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How cost effective is universal varicella vaccination in developing countries? A case-study from Colombia

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ABSTRACT

Objective: Varicella vaccination has not been introduced worldwide, especially in developing countries. The present study assesses the potential epidemiological and economic impact of one-dose and two-dose varicella vaccination schemes in Colombia, a south American upper middle-income country.
Methods: A decision-tree based model was developed. Varicella cases were estimated based on previous reports of seropositivity within the country. Cost per life-year gained (LYG) was the main outcome measure. Costs from the health care system perspective were expressed in 2008 American dollars. Deterministic and probabilistic sensitivity analyses were performed.
Results: In Colombia, there would be 700,197 varicella cases in an average year plus 60 yearly deaths without vaccination. It was estimated that health care costs for all cases during 30 years period could be around US $88,734,735 (with discount). Cost per LYG of one-dose vaccination was US $2519 and using a two-dose scheme was US $5728.
Conclusion: Vaccinating against varicella in Colombia, an upper middle-income South American country is cost-effective under the assumptions used in this study. Decision-makers should consider introducing universal varicella vaccination in Colombia, given the effectiveness, safety and cost-effectiveness of this intervention.

1. Introduction

Varicella is a highly contagious disease caused by the varicella-zoster virus (VZV) [1–4]. Symptomatology of varicella (or chickenpox) is usually mild and self-limited, although some cases may have severe complications, especially in adults, infants, and immunocompromised subjects [5]. The varicella vaccine has been added to the immunization schedule of 26 countries worldwide [6], but questions remain about two possible secondary effects: an increase of the disease in adults, where the risk of complications is greater [7,8], and the increase in herpes-zoster (HZ) due to the possible lack of boost-effect provided by varicella circulation in children [9–11]. Two recent population-based studies found that HZ does not increase after the introduction of the vaccine [12,13], and varicella burden of disease has decreased significantly in the United States since the introduction of this vaccine [14,15], although this study may have serious limitations [16].

The implementation of the varicella vaccine in developing countries has been slow, and little is known about the burden of disease in these countries [6]. In Latin America, only five countries have introduced the vaccine: Uruguay, Ecuador, Costa Rica, Argentina and Brazil. Colombia is a South American country that has not introduced universal varicella vaccination in its schedule. The relatively mild disease and lack of epidemiological evidence on fatalities associated to varicella disease have not allowed making appropriate recommendations to health decision-makers in this upper middle-income developing country.

Seroprevalence studies have been reported so far in Latin America for at least five countries [17–21], including Colombia. Seroprevalence goes from 69.5% in Bogota (Colombia), to 98.5% in Buenos Aires (Argentina). However, there are few studies in Latin America and the Caribbean about the convenience or not of introducing varicella vaccination. Brazil is the only country that has previously performed a cost-effectiveness analysis of the introduction of the varicella vaccine in their expanded program on immunization (EPI), and their results suggest this vaccine is cost-effective [22].

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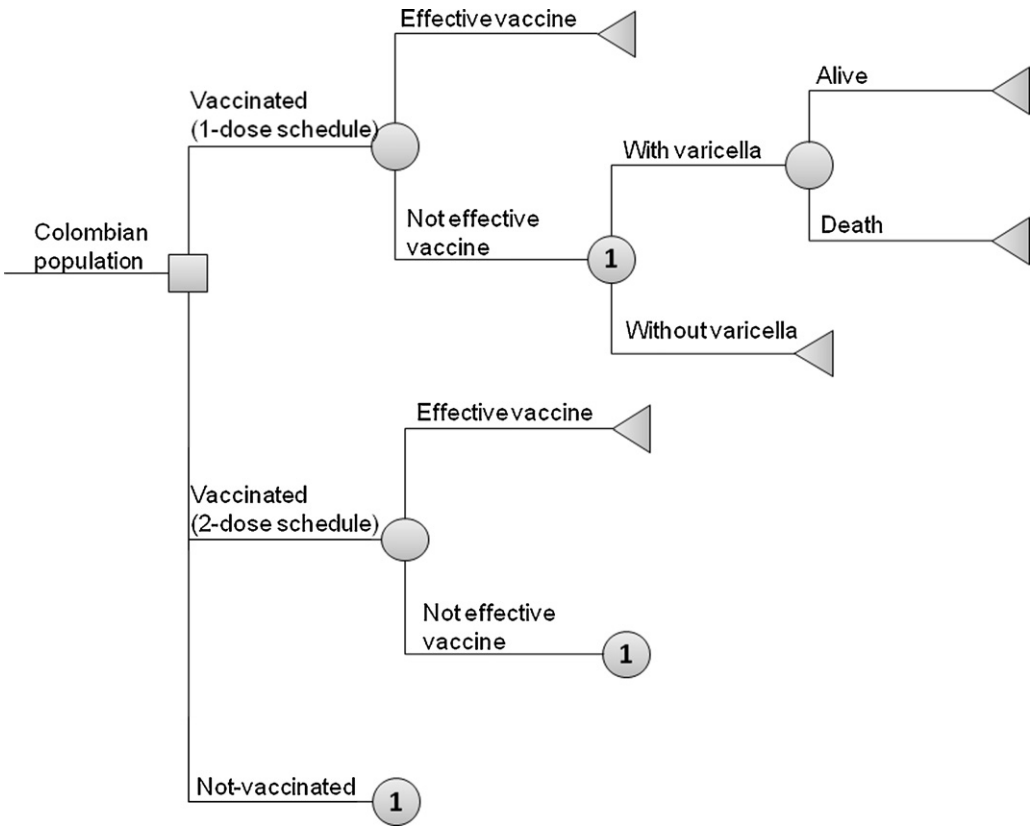

