Cost-effectiveness of Combined Outreach for the Pneumococcal and Influenza Vaccines

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Background: We conducted a cost-effectiveness analysis as part of a randomized, controlled trial of a community-based outreach initiative to promote the pneumococcal and influenza vaccines for people aged 65 years or older.

Methods: The analysis was based on primary data from the trial on the increase in vaccination rates and cost of the intervention, and published estimates of the effectiveness of the vaccines and cost of treatment. We performed partial stochastic analyses based on the confidence intervals (CIs) of the effectiveness of the intervention and of the vaccines.

Results: The cost-effectiveness ratio of the combined-outreach initiative as implemented was $35,486 per quality-adjusted life-year (QALY), whereas it was $53,547 per QALY for the pneumococcal vaccine and $130,908 per QALY for the influenza vaccine. In partial stochastic analyses, the quasi-CI of the combined-outreach initiative ranged from $15,145 to $152,311 per QALY. The cost-effectiveness ratio of the intervention targeted to people who had never received the pneumococcal vaccine or who had not received the influenza vaccine in the previous year was $11,771 per QALY, with a quasi-CI of $3,330 to $46,095 per QALY. With the use of the projected cost of replicating the intervention, the cost-effectiveness ratio was $26,512 per QALY for the initiative as implemented and $7,843 per QALY for a targeted initiative.

Conclusions: The community-based outreach initiative to promote the pneumococcal and influenza vaccines was reasonably cost-effective. Further improvements in cost-effectiveness could be made by targeting the initiative or through lessons learned during the first year that would reduce the cost of the initiative in subsequent years.

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Pneumococcal and influenza infections continue to cause substantial morbidity and mortality, and immunization against these infections remains an important public health activity. Several major advisory groups recommend the pneumococcal vaccine (Pneumovax) and the influenza vaccine for people aged 65 years and older, and research has shown that the vaccines are cost-effective. The pneumococcal vaccine was cost saving in preventing pneumococcal bacteremia among people aged 65 years and older. The influenza vaccine was cost saving or the net cost per person vaccinated was about $7 for people aged 65 years and older. (A number sign [#] denotes that the estimates were adjusted to 1996 dollars to the extent information in the original article was available to do so.)

Less is known about the cost-effectiveness of interventions to promote the vaccines, and there has never been a cost-effectiveness analysis (CEA) of a community-based outreach initiative. Previous researchers analyzed interventions by providers or insurers to promote the influenza vaccine, including letter or postcard reminders from physicians’ offices, telephone reminders from nurses, personal reminders from physicians, and letter reminders from community pharmacists. Estimates of the cost per additional person vaccinated ranged from $5 to $20 for the intervention to promote the vaccine and from $14 to $32 for the intervention plus the vaccine.

We conducted a CEA as part of a randomized controlled trial of a community-based outreach initiative to promote the pneumococcal vaccine and influenza vaccine for people aged 65 years and older. The research presented below extends the literature on the cost-effectiveness of interventions to promote vaccines with 3 innovations. (1) It was the first CEA of a community-based outreach initiative in...
MATERIALS AND METHODS

RANDOMIZED CONTROLLED STUDY OF COMBINED OUTREACH FOR THE PNEUMOCOCCAL AND INFLUENZA VACCINES

The population, interventions, and outcome measures of the trial are described briefly below. Pls see Krieger et al for a report of the randomized controlled trial that conforms to the recommendations of Begg and colleagues.

Study Site and Population

The intervention was conducted at an urban senior center in Seattle, Wash, from October 14 to November 22, 1996. Participants were recruited from the senior center membership and a marketing database with seniors who resided in the 5 contiguous ZIP codes. Potential participants were mailed an invitation letter and a baseline questionnaire. Those who returned the survey and met the study inclusion criteria (aged 65 years or older and residence in the targeted ZIP code areas) were enrolled. No exclusion criteria were applied. As shown in Figure 1, 1246 people were enrolled and randomized at baseline and 1083 people completed the follow-up survey. Randomization was by systematic allocation of alternate respondents to either control or intervention groups.

