vaccination, from provider reminder, to provider advice to client, to client assent.

Reach, Cost, and Cost Effectiveness by Type of Setting

Table 3 and Appendix Chart 3 provide a summary, by type of setting, of the reach, cost per person, and cost per vaccinated person. Some results here are repeated from the analyses based on type of intervention strategy because those strategies were designed and defined in terms of specific settings, such as in schools and in WIC offices. Combined interventions implemented in multiple settings appear here in the category of community. The settings of interventions in the included studies were clinic, community, home, hospital, MCO, pharmacy, school, and WIC.

The greatest reach was achieved primarily in healthcare systems such as MCOs, where implementers were able to access clients through membership databases, and in hospital settings, where implementers targeted admitted patients. Large segments of target populations were also reached by bringing vaccines and their administration to clients in non-healthcare settings such as schools and WIC offices. Cost to implement was highest among interventions in homes, communities, and WIC settings and lowest in MCOs and general practice clinics. The rank order of cost to vaccinate an additional person mirrored the order observed for cost to implement.

Appendix Table 4 provides median or mean cost per vaccinated person cross-tabulated by type of vaccine and setting. The most prevalent types of vaccines evaluated in immunization programs that were also implemented in multiple settings were various childhood series, influenza, and hepatitis B. These are in the first three rows of the table. For the childhood series, the most cost effective were interventions implemented by MCOs, the least were those based in community settings, with those based in homes in the middle range. The cost per person vaccinated in influenza vaccination programs was lowest for MCOs, followed by clinics and schools. Vaccination programs for hepatitis B that targeted children in their school setting achieved additional vaccinations at much lower cost than those based in the community setting, where many were tailored to high-risk injection drug users.

As seen in the cost per vaccinated person based on settings, intervention strategies in the community setting had the highest cost per vaccinated person and those in MCOs had the lowest, regardless of the vaccine. Two factors that contributed to the small magnitude for MCOs were the large numbers of patients targeted and the interventions in operation, namely, client reminders by mail or phone that are less costly to implement. On the other hand, the studies included in the community settings category were combined interventions that include strategies such as home visits, client or provider education, mass media, and client or provider incentives that are more resource intensive to implement.

The remaining values presented in Appendix Table 4 for other vaccines are either based on small numbers of estimates or are isolated to a few specific settings.

Cost Effectiveness by Baseline Rate of Coverage

The median baseline rate was 44% (interquartile interval=15%, 64%) for those studies also reporting cost per APV. The median cost per APV was \$22 for interventions occurring in populations with low baseline rates of coverage (< 15%), \$59 for those with medium coverage rates (15%–64%), and \$204 for those with high baseline coverage (>65%). The data indicate the cost to vaccinate an additional person increases with baseline coverage rates.

Discussion

A limitation of the present review is the search period that ended in February 2012, which missed more-recent research in the field. An informal search indicates there is a growing body of research focused on uptake of adolescent and early adult vaccines such as human papillomavirus and meningococcal conjugate vaccine as well as research on strategies that leverage the technologies of social media and electronic health records.

Because few studies evaluated the economics of strategies among rural populations, more research is needed to identify cost-effective strategies for rural areas. Most economic studies were among children, with few focusing on adolescents. The 2000 review had none, and in the present review only six studies focused on adolescents, primarily “catch-up” hepatitis B vaccinations for middle school children.

Although reporting of costs and cost components has improved since the 2000 review,⁷ many studies still ascribe no economic value to volunteer work or in-kind contributions, preventing accurate estimates of societal costs. Among studies in this review, volunteers were common in community mobilization and community initiatives, and staff from schools or public health departments were used in school-based vaccination programs, sometimes to the detriment of their usual duties.¹⁷

Given the relatively high cost observed for strategies using client incentives and rewards, further research may determine the optimal type, magnitude, and timing of incentives. Evidence indicates generosity is neither necessary nor sufficient for a successful program. Small cash gifts can motivate homeless people to return for multiple doses of hepatitis B vaccinations.^{26,57} A program that generously distributes infant care products can fail to produce more vaccinations.⁴⁴ Research on finer details is needed to optimally match the incentive to the target population and to design the process such that incentive receipt is more closely contingent on vaccination receipt.

Finally, no intervention strategy considered in this review can be effective without adequate vaccine supply and adequate reimbursement for the providers' time to vaccinate. Although this review of evaluation studies proceeded under the assumption that all vaccines were readily available, the broader vaccine literature raises concerns about adequate financing to purchase and administer recommended vaccines,^{96,97} particularly the vaccine administration cost of Medicaid-eligible patients in private clinics.^{98,99} Issues related to financing vaccine purchases and administration will need to be addressed for success of interventions recommended by the Task Force to increase population-level coverage in real-world implementations.

Conclusions

This review provided estimates of reach, cost, and cost effectiveness for each of 12 interventions recommended by the Community Preventive Services Task Force to increase vaccination coverage. Strategies such as reminder systems targeted to clients and providers showed lower cost to implement and also lower cost per APV. On the other hand, strategies based on home visits and combination strategies in community settings cost more to implement and also to vaccinate an additional person. Strategies designed to reach large segments of a target population, such as those based in schools and WIC settings, cost relatively more to implement but were able to vaccinate large numbers at a cost in the middle range of cost effectiveness. Schools and WIC settings may also be convenient to reach children who might otherwise be unvaccinated, under-immunized, or underserved.

This review does not emphasize the ranking of strategies based on cost or cost effectiveness, as is commonly done in league tables, because a particular strategy may be preferred based on other considerations for a specific population and vaccine. The results from this review are presented as an economic assessment of a portfolio of strategies shown to be effective in increasing vaccination coverage, with local decision makers expected to choose interventions that fit their local needs, available resources, and budget. The estimates provided by this review for cost per capita to implement the different interventions and

estimates of the likely cost to vaccinate an additional person using those interventions are useful information in that decision-making process.

