Costs of vaccine programs across 94 low- and middle-income countries

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ABSTRACT

While new mechanisms such as advance market commitments and co-financing policies of the GAVI Alliance are allowing low- and middle-income countries to gain access to vaccines faster than ever, understanding the full scope of vaccine program costs is essential to ensure adequate resource mobilization. This costing analysis examines the vaccine costs, supply chain costs, and service delivery costs of immunization programs for routine immunization and for supplemental immunization activities (SIAs) for vaccines related to 18 antigens in 94 countries across the decade, 2011–2020. Vaccine costs were calculated using GAVI price forecasts for GAVI-eligible countries, and assumptions from the PAHO Revolving Fund and UNICEF for middle-income countries not supported by the GAVI Alliance. Vaccine introductions and coverage levels were projected primarily based on GAVI's Adjusted Demand Forecast. Supply chain costs including costs of transportation, storage, and labor were estimated by developing a mechanistic model using data generated by the HERMES discrete event simulation models. Service delivery costs were abstracted from comprehensive multi-year plans for the majority of GAVI-eligible countries and regression analysis was conducted to extrapolate costs to additional countries.

The analysis shows that the delivery of the full vaccination program across 94 countries would cost a total of $62 billion (95% uncertainty range: $43–$87 billion) over the decade, including $51 billion ($34–$73 billion) for routine immunization and $11 billion ($7–$17 billion) for SIAs. More than half of these costs stem from service delivery at $34 billion ($21–$51 billion)—with an additional $24 billion ($13–$41 billion) in vaccine costs and $4 billion ($3–$5 billion) in supply chain costs.

The findings present the global costs to attain the goals envisioned during the Decade of Vaccines to prevent millions of deaths by 2020 through more equitable access to existing vaccines for people in all communities. By projecting the full costs of immunization programs, our findings may aid to garner greater country and donor commitments toward adequate resource mobilization and efficient allocation. As service delivery costs have increasingly become the main driver of vaccination program costs, it is essential to pay additional consideration to health systems strengthening.

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1. Introduction

This decade (2011–2020) has been labeled "the Decade of Vaccines" after various country governments and international donors committed to help discover, develop, and deliver vaccines to people in the world's poorest countries. Understanding the full scope of vaccination program costs is vital to ensuring adequate resource mobilization to attain the goals envisioned by the Decade of Vaccines Collaboration. This costing analysis responds to the requests of the World Health Organization (WHO) Strategic Advisory Group of Experts (SAGE) as part of the Decade of Vaccines Economics (DOVE) project to strengthen methods for estimating and projecting immunization program resource requirements [1]. While the study builds on lessons learned from previous costing exercises, it extends beyond prior efforts by transparently modeling more detailed cost components (vaccine, supply chain, service delivery), exploring enhanced model methods, and providing sensitivity and scenario analyses. By taking a bottom-up approach to cost each component, this analysis identifies specific cost drivers of immunization programs. The aim of this paper is to detail the model structure, input sources, modeling methods, and baseline results of vaccination program costs.

2. Methodology

2.1. Analysis scope

The costing analysis focused on 94 low- and middle-income countries identified by the global vaccine action plan (GVAP) and country eligibility policy of the GAVI Alliance across the Decade of Vaccines, 2011–2020. The GVAP, endorsed by 194 Member States at the World Health Assembly in 2012, centered around low- and middle-income countries that currently or have previously received support from the GAVI Alliance [2]. Based on current GAVI classifications, the 94 countries include 36 low-income countries, 17 intermediate countries, 20 graduating countries, and 21 countries not eligible for GAVI support [3] [2]. A full list of countries is included in the online supplement.

The vaccines included in this analysis are relevant to 18 antigens and encompass immunizations delivered through routine immunization programs and supplemental immunization activities (SIAs). The complete list of vaccines is provided in Table 1.

Introduction years for routine vaccines, the timing of SIAs and the number of vaccine doses annually delivered to each country rely on GAVI's Adjusted Demand Forecast version 9.0 (ADF v9) [4]. The ADF also includes forecasts for introductions of future vaccines, both licensed and unlicensed, in countries' national immunization programs. For the frequency and timing of SIAs for measles, measles–rubella (MR), and measles–mumps–rubella (MMR) vaccinations, forecasts additionally used information from the World Health Organization (WHO) [5]. For SIAs for oral polio vaccine (OPV), forecasts relied on information from the Global Polio Eradication Initiative [6].

As for the model structure, separate methodologies were developed for vaccine, supply chain, and service delivery cost components associated with routine immunization and SIAs. The methodologies and assumptions relied on the most recent information and price data from the GAVI Alliance [3,4,7–11], the PAHO Revolving Fund [12–15], UNICEF Supplies and Logistics [16], as well as country-specific models developed by the HERMES (Highly Extensible Resource for Modeling Event-Driven Supply Chains)

Logistics Modeling Team [17,18]. For additional data underlying the model such as population data, immunization coverage rates and economic growth, we relied on datasets validated by third-party multilateral agencies [19–22]. Service delivery cost projections relied primarily on data obtained from country-specific comprehensive multi-year plans (cMYPs) overseen by the World Health Organization [23].

2.2. Costing scope and components

This costing analysis assesses the vaccine costs, supply chain costs, and service delivery costs of immunization programs for routine immunization and for SIAs, consisting of the following components:

Routine immunization:

1. *Vaccine costs:* Costs to procure vaccines, related injection equipment and safety boxes.
2. *Supply chain costs:* Costs for transportation, both immunization-specific and shared[3], including amortization for vehicles, fuel costs, and per diems; costs for storage including amortization for equipment, maintenance, and energy cost; and costs of labor.
3. *Service delivery costs:* Costs of personnel, both immunization-specific and shared[4]; and non-personnel costs including program management, training, social mobilization, surveillance, and other recurrent costs related to vaccination.

Supplemental immunization activities:

1. *Vaccine costs:* Costs to procure vaccines, related injection equipment and safety boxes.
2. *Operational costs:* Cost to deliver vaccines and manage vaccination campaign efforts.

The categorization of costs reflects cMYP classifications and definitions utilized in previous vaccine program analyses [24–26]. All costs are presented in constant 2010 US dollars (US$2010).

2.3. Baseline cost estimations and projections

2.3.1. Routine and supplemental vaccine costs

The costs of vaccines for both routine and SIA delivery strategies encompass: (1) vaccine-specific price per dose (including freight); (2) vaccine-specific injection equipment and safety box price per dose; and (3) the number of required vaccine doses (including wastage and buffer doses), relying on data from the GAVI Secretariat for GAVI-supported vaccines[5] and GAVI Strategic Demand Forecast (SDF)-based demand forecasts for traditional vaccines[6] [4].

The analysis incorporates the prices of vaccines relevant to 18 individual antigens of three different types: (1) GAVI country prices; (2) PAHO country prices; (3) and non-GAVI, non-PAHO prices.

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[3] Shared transportation costs are defined as the costs of transportation when vehicles are utilized across multiple programs or activities in the health sector including immunization.

[4] Shared personnel costs are defined as the value of human resources providing immunization services as well as other curative and preventive services where a health workers' time may be shared across different programs or activities.

[5] GAVI-supported vaccines include pentavalent, rotavirus, pneumococcal, HPV, measles, measles–rubella, yellow fever, and meningococcal A, as well as vaccines that are under consideration to receive GAVI support within the decade—Japanese encephalitis, typhoid, IPV (inactivated polio vaccine), and cholera (stockpiles only).

[6] Traditional vaccines are defined as BCG, DTP, HepB birth dose, measles–mumps–rubella, and OPV (oral polio vaccine).