Intervention

For the intervention group, a project coordinator sent each participant a specially designed educational brochure and a postage-paid reply card for tracking immunization status. If the participant replied that he or she had not been vaccinated or if the card was not returned, a senior volunteer called the participant. Senior volunteers received training about the pneumococcal and influenza vaccines and were responsible for contacting 20 to 25 participants. The volunteers received technical support from the project coordinator.

Other vaccine promotion activities at the senior center were available to both the intervention and control groups, including a volunteer nurse who was on site for 2 hours each weekday to give vaccines free of charge, and announcements about vaccines appeared in the newsletter and were announced at events. Vaccines were also given at other community sites, such as pharmacies and grocery stores, and the regional Medicare provider review organization sent letters to all African Americans in King County (in which Seattle is located) who were enrolled in Medicare in October 1995 and October 1996 to encourage them to get the influenza vaccine.

Outcome Measures

The primary outcomes were the proportion of individuals who reported receiving the pneumococcal vaccine and the proportion who reported receiving the influenza vaccine. Use of self-report data on immunization status is a common practice. Data were collected through the baseline survey in September 1996 and the follow-up survey in March 1997.

MODEL FOR THE CEA

The CEA of the combined-outreach initiative was constructed from 2 independent analyses: (1) the pneumococcal vaccine against pneumococcal bacteremia and (2) the influenza vaccine against influenza and pneumonia. Figure 2 is a model that shows these 2 relationships, as well as a possible relationship between the pneumococcal vaccine and pneumococcal pneumonia. The analysis does not include the pneumococcal vaccine against pneumococcal pneumonia, because the vaccine’s effectiveness among people aged 65 years and older is controversial. The results of a recent clinical trial showed that the vaccine was not effective among the elderly who had previously been treated as inpatients for community-acquired pneumonia. In addition, a recent meta-analysis of randomized controlled trials showed that the vaccine was not effective in reducing the incidence of definitive pneumococcal pneumonia or mortality among high-risk patients, which included the elderly. (See the “Comment” section.)

There is a decision tree for each independent CEA. A sample decision tree for the influenza vaccine is displayed in Figure 3. The decision tree begins on the left side and shows the initial randomization of participants into either the intervention or control group. Moving to the right, participants made a decision about getting a vaccine, but the probability of getting a vaccine was higher for the intervention group than the control group. Next, some participants became ill and others did not, but the probability of becoming ill was lower for people who were vaccinated than for those who were not. Finally, some participants died and other did not, but the probability of dying was lower for people who were vaccinated than for those who were not, because the vaccine eliminated influenza and pneumonia as a cause of death when it was effective. The last branch of the tree embodies the assumption that the vaccine affected the incidence of the illnesses, but not the severity when they occurred. The last branch also reflects the competing risk analysis in which the vaccine affected mortality from influenza and pneumonia, but not from other causes.

The decision tree for bacteremia (not shown) would be similar to Figure 3, but it would have 6 cycles rather than 1 cycle, because the duration of immunity for the pneumococcal vaccine was 6 years and the duration for the influenza vaccine was 1 year.

For each independent CEA, we performed 5 different calculations. First, we performed 2 calculations for each group: (1) the total cost of the intervention (when relevant), vaccine (including treatment of side effects), and treatment of illnesses, and (2) the total QALYs lost because of vaccine side effects, morbidity, and mortality. Then, between the intervention and control groups, we calculated the marginal cost and marginal effectiveness, which were the difference between the costs and the QALYs, respectively, of the groups. Finally, we calculated the cost-effectiveness ratio, which was the ratio of marginal cost to marginal effectiveness.

For the CEA of the combined outreach initiative, we performed the same 5 calculations with the use of the sum of the costs and effectiveness of each independent analysis. The cost of the intervention, however, was counted only once. In addition, when people got the influenza and
pneumococcal vaccines at the same time, the participants' expenditures for transportation and the social cost of the participants' and caregivers' time to obtain the vaccines were counted only once. The CEA of the combined outreach initiative did not allow for an interaction between the effectiveness of the pneumococcal vaccine and the influenza vaccine. Previous research suggested that there was no incremental effect of the pneumococcal vaccine in preventing pneumonia or pneumococcal pneumonia among elderly people who received the influenza vaccine, but neither was there a reduction in effectiveness.28