Acknowledgments

VJ and SC contributed to the study design, literature search, data extraction, data analysis, drafts, and revisions of the manuscript. DH contributed to the study design, critically supervised the methodologies of the project, and reviewed drafts of the manuscript. JM and AP participated in the study design, initial screening process, drafts, and review of drafts of the manuscript. JC and the Community Preventive Services Task Force directed conceptualization of the review and selection of interventions included in the review, exercised overall oversight of the work, and drew conclusions from the reviewed body of evidence.

The authors are thankful for the contribution and expertise of the review coordination team. The authors would like to thank the following Community Guide staff for their assistance: Anil Thota and Randy Elder for CDC internal review, Kate W. Harris and Kristen Folsom for editorial assistance, and Onnalee Gomez for library services. We acknowledge review or comments from experts at CDC’s National Center for Immunization and Respiratory Diseases—Mark Messonnier, Fang Jun Zhou, and Megan Lindley—and from Alan Hinman at The Task Force for Global Health in Atlanta, Georgia.

Appendix

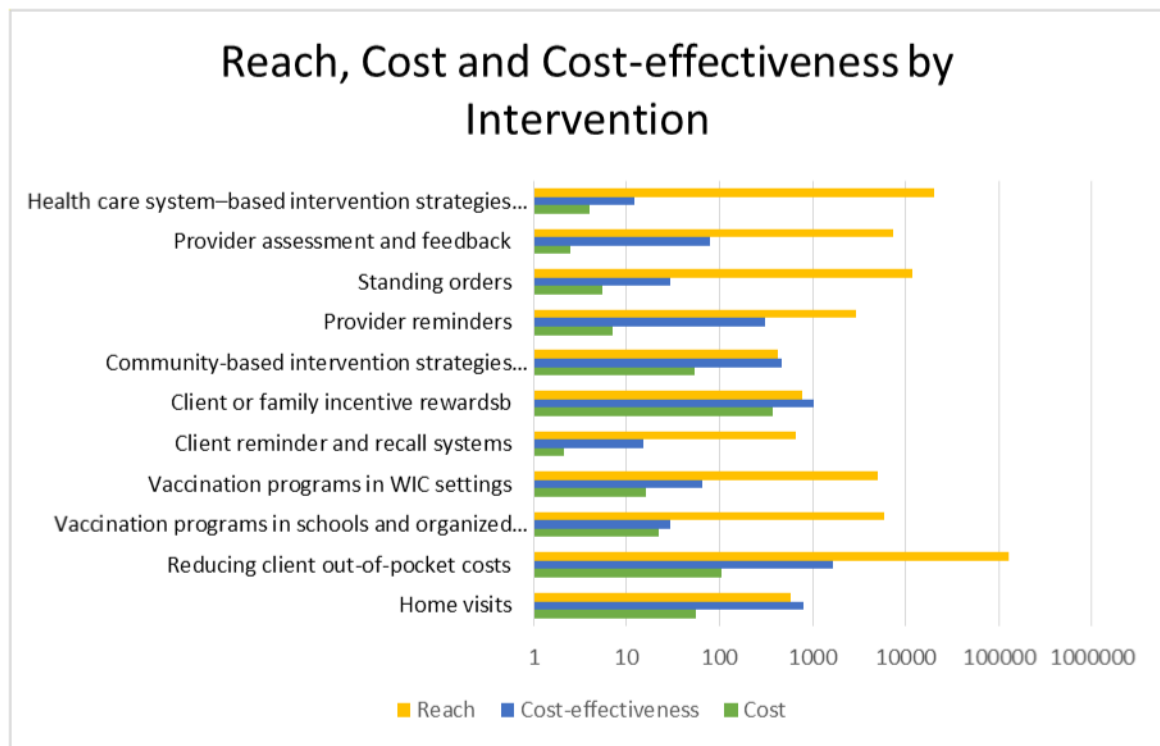


Chart 1.

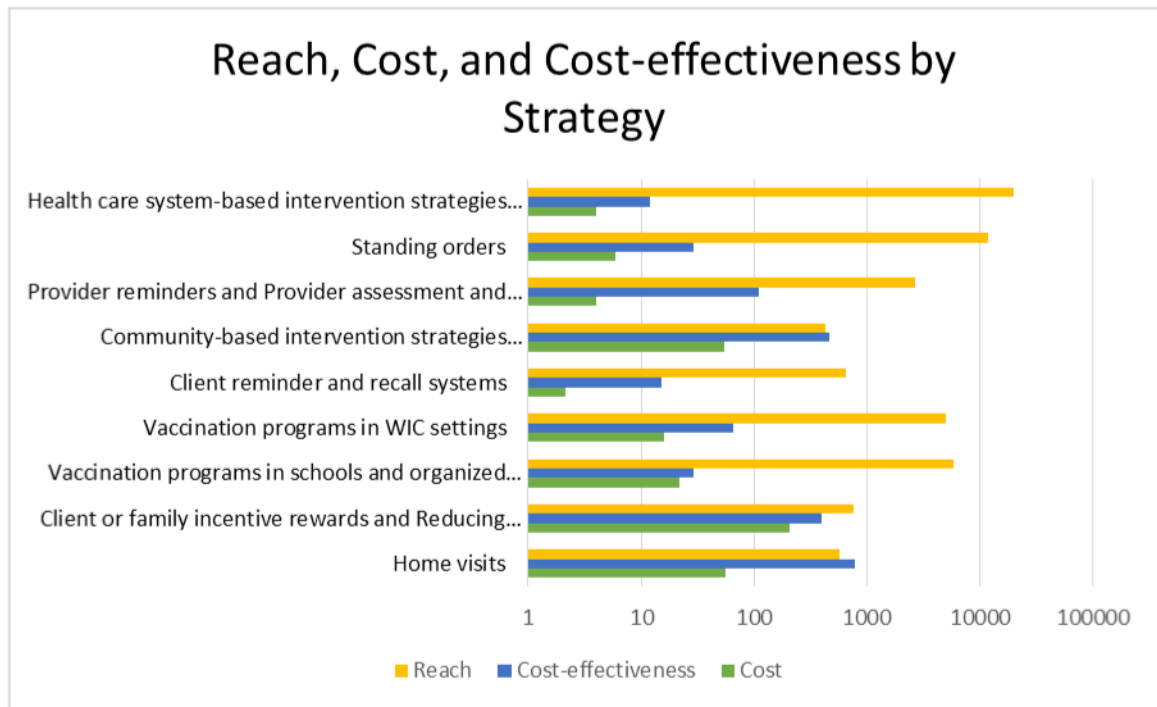


Chart 2.

