Towards the introduction of pneumococcal conjugate vaccines in Bhutan: A cost-utility analysis to determine the optimal policy option

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1. Introduction

Pneumococcal disease is an infection caused by the Streptococcus pneumoniae (S. pneumoniae) bacteria [1]. This infection can result in meningitis, bacteraemia, pneumonia, and acute otitis media (AOM). Pneumonia has been a leading cause of child morbidity and mortality globally, accounting for about 1.6 million deaths annually in children under five years of age [2]. Incidence and mortality rates are high in low-income countries with the majority of pneumococcal deaths occurring in Africa and Asia. To combat pneumococcal disease, various types of vaccines have been developed. Currently, 10-valent pneumococcal conjugate vaccine (PCV10) and 13-valent pneumococcal conjugate vaccine (PCV13) are available on the market, which have proven to be safe and efficacious against S. pneumoniae [3]. The high burden of pneumococcal disease in developing countries has led to global efforts in expanding the access to vaccines in these regions.

Bhutan is a lower middle-income country located in South Asia where pneumococcal infections remain a major cause of morbidity and mortality among young children. In 2015, there were 349 cases of meningitis and 10,891 cases of pneumonia [4]. The case fatality rate of meningitis due to S. pneumoniae was 7%. The Bhutanese government spends a large amount of health budget on the
treatment of pneumococcal disease, which also have high societal costs. The National Committee for Immunization Practice, an independent technical advisory committee to advice and guide the Ministry of Health, Bhutan, recommended the introduction of pneumococcal conjugate vaccines in the country, that was needed to conduct an economic evaluation.

The Expanded Programme on Immunization was first launched in Bhutan in 1979. The programme maintains high coverage with a routine immunization package. Bhutan has graduated from Gavi, the Vaccine Alliance’s support in 2016 as its economic classification status has changed from a low income to lower-middle income country. As such, considerations around value for money and financial sustainability of the routine vaccination programme are of critical importance to Bhutan because introducing new vaccines poses a direct and long-term financial burden to the government. Prior to the introduction of the vaccines, the World Health Organization’s Strategic Advisory Group of Experts on Immunization recommends all member states to conduct a systematic decision making process based on review of evidence from cost-effectiveness analysis and budget impact analysis studies [5]. Subsequently, the High Level Committee, the highest decision making body in the Ministry of Health, Bhutan, directed to conduct a cost-utility analysis of PCVs to inform policy decision and vaccine implementation.

In response to policy makers in Bhutan, this study aimed to determine the costs, outcomes and cost-effectiveness of the introduction of PCV10 and PCV13 compared to a no vaccination policy. In addition, the study also determined the feasibility of the vaccination policy by assessing human resource on health impact and 5-year budget impact for introduction of pneumococcal conjugate vaccines.

2. Methods

A model-based cost-utility analysis (CUA) was performed and government perspective was considered for the study. A Markov model was constructed to estimate the costs and health outcomes of infants using a lifetime horizon with a 3% discount rate per annum. Each of the three policy options, namely no vaccination, PCV10, and PCV13 were evaluated. The vaccine schedule was two-dose primary series at 2 months and 4 months, and one booster at 12 months of age (2 + 1 schedule). Health outcomes measured included number of pneumococcal episodes averted, number of deaths prevented due to the vaccination programme and quality-adjusted life year (QALY). The incremental cost-effectiveness ratio (ICER) was presented as cost in United State Dollar (USD) per QALY gained (USD 1 = Bhutanese Ngultrum 65).

2.1. Model structure and assumptions

A Markov model with one-year length of cycle was adapted from a Thai study [6] to compare costs and health outcomes of PCVs with no PCV programme for each age-specified cohort as seen in Fig. 1. The model assumes that vaccinated and unvaccinated individuals can experience each three different health events: no infection, S. pneumoniae infection, and death from all other causes. S. pneumoniae infection leads to four main diseases including meningitis, bacteraemia, pneumonia and AOM. Moreover, meningitis is associated with sequelae such as epilepsy, hearing loss, and neurodevelopment impairment, as well as AOM causes hearing loss. A cost-utility of vaccination programme for a single hypothetical birth cohort born in 2016 was simulated for a lifetime horizon which means that all individuals in this group are followed until transition to the death state at a maximum of 100 years of age. For a budget impact analysis, vaccination on hypothetical cohorts of infants born during 2016–2020 were examined over a period of five years. Two vaccine scenarios i.e. with and without indirect effects were modeled.

2.2. Model input parameters

2.2.1. Epidemiological data

The disease incidence rates of meningitis, bacteraemia, pneumonia, and acute otitis media were derived from the Annual
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