**UNCERTAINTY**

The major sources of uncertainty that were incorporated into the model were the effectiveness of the intervention and the effectiveness of the vaccines. To address this uncertainty, we performed partial stochastic CEAs.29 For these analyses, we calculated quasi-confidence intervals (CIs) for the cost-effectiveness ratio based on the CIs of the estimates of the effectiveness of the intervention and the vaccines. The measure of effectiveness was the difference in rates (vaccination rates in the case of the intervention and incidence rates of the illnesses in the cases of the vaccines), and the upper and lower bounds in effectiveness were based on the CI for the difference in rates. Values of effectiveness of the intervention and the vaccines used in the base case, lower bound, and upper bound estimates are listed in Table 1. The choice of these values is justified in the following subsections.

We performed 3 sets of estimates based on 3 sets of CIs: (1) the effectiveness of the intervention, (2) the effectiveness of the vaccine, and (3) the effectiveness of the intervention and the vaccine. For example, the lower bound of the quasi-CI of the first set of estimates was calculated by means of the upper bound of effectiveness of the intervention.

Values of other variables and their sources are listed in Table 2. For many variables, a 1-way sensitivity analysis in which the values were changed within reasonable bounds did not change the cost-effectiveness ratio by more than $1000. Examples include the cost of the vaccines, the frequency of influenza epidemic years, and probability of a bed-disability day from influenza and pneumonia. These variables are identified with an asterisk in Table 2. For other variables, changing the values would substantially change the cost-effectiveness ratio. These variables include the discount rate; the cost of the intervention, for which the 1-way sensitivity analyses are reported; and the incidence of and mortality rate from bacteremia. (See the “Comment” section.)

**Effectiveness of the Community-Based Outreach Initiative to Promote the Pneumococcal and Influenza Vaccines**

The point estimate and CIs for the effectiveness of the intervention were obtained from the randomized controlled trial. The measure of effectiveness was the difference in vaccination rates between the intervention and control groups; for the vaccination rates, please see Krieger et al. The trial showed that the effectiveness varied by vaccine and by prior immunization status, so we performed 2 sets of estimates for the cost-effectiveness: (1) one set for the intervention as implemented and (2) one set for an intervention that would be targeted to people who had never received the pneumococcal vaccine or who did not receive the influenza vaccine in the previous year. For the reference case of the first set of estimates, the intervention was 15% effective in promoting the pneumococcal vaccine and 0% effective in promoting the influenza vaccine. For the second set, the intervention was 21% effective in promoting the pneumococcal vaccine and 27% effective in promoting the influenza vaccine. The second set of estimates embodies the assumption that the effectiveness of the intervention for those subsamples could be extended to a sample as large as the full sample in a targeted outreach initiative.

**Effectiveness of the Pneumococcal Vaccine Against Pneumococcal Bacteremia**

Estimates of effectiveness and CIs were based on a case-control study in which a significant negative relationship was found between effectiveness of the vaccine and number of years since vaccination and between effectiveness and patient’s age. Using those data, Sisk et al estimated a declining, linear relationship between effectiveness and immunity during a 6-year period for 3 age strata: 65 to 74 years, 75 to 84 years, and 85 years or older. For the reference case, we assumed that effectiveness was the weighted average of the 65- to 74-year and 75- to 84-year age strata reported by Sisk et al, where the weights were the numbers of people in each 10-year age interval in the stationary population. We used the average for these 2 strata because the average age of the participants of the trial was 75 years. Only a few participants were aged 85 years and older, and the available evidence suggested that the vaccine was not effective for people aged 85 years or older. Note that the outcome measure reported by Shapiro et al and Sisk et al was incidence of pneumococcal bacteremia, and we assumed that their estimates could be applied to hospitalizations and mortality.

**Effectiveness of the Influenza Vaccine**

The point estimate and CI were based on the randomized controlled trial of the efficacy of the influenza vaccine among people aged 60 years and older in whom the vaccine reduced the incidence of influenza by 50%. For the reference case estimate, we assumed that the vaccine reduced disability days, outpatient visits, hospitalizations, and mortality by 50%. Although the outcome measure of the trial was incidence of influenza, this estimate was within the range of estimates from case-control studies for the effectiveness of the vaccine in reducing hospitalizations and mortality.

