

Increasing Coverage of Appropriate Vaccinations



A Community Guide Systematic Economic Review

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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 MCOs 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 (i.e., percentage of target population vaccinated) remains below optimum, and Healthy People 2020⁶ makes several recommendations for clinical and community-level interventions to increase coverage.

The present systematic economic review estimated the reach, cost to implement, and cost effectiveness of 12 interventions found to be effective for 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

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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 U.S. Department of Agriculture's 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, 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:

$$\begin{aligned} \text{intervention cost} = & (\text{quantity of materials} \\ & \times \text{unit cost of materials}) + (\text{quantity of labor} \\ & \times \text{unit cost of labor}). \end{aligned}$$

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:

$$\begin{aligned} \text{APV} = & n \times \text{incremental percentage coverage} \\ & (\text{owing to intervention}), \end{aligned}$$

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 APVs. 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:

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

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 noneconomic.¹⁰

Considerable variability is expected of effectiveness 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 of effectiveness 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](#) (available online). 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](#) (available online), [Appendix Chart 1](#) (available online), 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 nonmedical 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 (available online) 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 nonmedical 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.

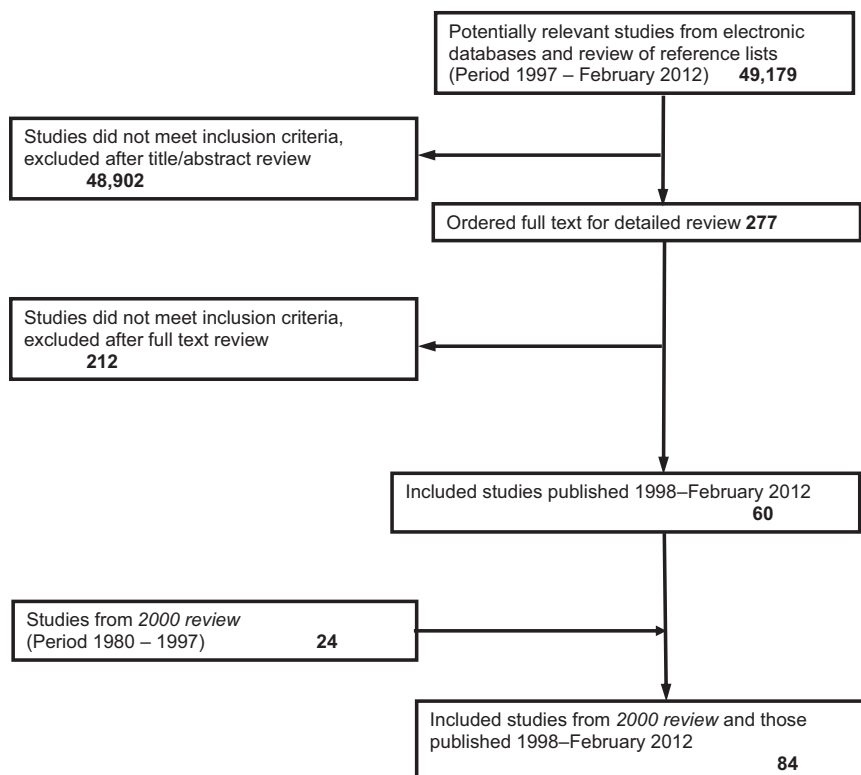


Figure 1. Search process.

