ABSTRACT

Objectives: This study evaluates the clinical and economic benefits of routine infant vaccination with the 7-valent pneumococcal conjugate vaccine (Prevenar®, PCV7) in Taiwan.

Methods: A decision-analytic model was populated with local age-specific incidence and seroprevalence data obtained from the National Health Insurance database (NHI) and published literature to simulate the expected health outcomes resulting from universal PCV7 vaccination of an annual birth cohort of ~204,000 children compared to an unvaccinated cohort over a ten-year horizon. Primary analyses were conducted from a payer perspective, with local direct costs associated with the treatment of pneumococcal disease derived from the NHI database (2002-2006). Vaccine efficacy rates for PCV7 were consistent with results from the Northern California Kaiser Permanente pivotal efficacy trial. The reduction in adult IPD cases and associated cost avoidance due to indirect (herd) protection was estimated in line with published overseas rates. One-way sensitivity analyses were performed to evaluate the sensitivity of the model findings to plausible variation in specific data inputs.

Results: In the birth cohort alone, universal PCV7 vaccination was estimated to prevent hundreds of IPD cases over a ten-year horizon, leading to a significant reduction in direct medical costs. Substantial cost savings were further generated when the impact of vaccination on all-cause pneumonia and otitis media was also considered. Indirect protection extended to the unvaccinated population led to a reduction of thousands of adult cases of IPD. From a payer perspective, universal PCV7 vaccination was estimated to have an incremental cost per life year gained of NT$374,573 (US$11,925) in the base case. Outcomes generated in secondary analyses were equally cost-effective.

Conclusion: With reference to the World Health Organization’s threshold for cost-effectiveness, results from this study indicate routine infant vaccination with PCV7 is a cost-effective intervention in Taiwan.

BACKGROUND

Streptococcus pneumoniae is a bacterial pathogen responsible for significant morbidity and mortality worldwide. Infection with S. pneumoniae may be invasive (meningitis, bacteremia and bacteraemic pneumonia) or non-invasive (pneumonia and otitis media) depending on the site of infection. In Taiwan, pneumococcal disease is a major health care burden, particularly in young children and the elderly. In 2006, all-cause pneumonia was recorded as the sixth most common cause of death (n=5,396) in Taiwan.1

The World Health Organization (WHO) considers that the 7-valent pneumococcal conjugate vaccine (PCV7) should be a priority for inclusion in national childhood immunization programs to reduce the heavy burden of pneumococcal disease worldwide.2

Assessments of the cost-effectiveness of public health interventions are assuming increasing influence in assisting decision-making in the Asia Pacific region. With increasing pressures on healthcare expenditure, an economic evaluation of universal infant vaccination with PCV7 is a useful decision tool for policy-makers to justify vaccine introduction as a worthwhile public health intervention in Taiwan.

OBJECTIVES

To evaluate the clinical and economic benefits of universal infant vaccination with PCV7 in Taiwan.

METHODOLOGY

A decision-analytic economic model developed in the UK3,4 was adapted to the Taiwanese population using local epidemiological and seroprevalence data to simulate the expected health outcomes resulting from universal PCV7 vaccination of a birth cohort of 204,459 infants compared with no vaccination over a ten-year time horizon (Figure 1).

In the primary analysis, the average cost of treatment for each clinical presentation of pneumococcal disease was determined from a payer perspective, and was estimated from two independent sources:

- National Health Insurance Database (2002-2006)
- Decision analysis tree constructed by Dr. Yu-Chering Huang

The cost of introducing a universal vaccination program included both PCV7 vaccine acquisition and administration costs. Direct costs associated with the management of pneumococcal disease, including hospitalization, healthcare professional consultation fees, ICU admissions, medications, diagnostic tests and long-term treatment costs for complications were included in the analysis. In the instance where local cost data was unavailable, published UK costs5 were converted to New Taiwan Dollars (NT$) and inflated to present values.

The primary analysis assumed PCV7 vaccinations were administered as a series of 4 doses at 2, 4, 6 and 12 months of age.

Vaccine efficacy rates observed in the Northern California Kaiser Permanente pivotal efficacy trial were applied, namely a 97.4% reduction in episodes of pneumococcal meningitis and bacteremia, a 6% reduction in all-cause pneumonia and a 7% reduction in all-cause otitis media.6 Efficacy rates against pediatric cases of all-cause pneumonia and otitis media were varied in secondary analyses, in line with published overseas effectiveness data, i.e. 39% reduction in all-cause pneumonia7 and 42.7% reduction in acute otitis media.8 The impact of using the vaccine efficacy rate for radiologically-confirmed pneumonia, according to the World Health Organization’s radiological criteria for pneumonia diagnosis i.e. 26% (95% CI: 6.5% to 40.7%), was also considered in an additional analysis.

