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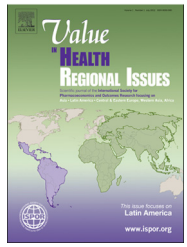

Cost-Effectiveness Analysis of Pneumococcal and Influenza Vaccines Administered to Children Less Than 5 Years of Age in a Low-Income District of Bogota, Colombia

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ABSTRACT

Background: The Colombian health authorities introduced the pneumococcal conjugated vaccine and the seasonal influenza vaccine into the national immunization schedule for children in 2009 and 2007, respectively. Despite this, the health authorities continue to be concerned about the high economic and disease burden among children from low-income households caused by these vaccine-preventable diseases. **Objectives:** 1) To evaluate the potential health outcomes of four vaccination strategies for subsidized children younger than 5 years in a low-income district in Colombia from a public, direct medical health care perspective. 2) To perform univariate, multivariate, and probabilistic sensitivity analysis to evaluate the robustness of these results. **Methods:** We built a Markov deterministic cohort model to evaluate five consecutive cohorts across four alternative situations: 1) no vaccination; 2) vaccination with the 10-valent pneumococcal conjugate vaccine (PCV10 vaccine); 3) vaccination with the trivalent inactivated vaccine (TIV) annually; and 4) combined vaccination with PCV10 vaccine and TIV. **Results:** The introduction of PCV10 vaccine and TIV and their combined use in particular would be highly cost-effective in comparison to no vaccination. For the combined vaccination with PCV10 vaccine and TIV, the incremental cost-effectiveness ratio would be $1,280 per disability-adjusted life-year (DALY) averted, the total incremental cost of the vaccination program would be $776,800, and it would avert four deaths and 332 DALYs for the five cohorts. **Conclusions:** The introduction of PCV10 vaccine and TIV would be highly cost-effective from a public, direct medical health care perspective. Despite these results, we have not observed decreases in severity or hospitalizations. Our findings highlight the need for further studies of the immunization campaign indicators and socioeconomic indicators for this low-income community.

Keywords: Colombia, cost-benefit analysis, influenza vaccines, pneumococcal vaccines.

Introduction

Influenza viruses and *Streptococcus pneumoniae* are significant pathogens that affect humans and are responsible for the majority of pneumonia morbidity and mortality worldwide [1,2]. The World Health Organization (WHO) estimated that 476,000 deaths were caused by pneumococcal infections in 2008 [3]. The pneumococcal disease rates and mortality are higher in developing countries than in industrialized settings [3]. In addition, *Streptococcus pneumoniae* is primarily responsible for otitis media, meningitis, and other clinical conditions such as sepsis and bacteremia [2,4]. The WHO assessed that the morbidity and mortality from influenza are likely to be underestimated in the tropics and subtropics. A systematic review covering 30 years of seasonal influenza epidemiology in sub-Saharan Africa showed that, on average, influenza accounted for about 10% (range 1%–25%) of all outpatient visits and for about 6.5% (range 0.6%–15.6%) of hospital admissions for acute respiratory infections (ARIs) in children [5,6].

In Colombia, the burden of disease caused by these two pathogens is also significant, particularly in children younger than 5 years [7–9]. To control and decrease the impact of diseases caused by pneumococcus and seasonal influenza viruses, Colombia introduced a heptavalent pneumococcal conjugated vaccine, PCV7, for children in 2009 [10] and subsequently changed to a decavalent pneumococcal conjugated vaccine (PCV10 vaccine) in 2011 [9,11]. The seasonal influenza vaccine was also included in the national immunization schedule for children aged between 6 and 18 months in 2007 and was extended to children aged between 6 and 60 months in 2009 [12,13]. Despite the introduction of these vaccines, the national health authorities continue to be concerned by the economic and high disease burden among children in the low-income strata. In fact, an increasing trend in the number of hospitalizations and mortality rates due to ARIs was observed for children younger than 5 years in the San Cristobal district of Bogota, Colombia [14]. This increase in ARIs among children from low-income households is particularly concerning [7,15].

Conflicts of interest: The authors declare that they have no conflicts of interest.