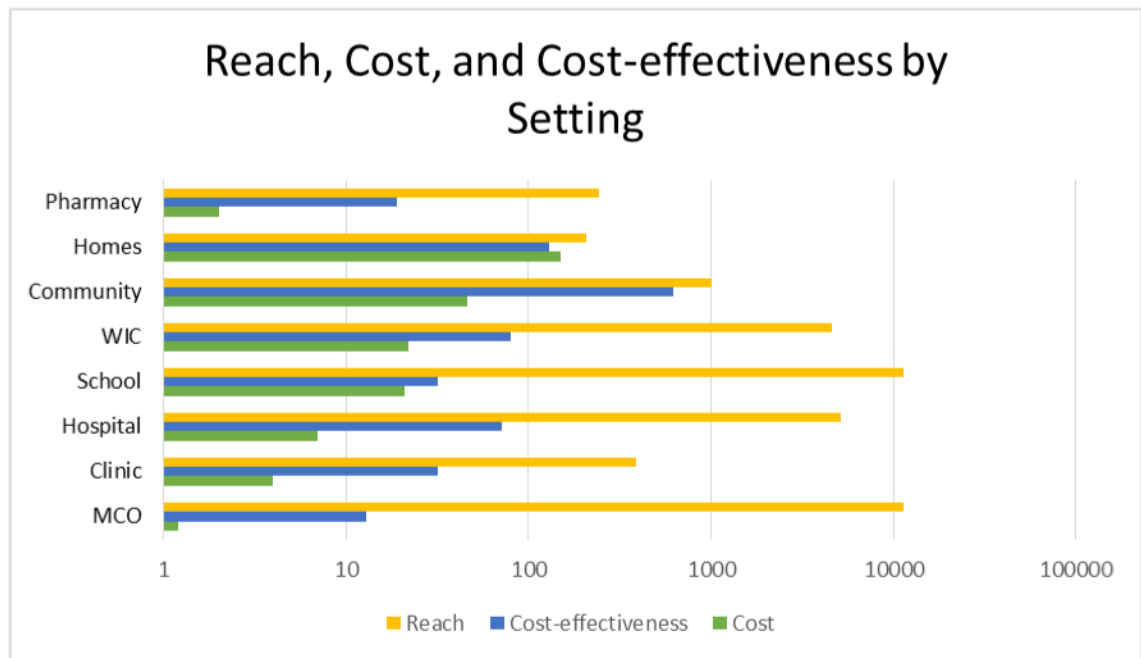


Chart 3.

Appendix Table 1

Definitions of Interventions to Increase Population Coverage of Appropriate Vaccinations Recommended by the Community Preventive Services Task Force

Intervention	Definition–Description
Enhancing access to vaccination services	
Home visits to increase vaccination rates	Home visits intended to increase vaccination rates provide vaccinations to clients in their homes or promote recommended vaccinations with referral to available immunization services. Home visits may be conducted either by vaccination providers, such as nurses, or by other providers, such as social workers. Visits generally include an assessment of client vaccination status and a brief discussion of the importance of the indicated immunizations. The intervention may be directed to all clients in a designated population, such as low-income single mothers, or only to those clients who have been unresponsive to previous intervention efforts, such as client reminder and recall systems. Home visits may be the primary or sole intervention or one component of a larger healthcare system or community-based program to increase vaccination rates.
Reducing client out-of-pocket costs for vaccinations	Reducing out-of-pocket costs to families for vaccinations or administration of vaccinations can be implemented by paying for vaccinations or administration, providing insurance coverage, or reducing copayments for vaccinations at the point-of-service.
Vaccination programs in schools and organized child care centers	Vaccination programs in schools or organized child care centers are multicomponent interventions delivered on-site to improve immunization rates in children and adolescents. These programs include two or more of the following components: (1) immunization education and promotion, (2) assessment and tracking of vaccination status, (3) referral of under-immunized school or child care center attendees to vaccination providers, and (4) provision of vaccinations. Additional components such as reduced client out-of-pocket costs, client incentives, and enhanced access to vaccination services may be provided. Organized child care centers include non-home day care, nursery or pre-school, and federal Head Start settings for children aged 5 years and younger. In most states, laws establishing vaccination requirements for school and child care center attendance require assessment, documentation, and tracking specific to each vaccine. Vaccination programs considered in this review either expanded the assessment and tracking process to other immunizations or conducted additional interventions. Vaccination programs are often collaborations between the school or child care center and local health departments, private healthcare providers, or community healthcare services.
Vaccination programs in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) settings	Coordinated vaccination interventions in Special Supplemental Nutrition Program for Women, Infants and Children (WIC) aim to assess the immunization status of participating infants and children and help them get recommended vaccinations. At a minimum, these interventions assess each child's immunization status and refer them to vaccination providers as appropriate. Additional intervention components may include client reminder and recall systems, manual tracking and outreach efforts, or client incentives to obtain recommended vaccinations (e.g., monthly voucher pickup schedules that require more frequent WIC visits when vaccinations are not up-to-date). In addition, access may be enhanced by providing vaccinations in WIC settings, or coordinating WIC programs with or near healthcare services.
Increasing community demand for vaccinations	
Client reminder and recall systems	Client reminder and recall interventions are used to remind members of a target population that vaccinations are due (reminders) or late (recall). Reminders and recalls differ in content and are delivered by various methods—telephone, letter, postcard, text messages, or other. Most reminder and recall systems involve a specific client, and may be accompanied by educational messages regarding the importance of immunization for the targeted vaccine.
Client or family incentive rewards	Client or family incentive rewards are used to motivate people to obtain recommended vaccinations. Rewards may be monetary or non-monetary, and they may be given to clients or families in exchange for keeping an appointment, receiving a vaccination, returning for a vaccination series, or producing documentation of vaccination status. Rewards are typically small (e.g., food vouchers, gift cards, lottery prizes, baby products). Incentive reward programs are distinct from interventions that increase access to vaccination services (e.g., the provision of transportation or child care, the administration of vaccinations at no or reduced cost to clients).
Vaccination requirements for child care, school, and college attendance	Vaccination requirements are laws or policies requiring vaccinations or other documentation of immunity as a condition of child care, school, and college attendance. Their purpose is to reduce the incidence of vaccine-preventable disease and associated morbidity and mortality by increasing vaccination rates. Laws are created by states, with the specific vaccines required established by the legislature and embodied in statutes or

