Comparing Health Outcomes and Costs of General Vaccination with Pneumococcal Conjugate Vaccines in Sweden: A Markov Model

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ABSTRACT

Background: Two new pneumococcal conjugate vaccines were licensed to immunize infants and young children against pneumococcal disease.

Objectives: The objective of this study was to estimate the expected health benefits, costs, and incremental cost-effectiveness of routine vaccination with the 10-valent pneumococcal nontypeable hemophilus influenza protein-D conjugate vaccine (PHiD-CV) compared with the 13-valent pneumococcal conjugate vaccine (PCV13) in Sweden.

Methods: A Markov cohort model was used to estimate the effect of vaccination at vaccine steady state, taking a societal perspective and using a 2+1 vaccination schedule. Price parity was assumed between the vaccines. Outcomes were measured by reduction in disease burden, costs, quality-adjusted life–years (QALYs) and incremental cost-effectiveness ratio.

Results: The results predicted that PCV13 would prevent 3 additional cases of invasive pneumococcal disease and 34 additional cases of pneumonia, whereas PHiD-CV would avoid 3 additional cases of mastoiditis, 1010 tube insertions, and 10,420 cases of ambulatory acute otitis media compared with PCV13. By combining morbidity and mortality benefits of all clinical outcomes, PHiD-CV would generate 45.3 additional QALYs compared with PCV13 and generate savings of an estimated 62 million Swedish kronors.

Conclusion: The present study predicted lower costs and better health outcome (QALYs) gained by introducing PHiD-CV compared with PCV13 in routine vaccination. Our results indicated that PHiD-CV is cost-effective compared with PCV13 in Sweden. (*Clin Ther*. 2012;34:177–189)

Key words: cost-effectiveness analysis, costs, health outcomes, PHiD-CV, PCV13, pneumococcal disease, vaccine

INTRODUCTION

Streptococcus pneumoniae (*S pneumoniae*) is an important cause of respiratory disease worldwide. It can cause disseminated invasive pneumococcal diseases (IPDs) such as bacteremia and meningitis; noninvasive lower respiratory tract infections such as pneumonia; and noninvasive upper respiratory tract infections, including sinusitis and acute otitis media (AOM).[1] IPD appears in all ages, but the peak incidence is seen in young children and among the elderly.

Haemophilus influenzae (*H influenzae*), a gram-negative coccobacillus that colonizes the human nasopharynx, is another major cause of infection, particularly in young children.[2] Nontypeable *Haemophilus influenzae* (NTHi) is most commonly linked with mucosal disease, such as OM and sinusitis.[3] In addition to these noninvasive infections, NTHi can also cause invasive disease (ID), such as meningitis and bacteremia.

There are 3 pediatric vaccines available to protect against *S pneumoniae* and related diseases. The 2 most recently introduced are (1) PHiD-CV,* a 10-valent conjugate vaccine that includes 10 serotypes (1, 4, 5, 6B, 7F, 9V, 14, 18C, 19F, and 23F) and uses a carrier protein derived from NTHi for 8 of the 10 serotypes included (By utilizing protein D from NTHi as a carrier protein, PHiD-CV may offer additional protection

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*Trademark: Synflorix® (GlaxoSmithKline, Solna, Sweden).

against NTHi); and (2) PCV13,[†] a 13-valent conjugate vaccine that includes 13 serotypes (1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F, and 23F). Like its predecessor, PCV7,[‡] PCV13 makes use of the CRM_{197} carrier protein and is therefore not expected to have an effect on disease caused by NTHi.

Several health economic analyses of pneumococcal vaccinations have previously been performed in Sweden and worldwide.[4–7] Most of these studies, however, explored the health economic impact of the 7-valent vaccine. With additional vaccines on the market, there is a need for new health economic analyses comparing the newer vaccines and the consequences on costs and effects, especially with respect to their differences in mode and breadth of protection.

For this reason, a Markov cohort model was built to simulate the epidemiologic burden of pneumococcal- and NTHi-related diseases (ID, pneumonia, and AOM) within a specific age cohort followed over a lifetime. The model can be applied to different epidemiologic situations, health care settings, and economic contexts, and can be used to evaluate different vaccination strategies.

The objective of this study was to estimate the expected health outcomes, costs, and incremental cost-effectiveness ratio (ICER) of routine vaccination with the 10-valent pneumococcal NTHi PHiD-CV compared with PCV13 in Sweden. The results aimed to demonstrate what the real life impact of vaccination could be if the vaccines were routinely used in Swedish infants.

PATIENTS AND METHODS

Model Structure and Analytical Approach

The model used for this analysis was a Markov cohort model developed in Microsoft Office Excel (2007; Microsoft, Redmond, Washington). Cohort models are particularly useful for determining the direct effect of medical interventions, which was the primary focus of this analysis. The approach was, however, less appropriate to assess the indirect effects of vaccination; therefore, it was less adequate for comparisons of vaccination versus no vaccination. The cohort model was developed at vaccine steady state. It simulated the disease process of ID, pneumonia, and AOM caused by *S pneumoniae* and NTHi in a birth cohort that was followed over lifetime with monthly cycles (n = 1200, or 100 years). The 3 disease types were further divided into 9 specific health care conditions, which together with "no disease" and "death," comprised the 11 health states analyzed in the model (Table I). These states were defined to capture the majority of the economic and health consequences of vaccination and were based on a previous model study commissioned by the National Board of Health and Welfare to evaluate if universal pneumococcal vaccination for children should be introduced in Sweden.[4]

Table I. Model disease states.

Hospitalized pneumococcal meningitis without long-term sequelae	ID
Hospitalized pneumococcal meningitis with long-term sequelae	ID
Hospitalized bacteremia without long-term sequelae	ID
Hospitalized bacteremia with long-term sequelae	ID
Hospitalized pneumonia	CAP
Nonhospitalized pneumonia	CAP
Myringotomies	AOM
Non-hospitalized AOM without complications	AOM
Mastoiditis	AOM
No pneumococcal disease	
Death	

AOM = acute otitis media; CAP = community-acquired pneumonia; ID = invasive disease.

For each vaccination scenario, the model estimated the expected effect of vaccination for each disease state (Figure 1). The number of pneumococcal- and NTHi-related outcomes, the number of deaths, and the number of survivors with sequelae were calculated. Costs and quality of life specific to each health state were estimated and summarized over the cohort's lifetime to calculate total accumulated costs and quality-adjusted life–years (QALYs). ICERs were computed, comparing the marginal benefits and costs of the 2 vaccination strategies (ie, PHiD-CV vs PCV13).

In base case, a 2+1 vaccination schedule (at 3, 5, and 12 months) was assumed because this schedule is currently used in Sweden. Vaccination coverage was assumed to be 100% (actual ~95%–98%), which might slightly overestimate the value of vaccination versus no vaccination, but should not distort the comparison between the different vaccines. Costs were in

[†]Trademark: Prevenar 13® (Pfizer Inc, New York, New York).
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