



Cost-effectiveness of a new rotavirus vaccination program in Pakistan: A decision tree model



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ABSTRACT

Background: Rotavirus gastroenteritis places a significant health and economic burden on Pakistan. To determine the public health impact of a national rotavirus vaccination program, we performed a cost-effectiveness study from the perspective of the health care system.

Methods: A decision tree model was developed to assess the cost-effectiveness of a national vaccination program in Pakistan. Disease and cost burden with the program were compared to the current state. Disease parameters, vaccine-related costs, and medical treatment costs were based on published epidemiological and economic data, which were specific to Pakistan when possible. An annual birth cohort of children was followed for 5 years to model the public health impact of vaccination on health-related events and costs. The cost-effectiveness was assessed and quantified in cost (2012 US\$) per disability-adjusted life-year (DALY) averted and cost per death averted. Sensitivity analyses were performed to assess the robustness of the incremental cost-effectiveness ratios (ICERs).

Results: The base case results showed vaccination prevented 1.2 million cases of rotavirus gastroenteritis, 93,000 outpatient visits, 43,000 hospitalizations, and 6700 deaths by 5 years of age for an annual birth cohort scaled from 6% current coverage to DPT3 levels (85%). The medical cost savings would be US\$1.4 million from hospitalizations and US\$200,000 from outpatient visit costs. The vaccination program would cost US\$35 million at a vaccine price of US\$5.00. The ICER was US\$149.50 per DALY averted or US\$4972 per death averted. Sensitivity analyses showed changes in case–fatality ratio, vaccine efficacy, and vaccine cost exerted the greatest influence on the ICER.

Conclusions: Across a range of sensitivity analyses, a national rotavirus vaccination program was predicted to decrease health and economic burden due to rotavirus gastroenteritis in Pakistan by ~40%. Vaccination was highly cost-effective in this context. As discussions of implementing the intervention intensify, future studies should address affordability, efficiency, and equity of vaccination introduction.

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1. Introduction

Globally, the number of diarrheal deaths for children younger than 5 years of age decreased significantly from 1.8 million in 2003 to perhaps 700,000 in 2011 as part of a general trend in overall mortality for this age group [1,2]. About 453,000 of these deaths are

Abbreviations: DALYs, disability-adjusted life-years; DPT3, final dose of diphtheria, pertussis, and tetanus vaccination; EMR, Eastern Mediterranean region; GAVI, Global Alliance for Vaccines and Immunization; GDP, gross domestic product; ICER, incremental cost-effectiveness ratio; PATH, Program for Appropriate Technology in Health; RVGE, rotavirus gastroenteritis; WHO, World Health Organization.

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due to diarrhea caused by rotavirus with Pakistan alone accounting for about 23,000–39,000 [2–4]. Rotavirus gastroenteritis (RVGE) accounts for 30–40% of diarrheal hospitalizations in this age group and places a significant health and economic burden on Pakistan as it does on many other middle- and low-income Asian and African countries [5–8]. Vaccination is an extremely promising strategy to reduce the burden of RVGE, and the World Health Organization (WHO) recommends implementing routine rotavirus vaccination for infants globally [9,10].

The efficacies of two different oral rotavirus vaccines were demonstrated in 2006 and in a Cochrane Review in 2012 to prevent about 85–95% of RVGE-associated hospitalizations [11–13]. The results were similar for high-income Asian countries, but the first clinical trial of vaccination in developing Asian countries reported a reduced, yet encouraging, efficacy of 48.3% against severe RVGE

[14,15]. A clinical trial sponsored by the Program for Appropriate Technology in Health (PATH) in Karachi, Pakistan recently completed data collection in December 2012 for the primary outcome but has not reported any results to date [16]. Notably, the Global Alliance for Vaccines and Immunization (GAVI) has secured a 67% reduction in price of the vaccine as they provide vaccines to an increasing number of developing countries [17]. While the efficacies appear comparable, we focus on RIX4414 (Rotarix®) in the present analysis because it requires only two doses instead of three and was chosen for the clinical trial in Karachi [13,18].

In Asia, the Philippines became the first country to implement a national rotavirus vaccination program in July 2012, but no GAVI-eligible countries on the continent have followed suit [19]. South Asian countries carry a significant proportion of the burden of disease with most cost-effectiveness analyses focusing on India [20–22]. Pakistan was included in an analysis of GAVI-eligible countries but has received little dedicated attention [8,23]. We evaluated cost-effectiveness of a national rotavirus vaccination program compared to current practice for a birth cohort in Pakistan (an estimated 4.8 million children in 2012) by calculating incremental cost-effectiveness ratios (ICERs) from the perspective of the health care system to aid policy makers in their decision regarding vaccine introduction [24].