Intervention	Definition–Description
	adopted as administrative rules by health or education departments. Institutions, such as colleges and private schools, may establish additional vaccination policies for attendance or residence. Vaccination requirements vary across jurisdictions by comprehensiveness, acceptable documentation of immunity, access to exemptions (especially nonmedical exemptions), and the type and consistency of enforcement.
Community-based interventions implemented in combination	Community-based interventions implemented in combination are a set of activities coordinated in a community to increase vaccination rates within a targeted population. Activities focus on increasing community demand for vaccinations and enhancing access to vaccination services. Efforts may also include interventions directed at vaccination providers. Programs are typically coordinated by a set of partnerships between community organizations, local government, and vaccination providers. Coordinated interventions may include client reminder and recall systems, the use of staff to conduct manual outreach and tracking of clients, mass and small media, educational activities, and expanded access to vaccination services.
Provider- or system-based interventions	
Provider reminders	Provider reminder interventions inform those who administer vaccinations that individual clients are due for specific vaccinations. Techniques by which reminders are delivered vary, but can include notes prepared in advance and posted in client charts, alerts in electronic medical records, and letters sent by mail or email.
Standing orders	Standing orders authorize nurses, pharmacists, and other healthcare personnel where allowed by state law, to assess a client's immunization status and administer vaccinations according to a protocol approved by an institution, physician, or other authorized practitioner. The protocol enables assessment and vaccination without the need for examination or direct order from the attending provider at the time of the interaction. Standing orders can be established for the administration of one or more specific vaccines to clients in health care settings such as clinics, hospitals, pharmacies, and long-term care facilities. In settings that require attending provider signatures for all orders, standing order protocols permit assessment and vaccination in advance of the provider signature.
Provider assessment and feedback	Provider assessment and feedback involves retrospectively evaluating the performance of providers in delivering one or more vaccinations to a client population and giving this information as feedback to the providers. Assessment and feedback can also involve other activities (e.g., incentives or benchmarking).
Healthcare system-based interventions implemented in combination	Health care system-based interventions implemented in combination involve the use of two or more coordinated interventions to increase vaccination rates within a targeted client population. Interventions are implemented primarily in health care settings, although efforts may include additional activities within the community. Specific interventions may include client reminder and recall systems; clinic-based client education; expanded access in health care settings; provider assessment and feedback; provider reminders; and standing orders. The selection and implementation of coordinated interventions may result from an overall quality improvement effort in a health care setting.

Source: Definitions developed by the Community Guide systematic review team.

Appendix Table 2

Search for Economic Evidence - Search Strategy and Inclusion Criteria

The present review included studies that reported economic outcomes from the *2000 review*¹ (search period 1980–1997) combined with studies identified from updated searches (search period 1997–February 2012) within the standard medical and health-related research databases, Google Scholar, and databases specialized to economics and social sciences. The details of the two sets of searches are provided below.

Search Strategy

Details of the original search (1980–1997)

The following five electronic databases were searched during the original review period of 1980 up to 1997: MEDLINE, Embase, Psychlit, CAB Health, and Sociological Abstracts. The team also reviewed reference lists in articles and consulted with immunization experts. To be included, a study had to:

- have a publication date of 1980–1997;
- address universally recommended adult, adolescent, or childhood vaccinations;
- be a primary study rather than, for example, a guideline or review;
- take place in an industrialized country or countries;

- be written in English;
- meet the definition of the interventions;
- provide information on one or more outcomes related to the analytic frameworks; and
- compare a group of persons who had been exposed to the intervention with a group who had not been exposed or who had been less exposed. In addition, we excluded studies with least suitable designs for two interventions (provider reminder/recall and client reminder/recall) where the literature was most extensive.

Details of the update search (1997–February 2012)

The team conducted a broad literature search to identify studies assessing interventions to improve vaccination rates. The following nine databases were searched during the period of 1997 up to February 2012: CABI, CINAHL, The Cochrane Library, EMBASE, ERIC, MEDLINE, PSYCHINFO, Soci Abs and WOS. In addition, Google Scholar and specialized databases (CRD-University of York; NHS EED, EconLit, and JSTOR), were also searched. Reference lists of articles reviewed as well as lists in review articles were also considered, and subject matter experts consulted for additional references.