Fig. 1. Decision tree model to assess the cost-effectiveness of varicella vaccination in Colombia.

A cost-effectiveness analysis of the introduction of the varicella vaccine in the Colombian immunization program was carried out with the objective of providing evidence for health decision-making and make recommendations to the EPI of Colombia.

2. Methodology

2.1. Model structure

An economic evaluation was carried out to estimate the impact of varicella vaccine introduction in Colombia. A decision-tree based model was developed in Microsoft Excel (Microsoft; Redmond, WA) to assess three alternatives of varicella vaccination in children under 2 years old: no vaccination, 1-dose of varicella vaccination at 12 months, and 2-dose varicella vaccination at 12 and 15 months of age.

The model hypothetically followed three sets (one set for every alternative) of all Colombian population, one set for every alternative. Each set of the model was composed by 30 sequentially added cohorts of all Colombian population (~44 million), for 30 years [23]. To estimate the effects of vaccination, in one set no varicella vaccine was used; in the second set, 30 consecutive cohorts of newborns (~850 thousands) [23] received one dose of varicella; and in the third set, 30 cohorts of newborns received the two dose scheme. At the end of the follow up, the first introduced vaccinated cohort was 30 years old and the last one was 1-year old. The impact of the varicella acute infection was estimated for every set of the population. The number of cases, deaths and hospitalization due to varicella were estimated for the 30 cohorts and compared across the three sets of population. The impact of vaccination was estimated as the difference in the incidence of cases, hospitalizations and deaths between populations. Fig. 1 depicts the basic model structure. Outcomes in every branch were assessed similarly. A perspective from the health care system was taken and the annual discount rate for cost and benefits in the base-case analysis was 3%.

The decision tree assumed that the probability (infection, health service utilization, hospitalization and surviving or not) of going through from one state to another was determined by vaccine coverage, vaccine efficacy, and infection risk for each age. For the decision model, it was assumed that non-protected vaccinated people had the same probabilities of infection than non-vaccinated people. Parameters of the model are listed in Table 1.

2.2. Burden of disease without vaccination

To estimate the varicella burden of disease two approaches were combined. First, we use a catalytic model from seroepidemiological studies in Colombia to estimate the incidence of infection. Second, a literature review was made to obtain the probabilities of being a clinical case, being hospitalized and die from varicella related complications.

2.2.1. Catalytic model

To estimate the frequency of cases, a function of $S^+(a)$ of the proportion of seropositivity individuals against antibodies of varicella were estimated based in a study from Bogota D.C. (capital city of Colombia). The adjusted function was this:

$$S^+(a) = 1 - \exp\left\{\left[\frac{k_1}{(k_2)^2}\right][(k_2 a + 1)\exp(-k_2 a) - 1]\right\}$$

where a is the person age, and k_1 and k_2 were the estimated parameters by least squares. To estimate the proportion ($P(a_f \rightarrow a_i)$) of new varicella cases between the ages a_i and a_f the following equation was used:

$$P(a_i \rightarrow a_f) = S^+(a_f) - S^+(a_i)$$