**DISCOUNT RATE**

We followed the recommendations of the Panel on Cost-effectiveness in Health and Medicine and discounted all future costs and benefits in the reference case by 3%. The
which effectiveness was measured in quality-adjusted life-years (QALYs). (See Krieger et al20 for estimates of the cost per person vaccinated.) (2) It was conducted from a societal perspective and conformed to the reference case recommended by the US Panel on Cost-effectiveness in Health and Medicine.21 It was based on primary data from a randomized controlled trial on the increase in the vaccination rate and the cost of the intervention and published estimates of the effectiveness of the vaccines in preventing illness and mortality and costs of treatment. (3) It demonstrated how the methods currently recommended for CEA can be used to add costs and effectiveness across more than 1 vaccine in a combined outreach initiative, or more generally across more than 1 CEA for any combined intervention.

RESULTS

Beginning with the reference case results, Table 4 reports the total cost and total effectiveness for the intervention group and the control group, as well as marginal cost, marginal effectiveness, and cost-effectiveness ratio for 6 estimates. The first 3 estimates in the top half of the table were for the combined outreach initiative, pneumococcal vaccine, and influenza vaccine as implemented. The ratio of the intervention as implemented was $35,486 per QALY for the combined outreach initiative, whereas it was $35,547 per QALY for the pneumococcal vaccine and $130,908 per QALY for the influenza vaccine. As shown, the marginal effectiveness of the pneumococcal vaccine was greater than that of the influenza vaccine, reflecting the relatively greater effect of the intervention on pneumococcal vaccine coverage than influenza vaccine coverage. The marginal effectiveness of the combined outreach initiative was the sum of the independent analyses (aside from rounding error), because combined outreach did not alter the effectiveness of the intervention or the vaccines. The marginal cost was roughly the same for all 3 estimates, because the cost of the intervention was the same for all of them.
The 3 estimates in the bottom half of the table were for the combined outreach initiative, pneumococcal vaccine, and influenza vaccine if the intervention could be targeted to seniors who had never received a pneumococcal vaccine or who had not received the influenza vaccine in the previous year. For each of these estimates, the marginal costs were lower and the marginal effectiveness was higher than in the estimates for the intervention as implemented. The cost-effectiveness ratios were $11771 per QALY for the combined outreach initiative, $38030 per QALY for the pneumococcal vaccine, and $22431 per QALY for the influenza vaccine.

The quasi-CIs estimated from the partial stochastic analyses are reported in Table 5. For the intervention as implemented, the quasi-CI of the pneumococcal vaccine that was calculated from the CI of effectiveness of the intervention ranged from $37305 to $82364 per QALY. The interval that was calculated from the CI of effectiveness of the vaccine ranged from $40498 to $144380 per QALY. The range was greater for the latter, because the CI of effectiveness of the vaccine was not symmetric and the lower bound of effectiveness of the vaccine was less than 50% for 5 of 6 years. Finally, the interval that was calculated jointly from CIs of effectiveness of the intervention and the vaccine ranged from $27944 to $218750 per QALY. The range of the quasi-CI that was calculated jointly was greater than the sum of

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reference Case</th>
<th>Upper Bound</th>
<th>Lower Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumococcal vaccine against bacteremia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness of intervention&lt;sup&gt;20&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No previous vaccine</td>
<td>21</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>Full sample</td>
<td>15</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Effectiveness of vaccine&lt;sup&gt;10&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1</td>
<td>82</td>
<td>93</td>
<td>56</td>
</tr>
<tr>
<td>Year 2</td>
<td>76</td>
<td>91</td>
<td>41</td>
</tr>
<tr>
<td>Year 3</td>
<td>70</td>
<td>89</td>
<td>26</td>
</tr>
<tr>
<td>Year 4</td>
<td>65</td>
<td>87</td>
<td>17</td>
</tr>
<tr>
<td>Year 5</td>
<td>59</td>
<td>85</td>
<td>10</td>
</tr>
<tr>
<td>Year 6</td>
<td>54</td>
<td>83</td>
<td>3</td>
</tr>
<tr>
<td>Influenza</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness of intervention&lt;sup&gt;20&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not immunized in previous year</td>
<td>27</td>
<td>40</td>
<td>14</td>
</tr>
<tr>
<td>Full sample</td>
<td>6</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Effectiveness of vaccine&lt;sup&gt;11&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>65</td>
<td>39</td>
</tr>
</tbody>
</table>

