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Estimating and comparing the clinical and economic impact of paediatric rotavirus vaccination in Turkey using a simple versus an advanced model

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ABSTRACT

Background: The burden of rotavirus disease is high in Turkey, reflecting the large birth cohort (>1.2 million) and the risk of disease. Modelling can help to assess the potential economic impact of vaccination. We compared the output of an advanced model with a simple model requiring fewer data inputs. If the results are similar, this could be helpful for countries that have few data available.
Methods: The advanced model was a previously published static Markov cohort model comparing costs and quality-adjusted life-year (QALY) outcomes of vaccination versus no vaccination. In contrast, the simple model used only a decision tree. Both models included data on demography, epidemiology, vaccine efficacy, resource use, unit costs, and utility scores from national databases and published papers. Only the perspective of the health care payer was considered in the analysis. The simple model had 23 variables, compared with 103 in the advanced model to allow additional comparisons of different vaccine types, dose schemes and vaccine waning.
Results: With the same input data, both models showed that rotavirus vaccination in Turkey would improve health outcomes (fewer QALYs lost to rotavirus disease). The projected annual cost offsets were $29.9 million in the simple and $29.4 million in the advanced model. Sensitivity analysis indicated that in both models the main cost driver was disease incidence followed by cost for hospital care and medical visits. Vaccine efficacy had a smaller effect.
Conclusion: Both models reached similar conclusions. Both projected that rotavirus vaccination in Turkey would improve health outcomes and may result in savings in direct healthcare costs to offset the cost of vaccination. The analysis indicated that the simple model can produce meaningful economic results in conditions where few data are available.

1. Introduction

Rotavirus is a major cause of acute gastroenteritis in young children worldwide, with an estimated 453,000 deaths annually in children aged <5 years, mainly in the developing world [1]. Almost every child will be infected with rotavirus before 5 years of age, with peak incidence at age 6–24 months [2,3]. Countries such as Turkey with a large annual birth cohort (>1.2 million) could experience a high rotavirus gastroenteritis (RVGE) burden, with consequences for health outcomes (mortality and morbidity), healthcare spending (medical visits and hospitalisations), and impaired quality of life (e.g. stress for parents) [3–8].

In the absence of detailed information on rotavirus disease in a country, models are helpful tools to explore the potential impact of new interventions such as vaccination [9]. Many models of rotavirus disease and the projected impact of vaccination have been reported, from simple to advanced [10–13]. Advanced models may include specific aspects of the clinical impact and cost of rotavirus disease over time and various potential vaccine effects, and can compare different vaccine types or estimate indirect vaccine effects.

Decision-makers need to choose an appropriate model for economic assessment of interventions in their country [14]. Model selection depends on three issues: the economic question to be answered; the data available to answer that question; and the

Abbreviations: GP, general practitioner; QALY, quality-adjusted life-year; RVGE, rotavirus gastroenteritis.

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audience to whom it is addressed. Simple questions should be answered by simple models that are straightforward to understand and accessible by a range of users. Advanced models can answer more complex questions, but require more data, more assumptions, and more skills to construct, understand and interpret the results. However, an advanced model should also be able to answer simple questions, and its results should not differ greatly from those of the simple model.

In the present paper, we have tested this hypothesis by comparing the results of a simple and an advanced model for estimating cost offsets and gain in quality-adjusted life-years (QALY) for rotavirus vaccination versus no vaccination. We selected Turkey for this study. It is a good example of a country with basic epidemiological data on ambulatory care and hospitalisation that needs to make decisions on healthcare investment. A complete economic assessment, addressing questions about optimal vaccine type, dose regimen and schedule, and the likely size of the vaccine effect over time, will require an advanced model. However, a simple model can evaluate the economic impact of rotavirus vaccination in the first instance. If a simple model is shown to produce results similar to those of an advanced model, this should help to raise confidence that meaningful assessments can be performed in countries with few data available.