Search Terms

- Immunization
- Vaccination
- Immunization Programs

To be included in the updated review, a study had to:

- have a publication date of 1997–February 2012;
- evaluate vaccinations with universal recommendations;
- meet the evidence review and *Community Guide* review team’s definition of the interventions;
- be a primary research study with one or more outcomes related to the analytic framework(s);
- take place in an high income country or countries;
- be written in English
- compare a group of persons who had been exposed to the intervention with a group who had not been exposed or who had been less exposed. In addition, we excluded studies with least suitable designs for two interventions (provider reminder/recall and client reminder/recall) where the literature was most extensive

Appendix Table 3

Community Preventive Services Task Force Recommended Interventions and Number of Included Economic Studies: Present Review and *2000 Review*

Intervention	Number of studies Jan 1980 – Feb 2012 <i>2000 Review</i> : Jan 1980 – Dec 1997	By vaccine	By country
Enhancing access to vaccination services			
Home visits	9 ¹⁻⁹ 4 ^{2,3,10,11^a}	HPV/MCV 1 ⁷ MMR 1 ⁵ Other childhood series 7 ^{1-4,6,8,9}	U.S. 5 ^{4,6-9} , U.K. 2 ^{2,3} ; Canada 1 ¹ ; Australia 1 ¹
Reducing client out-of-pocket costs	3 ^{12,14} 1 ¹³	Influenza ^{12,13} Childhood series 1 ¹⁴	U.S. 1 ¹⁴ Japan 1 ¹² ; Denmark 1 ¹³
Vaccination programs in schools and organized child care centers	School-based 14 ^{15,28} ; Child care 3 ^{29,31} ; No economic review conducted ^b	Varicella 1 ²⁷ Influenza 9 ^{15,18,20,22,23,29,31} Hepatitis B 7 ^{16,17,21,24-26,28}	U.S. 12 ^{15,24,30,31} Canada 3 ^{25,27} ; U.K. 1 ²⁸ ; Multiple non-U.S. locations 1 ²⁹
Vaccination programs in WIC settings	3 ^{32,34} 2 ^{32,34}	Childhood Series 3 ^{32,34}	U.S. 3 ^{32,34}

Intervention	Number of studies Jan 1980 – Feb 2012 2000 Review: Jan 1980 – Dec 1997	By vaccine	By country
Increasing community demand for vaccinations			
Client reminder & recall systems	24 ^{4,6,13,35-54} 11 ^{13,36-38,40,45-48,52,53}	Influenza 8 ^{13,35-41} Pneumococcal 1 ⁴² Influenza and pneumococcal 1 ⁴³ DTP/DTaP 1 ⁴⁴ MMR 2 ^{5,45} Tetanus 2 ^{46,47} Other childhood series 9 ^{4,6,48-54}	U.S. 18 ^{4,6,35,36,38,40-46,48-52,54} Denmark 1 ¹³ New Zealand 1 ⁵³ U.K. 1 ³⁹ Canada 3 ^{3,37,47}
Client or family incentive rewards	7 ^{c,55-62} No economic review conducted ^b	Hepatitis B 4 ^{59,62} Influenza 1 ^{57,58} Childhood series 2 ^{55,56}	U.S. 4 ^{59,62} Australia 2 ^{55,56} Germany 1 ^{57,58}
Vaccination requirements for child care, school & college attendance	2 ^{63,64} No studies found	Hepatitis B 1 ⁶³ Varicella 1 ⁶⁴	U.S. ^{63,64}
Community-based intervention strategies implemented in combination	22 ^{1,6-11,20,40,54,59,61,65-74} 2 ^{68,73}	Hepatitis B 4 ^{59,61,66,74} Influenza 3 ^{20,40,72} MMR 1 ⁷¹ DTP 1 ⁷³ Other childhood series 13 ^{1,6-11,54,65,67-70}	U.S. 19 ^{6-11,20,40,54,59,61,65-70,73,74} Australia 1 ⁷¹ ; Canada 1 ⁷² ; Finland 1 ⁷¹
Provider- or system-based interventions			
Provider reminders	4 ^{47,75-77} 3 ^{46,47,77^d}	Pneumococcal 1 ⁷⁵ Influenza and pneumococcal 1 ⁷⁶ Tetanus 1 ⁴⁷ Childhood series 1 ⁷⁷	U.S. 4 ^{47,75-77}
Standing orders	3 ^{76,78,79} No studies found	Tdap 1 ⁷⁸ , Pneumococcal 1 ⁷⁹ Influenza and pneumococcal 1 ⁷⁶	U.S. 3 ^{76,78,79}
Provider assessment & feedback	3 ^{80,82} No studies found	Childhood series 3 ^{80,82}	U.S. 2 ^{81,82} Canada 1 ⁸⁰
Health care system-based intervention strategies implemented in combination	5 ^{46,78,83-85} 1 ^{73, e}	Pneumococcal 2 ^{83,85} Tetanus 1 ⁴⁶ Tdap 1 ⁷⁸ Childhood series 1 ⁸⁴	U.S. 4 ^{46,78,83,84} Canada 1 ⁸⁵

^aTwo studies ^{2,10} classified as home visits in the 2000 review are now reclassified as a combination strategy in the community.

^bThere was insufficient evidence for the Task Force to determine effectiveness.

^cTwo papers ^{57,58} based on a German program are considered a single study.

^dOne study ⁴⁶ classified as a provider reminder in the 2000 review is now reclassified as a client reminder and also as a combination strategy in the community.

^eOne study ⁷³ classified as a combination strategy within health systems in the 2000 review is now reclassified as a combination strategy in the community.