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

Intervention strategy	Median intervention group size (IQI); number of estimates	Median cost PPPY in US\$ (IQI); number of estimates	Median cost per vaccinated person in US\$; number of estimates
Enhancing access to vaccination services			
Home visits	575 (215, 1,500); 10 ^{46,47,54,63,64,67,73,83,84}	56 (45, 138); 10 ^{46,47,54,63,64,67,73,83,84}	787 (163, 2,281); 10 ^{46,47,54,63,64,67,73,83,84}
Reducing client out-of-pocket costs	129,167 ^a ; 1 ⁵¹	104 (35, 222) ^b ; 3 ^{34,51,89}	1,640 (114, 3,165) ^b ; 2 ^{51,89}
Vaccination programs in schools and organized child care centers	5,840 (1,024, 30,483); 20 ^{17,18,20,22,27,30,36,40,41,48,49,52,56,65,66,68,69}	22 (7, 35); 16 ^{17,20,22,27,36,40,41,49,56,65,66,68,69}	29 (15, 54); 17 ^{17,18,20,22,27,36,40,41,49,56,65,66,68,69}
Vaccination programs in WIC settings	4,967 (3,645, 11,657); 4 ^{31,82}	16 (10, 27); 4 ^{31,82}	66 (35, 103); 4 ^{31,82}
Increasing community demand for vaccinations			
Client reminder and recall systems	654 (273, 5,669); 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, 8.00); 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, 184); 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 ^c	774 (39, 18,942); 6 ^{15,26,37,5760-62}	372 (112, 559); 4 ^{26,57,60-62}	1,032 (248, 2,447) ^b ; 3 ^{26,57,60}
Vaccination requirements for child care, school, and college attendance	4.1 million ^a ; 1 ¹¹	—	—
Community-based intervention strategies implemented in combination	429 (185, 6,013); 25 ^{19,23,26,32,44,54,55,57,63,64,67,71,73,74,81,88,90,92-95}	54 (14, 214); 22 ^{19,26,32,54,55,57,63,64,67,71,73,74,81,88,90,92-95}	461 (51, 798); 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, 19,770); 4 ^{33,58,72,91}	7 (2, 47); 4 ^{33,72,91}	309 (29, 559); 4 ^{33,72,91}
Standing orders	11,813 (1,068, 24,266); 4 ^{29,33,50}	5.55 (5, 13); 4 ^{29,33,50}	29 (18, 63); 4 ^{29,33,50}
Provider assessment and feedback	7,392 (1,643, 18,034) ^b ; 3 ^{16,24,45}	2.50 (0.22, 4) ^b ; 3 ^{16,24,45}	80 ^a ; 1 ⁴⁵
Healthcare system–based intervention strategies implemented in combination	20,000 (567, 212,500); 5 ^{12,28,29,53,78}	4 (0.84, 13.00); 4 ^{12,29,53,78}	12 (6.00, 21.00) ^b ; 3 ^{12,29,78}

^aMean.

^bMean and range.

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

IQI, interquartile interval; PPPY, per person per year; WIC, U.S. Department of Agriculture's Special Supplemental Nutrition Program for Women, Infants, and Children.

Table 2. Reach, Cost, and Cost-Effectiveness by Type of Intervention

Intervention strategy	Median intervention group size (IQI); number of estimates	Median cost PPPY in US\$ (IQI); number of estimates	Median cost per vaccinated person in US\$; number of estimates
Home visits	575 (215, 1,500); 10 ^{46,47,54,63,64,67,73,83,84}	56 (45, 138); 10 ^{46,47,54,63,64,67,73,83,84}	786 (163, 2,281); 10 ^{46,47,54,63,64,67,73,83,84}
Client or family incentive rewards and reducing client out-of-pocket costs	774 (85, 53,226); 8 ^{15,26,37,51,57,60-62,89}	209 (77, 552); 6 ^{26,51,57,60-62,89}	399 (181, 2,806); 5 ^{26,51,57,60,89}
Vaccination programs in schools and organized child care centers	5,840 (1,024, 30,483); 21 ^{17,18,20,22, 27,30,36,40,41,48,49,52,56,65,66,68,69}	22 (7, 35); 16 ^{17,20,22,27,36, 40,41,49,56,65,66,68,69}	29 (15, 54); 17 ^{17,18,20,22,27,36,40,41,49,56,65, 66,68,69}
Vaccination programs in WIC settings	4,967 (3,645, 11,657); 4 ^{31,82}	16 (10, 27); 4 ^{31,82}	66 (35, 103); 4 ^{31,82}
Client reminder and recall systems	654 (273, 5,669); 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, 8); 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, 184); 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, 6,013); 25 ^{19,23,26,32,44,54,55,57, 63,64,67,71,73,74,81,88,90,92-95}	54 (14, 214); 22 ^{19,26,32,54,55,57,63,64,67, 71,73,74,81,88,90,92-95}	461 (51, 798); 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, 15,200); 8 ^{16,24,33,45,58,72,91}	4 (0.32, 7); 7 ^{16,24,33,45,72,91}	111 (41, 542); 5 ^{33,45,72,91}
Standing orders	11,813 (1,068, 24,266); 4 ^{29,33,50}	6 (5, 13); 4 ^{29,33,50}	29 (18, 63); 4 ^{29,33,50}
Healthcare system-based intervention strategies implemented in combination	20,000 (567, 212,500); 5 ^{12,28,29,53,78}	4 (0.84, 13); 4 ^{12,29,53,78}	12 (6, 21) ^a ; 3 ^{12,29,78}

