A Cost-effective Analysis of Vaccinating the Elderly with 23-valent Pneumococcal Polysaccharide Vaccine (PPV23) in Germany

Jiang Y1, Gauthier A1, Annemans L2, van der Linden M3, Nicolas-Spony L4, Bresses X5
1Amaris Consulting UK, London, United Kingdom, 2Ghent University, Ghent, Belgium, 3National Reference Centre for Streptococci, Aachen, Germany, 4Sanofi Pasteur MSD, Lyon, France

BACKGROUND & OBJECTIVES

- Streptococcus pneumoniae can cause non-invasive (pneumonia) and invasive pneumococcal diseases (IPD: meningitis, bacteraemic pneumonia and bacteraemia) and results in high morbidity and mortality worldwide, including 1.6 million deaths annually. In Germany, approximately 1,200 death occur each year due to IPD [1,2,3].
- Children, people with immunodeficiency or chronic diseases and the elderly are particularly vulnerable to S. pneumoniae infection. Vaccination appears to be the only public health action that could reduce the impact of IPD [1,2,4,5].
- In Europe, the 23-valent pneumococcal polysaccharide vaccine (PPV23) is the only pneumococcal vaccine indicated in adults, and it covers 80% to 90% of serotypes causing IPD. In Germany, it has been recommended and funded in individuals aged 60 and older since 1998 [6,9].
- In the US, the implementation of the PCV (pneumococcal conjugate vaccine) vaccination programme in children led, ten years after its introduction, to a decrease in the incidence of IPD caused by serotypes covered by the PCV vaccine, and to an increase in IPD caused by the non-PCV serotypes [10].
- This study aimed to assess the cost-effectiveness of PPV23 in the elderly in Germany, accounting for the decreased IPD incidence induced by the PCV/13 vaccination of children.

METHODS

Target population:
- All individuals aged 60 years and older, including low-risk, immuno-suppressed and immunocompetent individuals.

Modelling approach:
- A population-based Markov model was developed, consisting of five health states: no pneumococcal disease, IPD, non-bacteraemic pneumococcal pneumonia (NBPP), post-menigitis sequelae and death (Figure 1). The approach was in line with the official recommendations [11] as well as published literature [12].
- The model accounted for changes in the incidence of IPD. After the introduction of PCV7/13 in infants and children in Germany, the incidence of IPD associated with the three PCV13 serotypes was assumed to decrease in adults while the incidence associated with serotypes covered by PPV23 but not PCV13 was assumed to increase. The assumptions were based on data observed in the US, where the increase and decrease in incidence observed in adults were fitted using a gamma distribution as a function of cumulative coverage rate observed in the children [10].
- The model followed a cohort of individuals receiving initial vaccination in 2011 until 100 years of age. The cohort consisted of 651,532 individuals, corresponding to 3% of the German population aged 60 years and older.
- The model compared PPV23 to no vaccination.
- Costs were estimated from the third-party payers’ perspective. Both costs and utilities (in QALYs) were discounted at 3.0%.

Data sources: the following parameters were applied in the model.

<table>
<thead>
<tr>
<th>Data point</th>
<th>Description</th>
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<tbody>
<tr>
<td>Demography</td>
<td>Population size and life table by age and year were obtained from Statistisches Bundesamt Deutschland [11].</td>
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</tbody>
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Size of the target population by risk group
Estimated based on the size of the eligible population of influenza vaccination (3.86,965, i.e., 12.83%, ±0.05%) [14].

IPD and NBPP incidence
The model applied the incidence of IPD observed in North-Rhine Westphalia, Germany (from 8.5 to 24.9 per 100,000 inhabitants in different age groups) [1] and distribution by serotype [15]. Relative risks of developing IPD by risk group (i.e., 4.9 ± 0.5; i.e., 5.5 ± 0.5) were estimated from a US study [16].

IPD incidence 

<table>
<thead>
<tr>
<th>Disease</th>
<th>Rate per 100,000</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pneumococcal disease</td>
<td>0.0</td>
<td>-</td>
</tr>
<tr>
<td>IPD</td>
<td>12.83</td>
<td>11.48-14.20</td>
</tr>
</tbody>
</table>

Vaccine effectiveness
The vaccine effectiveness was obtained from published literature [17]. 64% against IPD in adults and 55% against IPD in children were assumed to be 100% vaccinated. The vaccine effectiveness against NBPP was assumed to be 0% [17].

Mortality
The proportion of meningitis in IPD (8.2%) was estimated based on German data [18]. The price of PPV23 was 30.25 €.

Costs
Baseline utilities (ranges from 0.51 to 0.77) and utility value associated with IPD (0.20-0.34 days) were obtained from a US cost effectiveness study in no German data was identified [19]. Utility due to NBPP was not accounted for in the model as in a previously published German cost-effectiveness study [20]. Utility multipliers associated with post-menigitis sequelae were obtained from a study (0.80 for hearing loss and 0.60 for others) [11].

Utilities

<table>
<thead>
<tr>
<th>Disease</th>
<th>Baseline utility</th>
<th>Utility multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pneumococcal disease</td>
<td>0.77</td>
<td>1.00</td>
</tr>
<tr>
<td>IPD</td>
<td>0.51-0.77</td>
<td>1.00</td>
</tr>
</tbody>
</table>

RESULTS

- Vaccinating the cohort of individuals aged 60 or older in 2011 was associated with an incremental cost-effectiveness ratio (ICER) of 12,875 € per QALY gained.
- Despite the decrease in IPD incidence among adults due to universal childhood vaccination with PCV7/13, vaccinating the elderly with PPV23 is still cost-effective. Assumptions on future trends on incidence led to an ICER ranging from 0.287 € to 14,699 € per QALY gained.
- A deterministic sensitivity analysis was conducted and demonstrated that vaccinating the elderly with PPV23 remained a cost-effective option in all cases except when assuming no effect against NBPP (85.569 € per QALY gained, see Figure 2). A vaccine effectiveness of 7% against NBPP was sufficient to reach an ICER of 50,000 € per QALY gained.
- Results were not sensitive to utility values associated with the IPD and NBPP health states.

CONCLUSION

- Although the vaccination of children against the pneumococcal diseases has resulted in a decreased IPD incidence in adults, vaccinating adults aged 60 or older with PPV23 remains cost-effective in Germany.
- A broad serotype coverage is important to prevent in a context of changing epidemic among pneumococci.

ACKNOWLEDGEMENT & REFERENCES

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