2. Materials and methods

We developed two models, an advanced model and a simple model deduced from it [13,15,16]. The simple model was designed to address three economic questions: the cost-effectiveness of rotavirus vaccination in infants versus no vaccination; one-way sensitivity analysis to identify the main results drivers; and the budget impact of introducing vaccination. The advanced model can also perform probabilistic sensitivity analysis and address more complex questions, such as the effect of a two- versus three-dose vaccine, different dosing schedules (e.g. 2–3 month dosing versus 3–5 month dosing), waning of vaccine effect over time and indirect protection. Because the objective of the present study was to compare the two model types, we present only results for outcomes common to both.

The advanced model has been described elsewhere [13]. Its main features are summarised here.

3. Model structure and design

3.1. Advanced

This static, deterministic, Markov cohort model compared the costs and QALY outcomes of vaccination versus no vaccination of a birth cohort of 1,257,583 infants followed for 5 years in Turkey. The initial model was developed by Melliez et al. [17]. We adapted it to address more complex questions, such as dose scheduling, vaccine waning and seasonality [13]. It can include 103 different variables and is presented in 25 Microsoft *Excel*® worksheets.

3.2. Simple

The simple model was a static, deterministic, decision-tree model comparing the costs and QALY outcomes of vaccination versus no vaccination of 5 1-year age groups (0–1 year; 1–2 years; 2–3 years; 3–4 years; 4–5 years), with 1,257,583 children per age-group assessed together over a period of 1 year [18]. Four health states were included: mild (seeking no medical advice), moderate (visiting a general practitioner [GP] at least) or severe (hospitalised) disease, or rotavirus-related death. It has a maximum of 23 different variables and is presented on a single worksheet (a copy of the simple model is provided as a Microsoft *Excel*® worksheet in supplementary material 1).

As well as the smaller number of variables in the simple model, the models differed in construction. In the simple model, a population up to age 5 years was modelled over 1 year, whereas in the advanced model a birth cohort aged with time in cycles of 1 month over 5 years. The advanced model allowed more precision about the timing of events. This increased detail allowed the advanced model to identify more clearly the time and age at which projected vaccine benefits occur, which could have consequences for dose scheduling.

4. Data input

4.1. Demographic data

Both models required the annual number of births or the total birth cohort and birth rate, and average life expectancy at birth, estimated for Turkey at 73.3 years [19].

4.2. Epidemiological data

4.2.1. Advanced

Since the distribution of RVGE cases is age-dependent, the disease age distribution simulated in the model followed a Weibull distribution (parametric characteristics alpha = 1.5, beta = 24.2) over 60 months. Data on medical visits were proportional to that distribution and have the same basic curve shape. However, hospitalisations may have an earlier age distribution than the baseline curve, so age-specific hospitalisation rates for RVGE were included (Table 1).

Non-age-dependent epidemiological variables included the probability of seeking medical advice (probability of a GP visit or a direct emergency room visit, probability of emergency room referral after a GP visit), and the probability of dying after hospitalisation for RVGE (Table 1).

4.2.2. Simple

The simple model did not use any prespecified parametric distribution for age-dependent variables. It estimated age-specific data using a fixed multiplication value for age-specific probabilities for each health state. The initial probability in the first age-group (0–1 year) defined the total number of cases in each health state and probabilities in the subsequent age-groups. The simple model did not account for breastfeeding or distinguish between nosocomial and community-acquired RVGE (both included in severe cases), and included no non-age-dependent epidemiological variables.

4.3. Utility data

Utility scores were obtained from a published study [20]. In both models, utility scores were adjusted to the appropriate time period (months for the advanced model, annual for the simple model) combined with the event duration and expressed as disutility scores: disutility score = (utility score − 1) × d/unit time (d: days) (Table 1). As disutilities involve otherwise healthy children, assuming a baseline utility value of 1 seems reasonable.

4.4. Resource use and cost

Direct medical costs were estimated in each model by multiplying the number of resource units by the unit cost. Vaccine costs were not included in this comparison, because vaccine cost does not differ between the model types and therefore cannot help to explain any differences in model outputs. Rotavirus vaccination