^aMean and range.

IQI, interquartile interval; PPPY, per person per year; WIC, U.S. Department of Agriculture's Special Supplemental Nutrition Program for Women, Infants, and Children.

Table 3. Reach, Cost, and Cost-effectiveness by Type of Setting

Intervention strategy	Median intervention group size (IQ); number of estimates	Median cost PPPY in US\$ (IQ); number of estimates	Median cost per vaccinated person in US\$; number of estimates
MCO	11,288 (9,153, 40,107); 10 ^{12,14,28,61,62,85,86}	1.20 (0.58, 1.90); 9 ^{12,14,61,62,85,86}	13 (10, 15); 8 ^{12,14,85,86}
Clinic	390 (216, 1,369); 40 ^{6,16,21,24,25,35,38,42,44,47,54,57,63,64,67,70,75,76,78,79,88,89,91,93,95}	4 (1.28, 23); 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, 350); 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, 24,266); 8 ^{29,33,50,58,72}	7 (5, 15); 7 ^{29,33,50,72}	71 (21, 508); 7 ^{29,33,50,72}
School	11,335 (2,010, 49,202); 18 ^{11,17,20,22,27,36,40,41,49,56,65,66,68,69}	21 (6, 35); 17 ^{11,17,18,20,22,27,36,40,41,49,56,65,66,68,69}	32 (16, 64); 18 ^{11,17,18,20,22,27,36,40,41,49,56,65,66,68,69}
WIC	4,585 (1,828, 9,554); 5 ^{31,32,82}	22 (10, 145); 5 ^{31,32,82}	80 (41, 3,116); 5 ^{31,32,82}
Community	1,009 (288, 6,416); 26 ^{15,19,23,26,37,44,46,47,51,53-55,57,59,60,71,74,81,90,92,94}	46 (14, 220); 22 ^{19,23,26,46,47,51,53-55,57,59,60,71,74,81,90,92,94}	617 (202, 2,450); 22 ^{19,23,26,40,46,47,51,54,55,57,59,60,71,74,81,90,92,94}
Homes	208 (81, 305) ^a ; 3 ^{73,83,84}	149 (78, 278) ^a ; 3 ^{73,83,84}	129 (100, 183) ^a ; 3 ^{73,83,84}
Pharmacy	242 ^b ; 1 ⁸⁰	2 ^b ; 1 ⁸⁰	19 ^b ; 1 ⁸⁰

^aMean and range.

^bMean.

IQI, interquartile interval; PPPY, per person per year; WIC, U.S. Department of Agriculture's Special Supplemental Nutrition Program for Women, Infants, and Children.

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 (available online) 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 health-care 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 nonhealthcare 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 (available online) 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](#) (available online) 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 ($\leq 15\%$), \$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.

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.

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Appendix

Supplementary data

Supplementary data associated with this article can be found at <https://www.thecommunityguide.org/sites/default/files/assets/vpd-ajpm-app-econ-increasing-coverage.pdf>.