<sup>*</sup> The measure of effectiveness was the difference in rates (vaccination rates in the case of the intervention and incidence rates of the illnesses in the cases of the vaccines), and the upper and lower bound in effectiveness were based on the confidence interval (CI) for the difference in rates. The upper bound of the CI for the effectiveness was used to calculate the lower bound of the cost-effectiveness ratio, because greater effectiveness leads to lower cost per quality-adjusted life-year. Similarly, the lower bound of the CI of effectiveness is used to calculate the upper bound of the cost-effectiveness ratio.

<sup>†</sup> All variables are weighted average for the 65- to 74- and 75- to 84-year age strata, where the weights were the number of people in each 10-year age interval in stationary population.<sup>30</sup>
the ranges calculated independently, because the effectiveness of the vaccine had a multiplicative rather than an additive effect.

For the intervention as implemented, the quasi-CI of the influenza vaccine that was calculated from the CI of effectiveness of the intervention ranged from $67,666 to $409,553 per QALY. The interval that was calculated from the CI of effectiveness of the vaccine ranged from $98,179 to $171,428 per QALY. The range was greater for the former, because the lower bound of the CI of effectiveness of the intervention was only 2% and the denominator of that ratio was relatively small. Finally, the interval that was calculated jointly from the CIs of effectiveness of the intervention and the vaccine ranged from $49,606 to $528,852 per QALY.

For the intervention as implemented, the quasi-CI of the combined outreach initiative that was calculated jointly ranged from $33,330 to $46,095 per QALY.

In a 1-way sensitivity analysis using a 5% rather than a 3% discount rate, the cost-effectiveness ratio of the combined outreach initiative was $40,830 per QALY for the intervention as implemented, and $13,428 per QALY for the targeted intervention. The higher discount rate increases the ratios, because it decreases the value of the future benefits in the denominator and it decreases the value of future cost savings in the numerator.

In a 1-way sensitivity analysis using $19,315 as the projected cost of replicating the intervention, the cost-effectiveness ratio for the combined outreach initiative was $26,512 per QALY for the intervention as implemented and $7,843 per QALY for the targeted intervention.

The CEA demonstrated that the combined community-based outreach initiative to promote the pneumococcal
and influenza vaccines had a lower cost per QALY and a narrower quasi-CI than an intervention to promote either vaccine alone. As implemented, the cost-effectiveness ratio of the combined outreach initiative was $35,486 per QALY, whereas it was $53,547 per QALY for the pneumococcal vaccine and $130,908 per QALY for the influenza vaccine. The merits of the combined outreach initiative were even more evident when we assessed the uncertainty of the estimates.

There is no single criterion of a cost-effectiveness ratio below which an intervention should be adopted. The US Panel on Cost-effectiveness in Health and Medicine recommended comparisons relative to other interventions, as presented in the preceding paragraph. As an alternative comparison, note that the median cost-effectiveness ratio of preventive interventions surveyed by 3 Canadian experts classified interventions into 3 categories by their cost-effectiveness ratios: (1) less than $28,000 per QALY, (2) $28,000 to $140,000 per QALY, and (3) more than $140,000 per QALY.\(^4^*\) A ratio in the first category was strong evidence for adoption of an intervention. A ratio in the second category was moderate evidence for adoption of an intervention; some interventions in the second category were routinely provided and others were not. A ratio in the third category was weak evidence for adoption. According to their categories, the combined outreach initiative, as well as independent interventions for the pneumococcal and influenza vaccines, would be in the second category of cost-effectiveness ratios. Considering the uncertainty of the

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**Table 2. Values of Other Variables Used in the Cost-effectiveness Model (cont)**