Appendix Table 4

Median or Mean Cost per Vaccinated Person (Number of Estimates) by Setting and Vaccine

	Clinic	Community	Hospital	MCO	Pharmacy	School
Childhood Series	\$225 (15) ^{4,6,8,9,48,49,51,53,54,82}	\$1,332 (8) ^{4,6,10,14,65,68}	\$577 ^a (1) ⁷⁷	\$13 ^a (3) ⁵²	—	—
Influenza	\$11 (8) ^{13,36,37,39,40}	\$69 ^a (3) ^{20,41,72}	—	\$13 ^a (2) ³⁵	\$19 ^a (1) ³⁸	\$15 (6) ^{15,18-20,22,23}

	Clinic	Community	Hospital	MCO	Pharmacy	School
HBV	\$399 ^a (1) ⁶¹	\$492 (8) ^{59,61,62,66,74}	—	—	—	\$38 (10) ^{16,17,21,24–26,28}
DTP/DTaP	\$12 ^a (2) ⁴⁴	—	—	—	—	—
DTP/OPV	—	\$17,187 ^a (1) ¹¹	—	—	—	—
Influenza-Pneumococcal Polysaccharide and Pneumococcal Polysaccharide	\$184 ^a (1) ⁴²	—	\$71 (5) ^{76,79}	\$64 ^a (2) ^{43,83}	—	—
MMR	\$232 ^a (1) ⁵	\$1,590 ^a (2) ^{5,71}	—	\$6 ^a (1) ⁴⁵	—	—
Tdap	—	—	\$21 ^a (1) ⁷⁸	—	—	—
Tdap/MCV/HPV	\$522 ^a (1) ⁷	—	—	—	—	—
Tetanus	\$9 (4) ^{46,47}	—	—	—	—	—
Varicella	—	—	—	—	—	\$102 ^a (2) ^{27,64}

^aMean

DTP, diphtheria, tetanus, pertussis; HPV, human papillomavirus; MCV, meningococcal vaccine; MMR, measles, mumps, rubella; Tdap, tetanus, diphtheria, pertussis; OPV, oral polio vaccine; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children

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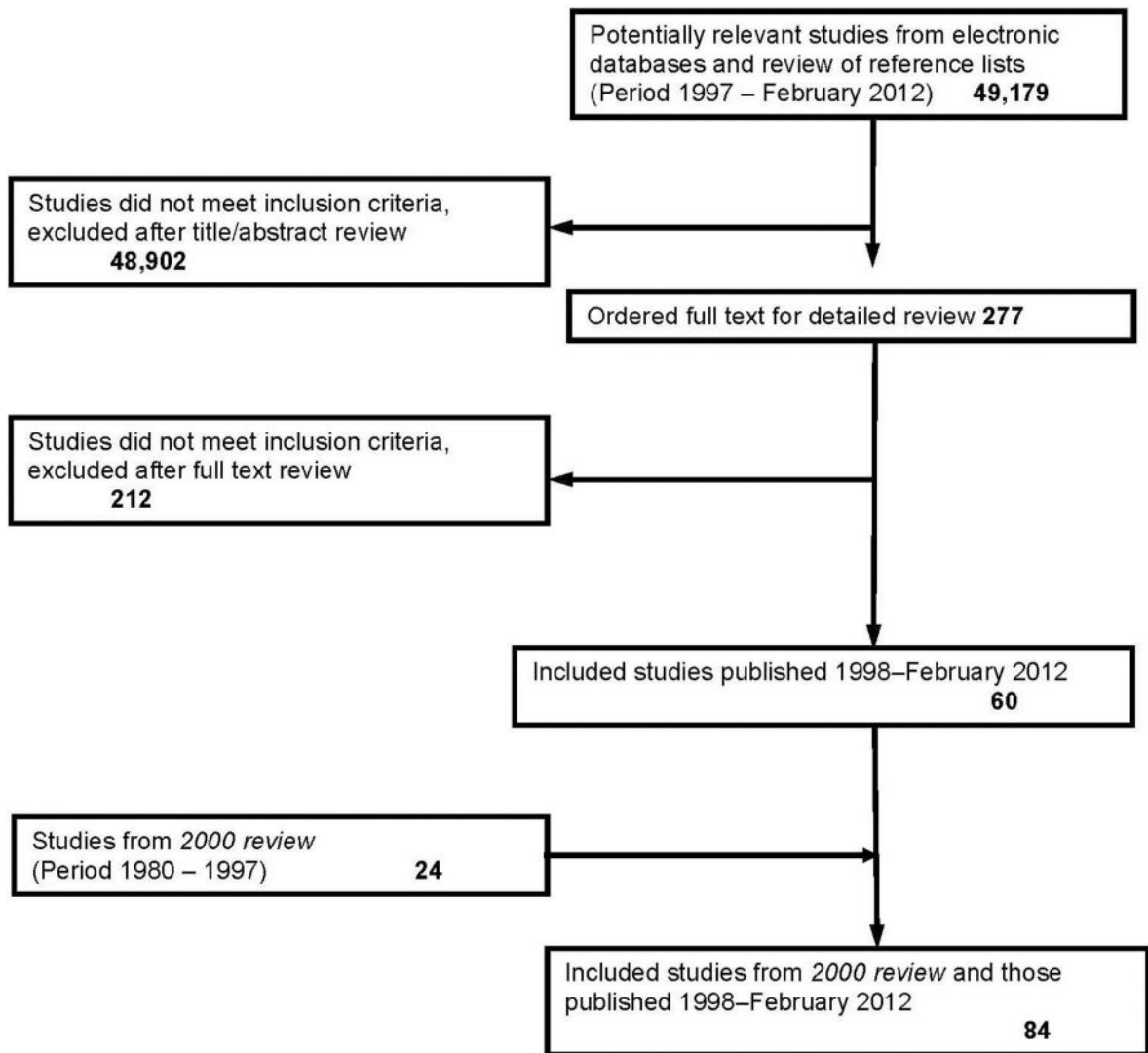


Figure 1.
Search process.