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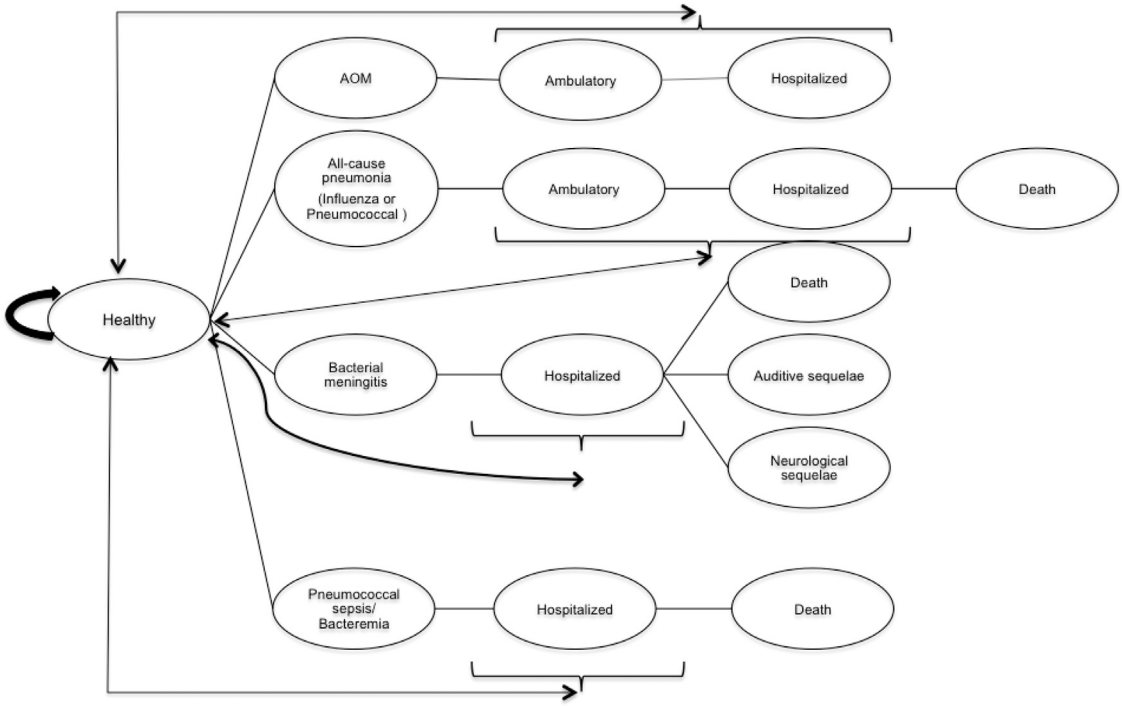

Fig. 1 – Diagram of the Markov and disease model. AOM, acute otitis media.

As a response to the national authorities' concern, we evaluated the theoretical health outcomes and economic effects of the introduction of these vaccines using a cost-effectiveness analysis in the subsidized population younger than 5 years in this low-income district of Bogota, Colombia. Restriction of the study to the subsidized population means we could capture children in the low-income strata. At the national level, the population of San Cristobal is covered by two health care regimes: contributive and subsidized. The contributive system, representing 62.1% of the district population, includes patients who can afford a premium rate calculated on the basis of the revenue of the patient. The subsidized regime, representing 37.9% of the district population, consists of patients who are not able to pay a premium rate for health care, but are allowed to seek a range of health services from the public health care providers [14–16].

Objectives

1. To evaluate the potential health outcomes—including disability-adjusted life-years (DALYs) averted, total number of deaths averted, and total life-years gained; incremental vaccination program costs; public health care system costs averted; and cost effectiveness—of the following strategies: 1) no vaccination; 2) vaccination with PCV10 vaccine for each annual birth cohort; 3) vaccination with seasonal influenza vaccine; and 4) combined vaccination with seasonal influenza vaccine and PCV10 vaccine. We assessed whether the intervention was cost-effective based on the main outcome: the incremental cost-effectiveness ratio (ICER) per DALY averted.
2. To perform univariate, multivariate, and probabilistic sensitivity analysis to evaluate the robustness of these results. We included a societal perspective in an attempt to capture a more complete scenario in the results.

Methods

Model

We built a Markov deterministic cohort model to estimate the incremental cost effectiveness of four vaccination strategies for children younger than 5 years in the San Cristobal district of Bogota, Colombia, for five consecutive birth cohorts.

The four vaccination strategies were as follows: 1) no vaccination; 2) vaccination with PCV10 vaccine for each annual birth cohort; 3) vaccination with seasonal influenza vaccine for children younger than 5 years; and 4) vaccination with seasonal influenza vaccine and PCV10 vaccine for children younger than 5 years. The national authorities do not recommend sole administration of influenza vaccine or PCV10 vaccine; however, these strategies were included for comparison purposes.

The analysis considered a public, direct medical health care perspective and a more general societal perspective for scenario analyses. Costs are reported in 2008 international dollars ($), with discounted costs and health outcomes at 3% per year, as recommended by the WHO [17].

In our model, children are annually vaccinated with the seasonal influenza vaccine. The annual birth cohorts receiving the PCV10 vaccine were vaccinated once during the 5-year time frame of the study according to the following schedule: first dose at age 2 months, second dose at age 4 months, and third booster dose at age 12 months. Figure 1 represents the Markov model and is based on and adapted from the models of Smith et al. [18] and Clark et al. [19]. All infants start the simulation in the "Healthy" state. During each annual cycle of the model, patients can do either of the following:

A. Remain "healthy."
B. Develop "all-cause acute otitis media" (AOM) with ambulatory treatment followed by recovery to the "healthy" state, or