<table>
<thead>
<tr>
<th>Variable (cont)</th>
<th>Values</th>
<th>Source/Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of hospitalization for P&amp;I</td>
<td>1.55%</td>
<td>CDC(^<em>); this is a weighted average of the probability in epidemic (40%) and non-epidemic years (60%)(^</em>)</td>
</tr>
<tr>
<td>Cost per hospitalization</td>
<td>$69843(^†)</td>
<td>CDC(^†); estimate from Medicare claims; cost estimate included a 20% markup for Medicare Part B physician services; assumes that all treated cases of P&amp;I were reported to Health Care Financing Administration with ICD-9 codes 480-487(^‡)</td>
</tr>
<tr>
<td>Probability of bed-disability days from P&amp;I</td>
<td>13.84%</td>
<td>OTA(^‡); based on total number of work-loss days and housekeeping-loss days per person for people 65 y and older; this was about 2 bed-days per episode of P&amp;I</td>
</tr>
<tr>
<td>Death rate from P&amp;I</td>
<td>126.7/100,000</td>
<td>US National Center for Health Statistics(^‡); weighted average death rate for 1996 for 10-y intervals (65-74 y and 75-84 y), where the weights were the number of people in each age interval in the stationary population(^‡)</td>
</tr>
<tr>
<td>Probability of dying when P&amp;I are eliminated</td>
<td>4.3731%</td>
<td>Based on death rate from P&amp;I, probability of death from all causes, and equation 32 of Chiang(^‡)</td>
</tr>
<tr>
<td>Death rate from all causes</td>
<td>3833.7/100,000</td>
<td>US National Center for Health Statistics(^‡); weighted average death rate for 1996 for 5-y intervals (65-69 y, 70-75 y, etc), where weights were number of people in each age interval in stationary population(^‡)</td>
</tr>
<tr>
<td>Probability of death from all causes</td>
<td>4.5173%</td>
<td>Calculated from weighted average of 5-y survival rates for 5-y age intervals (65-69 y, 70-75 y, etc) (Greg Spengler, PhD, written communication, December 8, 1999), where weights were number of people in each age interval in stationary population(^‡); probability of dying is 1 minus the probability of surviving; 5-y probability was then converted to 1-y probability</td>
</tr>
<tr>
<td>Life-years saved</td>
<td>13.51 y</td>
<td>Anderson(^‡); calculated as weighted average number of years of life remaining for 5-y age intervals (65-69 y, 70-75 y, etc), where weights were number of people in each age interval in stationary population</td>
</tr>
<tr>
<td>Average life expectancy for people between 65 and 85 y old</td>
<td>13.51 y</td>
<td>Anderson(^‡)</td>
</tr>
<tr>
<td>Value of 1 y of average health measured in quality-adjusted life-years (QALYs)</td>
<td>0.71</td>
<td>Erickson et al(^‡); weighted average QALY for 5-y intervals (65-69 y, 70-75 y, etc), where weights were number of people in each age interval in stationary population</td>
</tr>
<tr>
<td>Discounted, quality-adjusted average life expectancy</td>
<td>8.02 QALYs</td>
<td>QALYs in future were discounted to reflect people’s preference for current benefits over future benefits</td>
</tr>
<tr>
<td>Quality of life weight for non-bed disability days</td>
<td>0.6</td>
<td>OTA(^‡)</td>
</tr>
<tr>
<td>Quality of life weight for bed-disability days</td>
<td>0.4</td>
<td>OTA(^‡)</td>
</tr>
<tr>
<td>Discount rate</td>
<td>3%</td>
<td>Weinstein et al(^‡)</td>
</tr>
<tr>
<td>Value of time for people 65 y and older</td>
<td>$9.80/h</td>
<td>US Bureau of Labor Statistics(^‡); Median weekly earning of people 65 y and older divided by 40 hours/wk</td>
</tr>
</tbody>
</table>

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**Table 3. Cost of the Community-Based Outreach Initiative to Promote the Pneumococcal and Influenza Vaccines**

<table>
<thead>
<tr>
<th>Category of Cost</th>
<th>Amount, $</th>
<th>% of Total Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>22,523</td>
<td>90</td>
</tr>
<tr>
<td>Senior center</td>
<td>19,335</td>
<td>77</td>
</tr>
<tr>
<td>Public Health staff</td>
<td>2415</td>
<td>10</td>
</tr>
<tr>
<td>Volunteers</td>
<td>773</td>
<td>3</td>
</tr>
<tr>
<td>Advisory committee</td>
<td>1658</td>
<td>7</td>
</tr>
<tr>
<td>Computer tracking system</td>
<td>895</td>
<td>4</td>
</tr>
<tr>
<td>Materials</td>
<td>25,076</td>
<td>100</td>
</tr>
</tbody>
</table>

Because of rounding, percentages may not total 100.