Indirect effects (herd protection) of PCV7 on unvaccinated adult populations were also considered by calculating the reduction in adult cases of IPD and associated cost savings, in line with published rates from the US experience.9 The mid-point estimate for the indirect effect was used in the primary analysis, namely 32% (range: 23-41%) for adults aged 20-39 years; 8% (range: 1-20%) for adults aged 40-64 years and 18% (range: 11-31%) for adults aged ≥65 years.

The cost-effectiveness of a universal PCV7 vaccination program was calculated in terms of cost per life-year gained (CLYG).

A discount rate of 3% was applied to both costs and benefits in the primary analysis. A series of one-way sensitivity analyses were performed to evaluate the sensitivity of the model findings to plausible variation in specific data inputs, including vaccine efficacy, the discount rate, disease incidence and serotype coverage.

Figure 1: Decision Analytic Model
RESULTS

Pneumonia was identified as the most common clinical presentation of pneumococcal disease after 12 months of age in pediatric patients (Figure 2).

Figure 2: Incidence of Pediatric IPD and All-Cause Pneumonia in Taiwan

Using costs from the NHI database, universal vaccination with PCV7 had a discounted incremental CLYG of NT$374,573 (US$11,925) from a payor perspective when the indirect effect was considered (Table 4). In a secondary analysis using costs from the decision tree, the discounted incremental CLYG was reduced to NT$371,815 (US$11,837).

By assuming 24% of all-cause pneumonia in adults was attributable to S. pneumoniae, in line with local rates, an additional 4,122 cases of pneumonia were estimated to be indirectly prevented, further reducing the incremental cost-effectiveness ratio to NT$358,271 (US$11,406) per discounted life year gained.

Table 4: Incremental Cost-effectiveness of PCV7 in Taiwan

<table>
<thead>
<tr>
<th>Payor Perspective – NHI Database</th>
<th>Incremental Cost per Life-Year Gained (CLYG) (NT$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Indirect Effects</td>
<td>$374,573 (US$11,925)</td>
</tr>
<tr>
<td>No Indirect Effects</td>
<td>$7,946,161 (US$252,982)</td>
</tr>
<tr>
<td>Payor Perspective – Decision Tree Analysis</td>
<td>Incremental Cost per Life-Year Gained (CLYG) (NT$)</td>
</tr>
<tr>
<td>With Indirect Effects</td>
<td>$371,815 (US$11,837)</td>
</tr>
<tr>
<td>No Indirect Effects</td>
<td>$7,892,616 (US$251,777)</td>
</tr>
</tbody>
</table>

*August 2008 exchange rate. US$=NT$ 31.41

Varying the vaccine efficacy rates for pediatric all-cause pneumonia and otitis media in line with effectiveness data from the US, further reduced the incremental cost-effectiveness ratios (Table 5).

Table 5: Impact of Vaccine Efficacy Against Pediatric Cases of All-Cause Pneumonia and Otitis Media

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Efficacy (%)</th>
<th>Incremental Cost per Life Year Gained (NT$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary Analysis</td>
<td>Secondary Analysis</td>
</tr>
<tr>
<td></td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>Otitis Media</td>
<td>$374,573</td>
<td>$372,331</td>
</tr>
<tr>
<td>All-Cause Pneumonia</td>
<td>$7,946,161</td>
<td>$7,796,697</td>
</tr>
<tr>
<td>With Indirect Effects</td>
<td>$371,815</td>
<td>$372,688</td>
</tr>
<tr>
<td>Without Indirect Effects</td>
<td>$7,892,616</td>
<td>$7,909,569</td>
</tr>
</tbody>
</table>

DISCUSSION

The World Health Organization CHOICE (CHOosing Interventions that are Cost-Effective) group has developed guidelines on generalized cost-effectiveness analyses for public health interventions and indicate that an appropriate threshold of cost-effectiveness is 3 times the GDP per capita. With respect to this threshold, universal PCV7 vaccination would be considered cost-effective in Taiwan if the CLYG is below NT$494,578 (using 2005 Taiwan GDP per capita of NT$498,326).

The indirect benefit extended to unvaccinated individuals following routine infant PCV7 vaccination has been reported in several countries, including the US, where it is estimated that PCV7 has prevented more than twice as many IPD cases through indirect effects than through its direct effect of protecting vaccinated children. Given the substantial impact of the indirect effect on disease burden, an economic evaluation would be considered incomplete if this effect was not included. It is clear from our present study that, by including the adult IPD cases prevented due to the indirect effect, PCV7 becomes highly cost-effective with respect to the WHO’s threshold for cost-effectiveness.

CONCLUSION

In Taiwan, universal infant PCV7 vaccination is expected to lead to a substantial reduction in the incidence of all clinical presentations of pneumococcal disease in both children and adults. With reference to the WHO’s threshold for cost-effectiveness, universal infant vaccination with PCV7 is a cost-effective intervention. This study will be useful to inform vaccine policy in Taiwan.

REFERENCES

12. CDC (Centers for Disease Control and Prevention), MMWR 2008; 57(48): 1093-393.