2. Data and methods

2.1. Model overview

We developed a decision tree model using Microsoft Excel to estimate health outcomes and costs associated with a rotavirus vaccination program in a hypothetical annual birth cohort of children for a 5-year period (Fig. 1). The analytic horizon constitutes the lifetime of the cohort. The estimates were developed using a generalized model populated with a combination of country-specific data and extrapolation from other countries where data were lacking. Costs and health outcomes were analyzed from the healthcare perspective.

Children either died or survived after RVGE. Children who survived experienced a number of different events: a response to treatment at home, in the hospital, or in an outpatient setting or subsequent death. The impact of vaccination on costs was broken down into costs related to vaccine program implementation and costs averted due to the reduced burden of disease. All costs were inflated to 2012 Pakistani Rupees and converted to 2012 US\$ using the appropriate exchange rates. The effects were quantified as deaths and disability-adjusted life-years (DALYs) averted due to vaccination.

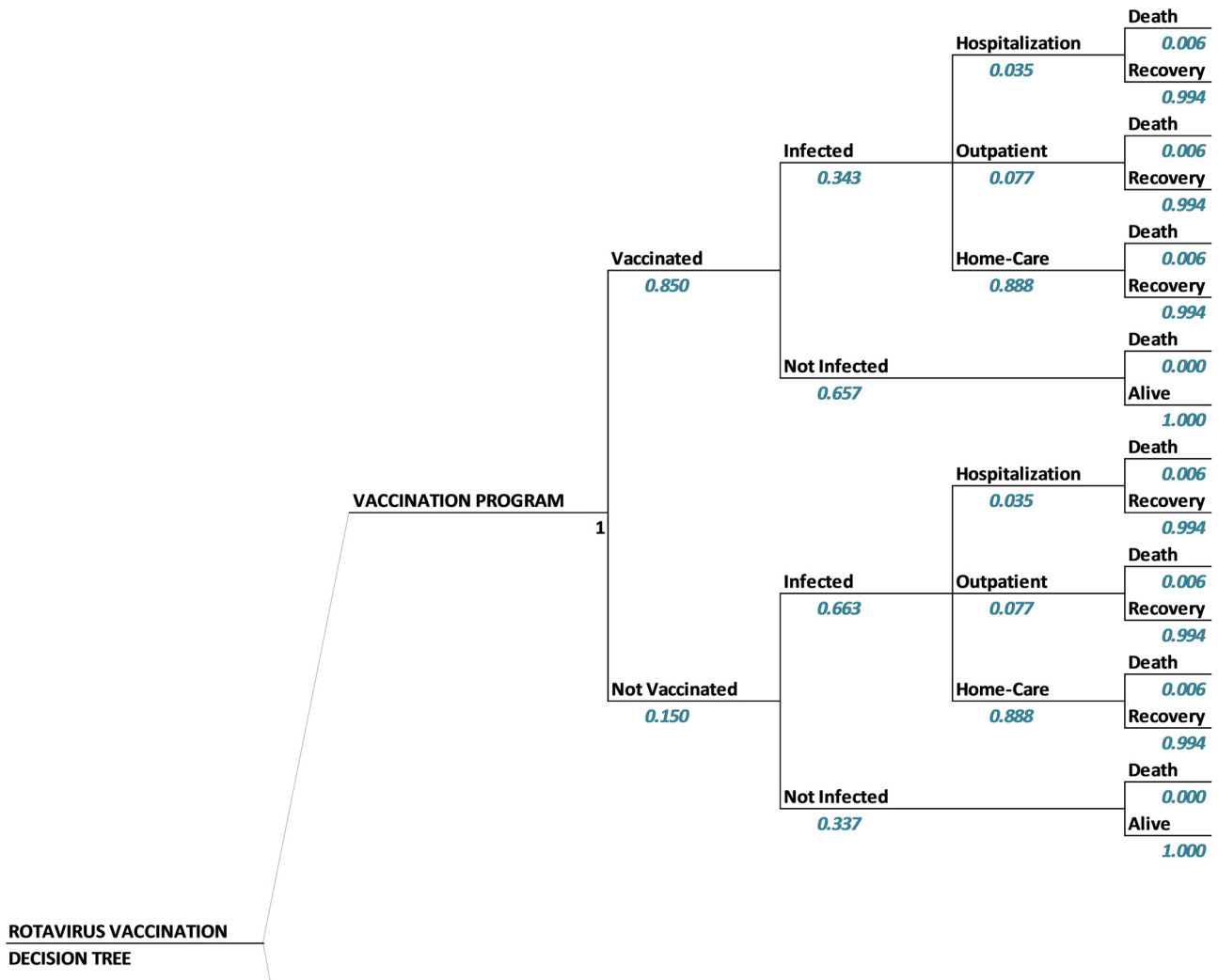


Fig. 1. National vaccination program arm of the decision tree model.

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