Table 1
Reach, Cost, and Cost-Effectiveness by Interventions Found to be Effective by the Task Force

Intervention strategy	Intervention group size Median (IQI, # Estimates)	Cost per person per year Median (IQI, # Estimates)	Cost per vaccinated person Median (IQI, # Estimates)
Enhancing access to vaccination services			
Home visits	575 (215 to 1,500, <i>n</i> =10) ^{46,47,54,63,64,67,73,83,84}	\$56 (\$45 to \$138, <i>n</i> =10) ^{46,47,54,63,64,67,73,83,84}	\$787 (\$163 to \$2,281, <i>n</i> =10) ^{46,47,54,63,64,67,73,83,84}
Reducing client out-of-pocket costs	129,167 ⁵¹	\$104 \$35 to \$222 ^{a,34,89,51}	\$1,640 \$114 to \$3,165 ^{a,89,51}
Vaccination programs in schools and organized child care centers	5,840 (1,024 to 30,483, <i>n</i> =20) ^{17,18,20,22,27,30,36,40,41,48,49,52,56,65,66,68,69}	\$22 (\$7 to \$35, <i>n</i> =16) ^{17,20,22,27,36,40,41,49,56,65,66,68,69}	\$29 (\$15 to \$54, <i>n</i> =17) ^{17,18,20,22,27,36,40,41,49,56,65,66,68,69}
Vaccination programs in WIC settings	4,967 (3,645 to 11,657, <i>n</i> =4) ^{31,82}	\$16 (\$10 to \$27, <i>n</i> =4) ^{31,82}	\$66 (\$35 to \$103, <i>n</i> =4) ^{31,82}
Increasing community demand for vaccinations			
Client reminder and recall systems	654 (273 to 5,669, <i>n</i> =34) ^{13,14,21,25,35,38,42,46,47,54,59,70,75,76,78-80,85,86,88,89,91,95}	\$2.13 (\$0.96 to \$8.00, <i>n</i> =34) ^{13,14,21,25,35,38,42,46,47,54,59,70,75,76,78-80,85,86,88,89,91,95}	\$15 (\$8 to \$184, <i>n</i> =32) ^{13,14,21,25,35,42,46,47,54,59,70,75,76,79,80,85-89,91,95}
Client or family incentive rewards ^b	774 (39 to 18,942, <i>n</i> =6) ^{15,26,37,57,60-62}	\$372 (\$112 to \$559, <i>n</i> =4) ^{26,57,60-62}	\$1,032 \$248 to \$2,447 ^{a,26,57,60}
Vaccination requirements for child care, school, and college attendance	4.1 million ¹¹	—	—
Community-based intervention strategies implemented in combination	429 (185 to 6,013, <i>n</i> =25) ^{19,23,26,32,44,54,55,57,63,64,67,71,73,74,81,88,90,92-95}	\$54 (\$14 to \$214, <i>n</i> =22) ^{19,26,32,54,55,57,63,64,67,71,73,74,81,88,90,92-95}	\$461 (\$51 to \$798, <i>n</i> =22) ^{19,26,32,40,54,55,57,63,64,67,71,73,74,81,88,90,92,94,95}
Provider- or system-based interventions			
Provider reminders	2,910 (1,660 to 19,770, <i>n</i> =4) ^{33,5872,91}	\$7 (\$2 to \$47, <i>n</i> =4) ^{33,72,91}	\$309 (\$29 to \$559, <i>n</i> =4) ^{33,72,91}
Standing orders	11,813 (1,068 to 24,266, <i>n</i> =4) ^{29,33,50}	\$5.55 (\$5 to \$13, <i>n</i> =4) ^{29,33,50}	\$29 (\$18 to \$63, <i>n</i> =4) ^{29,33,50}
Provider assessment and feedback	7,392 1,643 to 18,034 ^{a,16,24,45}	\$2.50 \$0.22 to \$4 ^{a,16,24,45}	\$80 ⁴⁵
Health care system-based intervention strategies implemented in combination	20,000 (567 to 212,500, <i>n</i> =5) ^{12,28,29,53,78}	\$4 (\$0.84 to \$13.00, <i>n</i> =4) ^{12,29,53,78}	\$12 \$6.00 to \$21.00 ^{a,12,29,78}

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^aMean and range.

^bTwo papers^{61, 62} based on a German program are considered a single study.

IQI, interquartile interval; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children