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\(^*\) One-way sensitivity analysis for individual vaccines indicated that changes in estimates did not affect the cost per QALY by more than $1000.

\(^†\) All cost estimates are adjusted for increases in the price of medical care by means of the Consumer Price Index for medical care.\(^†\)

\(^‡\) ICD-9 indicates International Classification of Diseases, Ninth Revision.
estimates, however, the quasi-CI of the combined outreach initiative ($15145 to $152311 per QALY) was more or less within the second category, whereas the quasi-CIs of an intervention for only the pneumococcal vaccine ($27944 to $218750 per QALY) was between the second and third categories and an intervention for only the influenza vaccine ($49606 to $528852 per QALY) was mostly in the third category.

The analysis also demonstrated that the cost-effectiveness ratio could be reduced by targeting the intervention.
tervention or lowering the cost of the intervention. The cost-effectiveness ratio of a combined outreach initiative targeted to people who had never received the pneumococcal vaccine or who had not received the influenza vaccine in the previous year was $11,711 per QALY, with a quasi-CI of $3,330 to $46,095 per QALY, which was more or less within the first category of interventions. For the intervention as implemented, participants were selected from a list of people aged 65 years and older who lived in specific ZIP code areas. For the targeted intervention, Medicare could provide a list of people for whom claims had been submitted for the pneumococcal and the influenza vaccines each year, and participants could be selected from the list of people aged 65 years and older who were not on the Medicare list in 2 previous years for the pneumococcal vaccine or the previous year for the influenza vaccine. Alternatively, managed care plans and physicians could report lists of patients who received the vaccines each year, and participants could be selected from the list of people aged 65 years and older who were not on the managed care plan and physician list. Note that the cost of the intervention reported above did not include the cost of identifying people for the targeted intervention.

Finally, the CEA of the combined, community-based outreach initiative highlighted the importance of evaluating interventions to promote vaccines and other preventive care. The CEA of the pneumococcal vaccine showed that it was cost saving, and CEs of the influenza vaccine suggested that it was cost saving or that the net cost per vaccine was about $7#. Promoting the pneumococcal vaccine was not effective against pneumococcal pneumonia for high-risk patients, but it raised the possibility that immunocompetent elderly people should not be characterized as high risk. Future research that focuses on the immunocompetence of the elderly rather than on their risk of infection may show that the pneumococcal vaccine is effective against pneumococcal pneumonia among the immunocompetent elderly. Such evidence would reduce the cost-effectiveness ratio for the pneumococcal vaccine and the combined outreach initiative.

Finally, the value of the effectiveness of the influenza vaccine on mortality in our estimates was limited to mortality from pneumonia and influenza. Again, we chose this approach so that our estimates could be compared with previous research that focused only on the costs of the vaccine. This approach assumed that most of the illness attributed to influenza during an epidemic would be reported with diagnostic codes for pneumonia and influenza. There was evidence from case-control studies, albeit mixed, that the influenza vaccine affected mortality from other causes in addition to pneumonia and influenza. The vaccine significantly reduced mortality from all causes and hospital deaths from all causes among elderly people living in the community. Mullooly et al, however, reported that the influenza did not significantly reduce hospital deaths among high-risk elderly living in the community. Limiting the effectiveness to mortality from pneumonia and influenza could represent an upward bias in the cost-effectiveness ratio.

The community-based outreach initiative to promote the pneumococcal and influenza vaccines was reasonably cost-effective at $35,486 per QALY. Further improvements in cost-effectiveness could be made by targeting the intervention to people who had never received the pneumococcal vaccine or who had not received the influenza vaccine in the previous year. Lessons learned during the first year of implementation would also reduce the cost of the outreach initiative in subsequent years.
REFERENCES


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