Table 2

Reach, Cost, and Cost-Effectiveness by Type of Intervention

Intervention strategy	Intervention group size Median (IQR, # Estimates)	Cost per person per year Median (IQR, # Estimates)	Cost per vaccinated person Median (IQR, # Estimates)
Home visits	575 (215 to 1500, <i>n</i> =10) ⁴⁶ , 47, 54, 63, 64, 67, 73, 83, 84	\$56 (\$45 to \$138, <i>n</i> =10) ⁴⁶ , 47, 54, 63, 64, 67, 73, 83, 84	\$786 (\$163 to \$2,281, <i>n</i> =10) ⁴⁶ , 47, 54, 63, 64, 67, 73, 83, 84
Client or family incentive rewards and Reducing client out-of-pocket costs	774 (85 to 53,226, <i>n</i> =8) ¹⁵ , 26, 37, 51, 57, 60, 62, 89	\$209 (\$77 to \$552, <i>n</i> =6) ²⁶ , 51, 57, 60, 62, 89	\$399 (\$181 to \$2,806, <i>n</i> =5) ²⁶ , 51, 57, 60, 89
Vaccination programs in schools and organized child care centers	5,840 (1,024 to 30,483, <i>n</i> =21) ¹⁷ , 18, 20, 22, 27, 30, 36, 40, 41, 48, 49, 52, 56, 65, 66, 68, 69	\$22 (\$7 to \$35, <i>n</i> =16) ¹⁷ , 20, 22, 27, 36, 40, 41, 49, 56, 65, 66, 68, 69	\$29 (\$15 to \$54, <i>n</i> =17) ¹⁷ , 18, 20, 22, 27, 36, 40, 41, 49, 56, 65, 66, 68, 69
Vaccination programs in WIC settings	4,967 (3,645 to 11,657, <i>n</i> =4) ³¹ , 82	\$16 (\$10 to \$27, <i>n</i> =4) ³¹ , 82	\$66 (\$35 to \$103, <i>n</i> =4) ³¹ , 82
Client reminder and recall systems	654 (273 to 5,669, <i>n</i> =34) ¹³ , 14, 21, 25, 35, 38, 42, 46, 47, 54, 59, 70, 75, 76, 78, 80, 85, 86, 88, 89, 91, 95	\$2.13 (\$0.96 to \$8, <i>n</i> =34) ¹³ , 14, 21, 25, 35, 38, 42, 46, 47, 54, 59, 70, 75, 76, 78, 80, 85, 86, 88, 89, 91, 95	\$15 (\$8 to \$184, <i>n</i> =31) ¹³ , 14, 21, 25, 35, 42, 46, 47, 54, 59, 70, 75, 76, 79, 80, 85, 89, 91, 95
Community-based intervention strategies implemented in combination	429 (185 to 6013, <i>n</i> =25) ¹⁹ , 23, 26, 32, 44, 54, 55, 57, 63, 64, 67, 71, 73, 74, 81, 88, 90, 92, 95	\$54 (\$14 to \$214, <i>n</i> =22) ¹⁹ , 26, 32, 40, 54, 55, 57, 63, 64, 67, 71, 73, 74, 81, 88, 90, 92, 95	\$461 (\$51 to \$798, <i>n</i> =22) ¹⁹ , 26, 32, 40, 54, 55, 57, 63, 64, 67, 71, 73, 74, 81, 88, 90, 92, 94, 95
Provider reminders and Provider assessment and feedback	2,705 (1,734 to 15,200, <i>n</i> =8) ¹⁶ , 24, 33, 45, 58, 72, 91	\$4 (\$0.32 to \$7, <i>n</i> =7) ¹⁶ , 24, 33, 45, 72, 91	\$111 (\$41 to \$542, <i>n</i> =5) ³³ , 45, 72, 91
Standing orders	11,813 (1,068 to 24,266, <i>n</i> =4) ²⁹ , 33, 50	\$6 (\$5 to \$13, <i>n</i> =4) ²⁹ , 33, 50	\$29 (\$18 to \$63, <i>n</i> =4) ²⁹ , 33, 50
Healthcare system-based intervention strategies implemented in combination	20,000 (567 to 212,500, <i>n</i> =5) ¹² , 28, 29, 53, 78	\$4 (\$0.84 to \$13, <i>n</i> =4) ¹² , 29, 53, 78	\$12 \$6 to \$21 ¹² , 29, 78

^aMean and range

IQR, interquartile interval; NA, Not applicable; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children

Table 3

Reach, Cost, and Cost-effectiveness by Type of Setting

Intervention strategy	Intervention group size: Median (IQR, # Estimates)	Cost per person per year: Median (IQR, # Estimates)	Cost per vaccinated person: Median (IQR, # Estimates)
MCO	11,288 (9,153 to 40,107, <i>n</i> =10) ^{12,14} ,28,61,62,85,86	\$1.20 (\$0.58 to \$1.90, <i>n</i> =9) ^{12,14} ,61,62,85,86	\$13 (\$10 to \$15, <i>n</i> =8) ^{12,14} ,85,86
Clinic	390 (216 to 1,369, <i>n</i> =40) ^{6,16,21} ,24,25,35,38,42,44-47,54,57,63,64,67,70,75,76,78,79,87,89,91,93,95	\$4 (\$1.28 to \$23, <i>n</i> =39) ^{6,16,21} ,24,25,35,38,42,45-47,54,57,63,64,67,70,75,76,78,79,88,89,91,93,95	\$32 (\$7 to \$350, <i>n</i> =33) ^{6,21,25} ,35,42,45-47,54,57,63,64,67,70,75,76,79,88,89,91,95
Hospital	5,161 (2,232 to 24,266, <i>n</i> =8) ^{29,33} ,50,58,72	\$7 (\$5 to \$15, <i>n</i> =7) ^{29,33} ,50,72	\$71 (\$21 to \$508, <i>n</i> =7) ^{29,33} ,50,72
School	11,335 (2,010 to 49,202, <i>n</i> =18) ^{11,17,20} ,22,27,36,40,41,49,56,65,66,68,69	\$21 (\$6 to \$35, <i>n</i> =17) ^{11,17,18} ,20,22,27,36,40,41,49,56,65,66,68,69	\$32 (\$16 to \$64, <i>n</i> =18) ^{11,17,18} ,20,22,27,36,40,41,49,56,65,66,68,69
WIC	4,585 (1,828 to 9,554, <i>n</i> =5) ^{31,32} ,82	\$22 (\$10 to \$145, <i>n</i> =5) ^{31,32} ,82	\$80 (\$41 to \$3116, <i>n</i> =5) ^{31,32} ,82
Community	1,009 (288 to 6416, <i>n</i> =26) ^{15,19,23} ,26,37,44,46,47,51,53-55,57,59,60,71,74,81,90,92,94	\$46 (\$14 to \$220, <i>n</i> =22) ^{19,23} ,26,46,47,51,53-55,57,59,60,71,74,81,90,92,94	\$617 (\$202 to \$2450, <i>n</i> =22) ^{19,23} ,26,40,46,47,51,54,55,57,59,60,71,74,81,90,92,94
Homes	208 81 to 305 ⁴⁷³ ,83,84	\$149 \$78 to \$278 ⁴⁷³ ,83,84	\$129 \$100 to \$183 ⁴⁷³ ,83,84
Pharmacy	242 ⁸⁰	\$2 ⁸⁰	\$19 ⁸⁰

^aMean and range

IQR, interquartile interval; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children