



Trends in childhood vaccine purchase costs in the US public sector: 1996–2014



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ABSTRACT

While vaccination remains as one of the most cost-effective preventive strategies, the cost of fully immunizing a child has grown considerably over the last few decades. This study examines trends in non-influenza childhood vaccine purchase costs in the public sector from 1996 to 2014. Non-influenza vaccine purchase cost per child for children aged 0 through 18 years was calculated based on public-sector purchase prices. Purchase cost changes were then decomposed into changes attributable to recommendation updates and changes attributable to price variation. The study analyzed the growth rate of combination vaccine prices separately and compared these prices with the sum of prices of component vaccines. It is found that the average annual growth rate of non-influenza vaccine purchase cost per child during 1996–2014 was 12.6%. The growth rate attributable to price changes was 1.0% on average. Combination vaccine prices showed greater variation. The study concludes that vaccine price variation was one but a minor reason for purchase cost changes. Recommendation updates, particularly the introduction of new vaccines, played a much larger role in raising the purchase costs. If the 12.6% annual growth rate found during 1996–2014 in the study continues to apply, the purchase costs of childhood vaccines may more than double by 2020.

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1. Introduction

Routine childhood vaccination in the United States has kept most vaccine-preventable diseases at the lowest levels ever [1]. A recent study [2] evaluating the economic impact of routine childhood immunization of the 2009 US birth cohort concluded that it averted 42,000 early deaths and 20 million cases of vaccine-preventable diseases and saved \$68.8 billion in societal costs. While vaccination remains as one of the most cost-effective preventive strategies, the cost of fully immunizing a child has grown considerably over the last few decades [3–5].

The public sector plays an important role in maintaining high vaccination rates among vulnerable children. The Centers for Disease Control and Prevention (CDC) has been purchasing recommended vaccines through CDC contracts and distributing them to state and local immunization programs for delivery to eligible children through private physicians' offices and public health clinics. CDC purchases accounted for about half of all vaccine doses sold in the US market during 1996–2014 (CDC unpublished data). A large part of that was for the Vaccines for Children (VFC) program.

The trends in vaccine purchase costs directly influence current and future budget planning for vaccine purchases at both federal and state levels.

The objective of this paper was to examine the cost of purchasing a complete series of recommended childhood vaccines for boys and girls aged 0 through 18 years respectively, over the years 1996–2014. Since VFC was implemented in Oct 1994, this period focused mostly on the post-VFC era. We decomposed the growth rate in purchase cost by source of the change – recommendation updates or changes in vaccine prices. We quantified the price trends of combination vaccines separately and compared the price differences between combination vaccines and their component vaccines. An earlier article [3] studying vaccine purchase costs presented the trends using minimum purchase costs for childhood vaccines from 1975 to 2001. This paper builds on the previous literature by providing price trend estimates from the most recently available price data. It also differs methodologically in the following ways: (1) we used quantity-weighted prices, rather than minimum prices of available vaccine products, to reflect the average price of the mixture of vaccine purchases; (2) we looked at children aged 0 through 18 years, rather than 0 through 6 years; (3) we separated purchase costs for boys and girls to account for differences in recommendations based on sex; and (4) we examined

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combination vaccines separately and additionally to the purchase costs based on non-combination vaccines.

2. Methods

2.1. Price and quantity of vaccines purchased in the public sector

The data used in this study were prices and quantities of vaccines purchased under CDC contracts with vaccine manufacturers. Price data were from the current and archived CDC Vaccine Price Lists [6] for years 1996–2014. We used the CDC costs per dose, which were the prices listed on CDC vaccine contracts. Yearly data were constructed based on price lists of April 1st (the starting date of most contracts) or the closest available ones for each year. The vaccines covered in the study were selected from pediatric/VFC vaccine price lists and excluded those from pediatric influenza vaccine price lists, since influenza vaccines are affected by seasonal factors and differ substantially from other pediatric vaccines. Data on quantities purchased for each vaccine on the contracts were also obtained from the CDC (unpublished data).

Since vaccine prices vary across different brands and sometimes packaging types, we aggregated prices at the vaccine level and calculated average prices with quantity weights. The average price of a particular vaccine i with J brands is calculated as below. Vaccine i can be any of the 12 vaccine types discussed in Section 2.2 or any of the combination vaccines discussed in Section 2.4. QN_{ij} denotes the quantity of vaccine i brand j . The price of brand j is the price of the particular brand. When there were more than one packaging types with different prices, it represents the quantity-weighted average price of brand j . All vaccine prices were adjusted to 2014 US dollars using the Consumer Price Index.

$$\text{Price of vaccine } i = \frac{\sum_{j=1}^J QN_{ij} \times \text{Price of brand } j}{\sum_{j=1}^J QN_{ij}}$$

2.2. Purchase cost

In order to show an overall price trend of all recommended non-flu pediatric vaccines, we constructed a purchase cost. It was defined as the total cost of purchasing a complete series of all recommended vaccines, except influenza vaccine, for children aged 0 through 18 years in a particular year [7]. The recommendations were the same for boys and girls except the human papillomavirus (HPV) vaccine. Boys were first recommended to receive HPV vaccines in 2011, four years after that for girls, and the only available HPV vaccine product for males as of 2014 was Gardasil®. We captured this difference by separating the cost trends for boys and girls starting in 2007. The HPV vaccine price faced by girls was the quantity-weighted average price of the two HPV brands (Gardasil® and Cervarix®).

When calculating the purchase cost, we considered 12 vaccine types that ACIP recommended for routine immunization for children aged 0 through 18 years for the years 1996–2014. They included diphtheria and tetanus toxoids and pertussis vaccine or diphtheria and tetanus toxoids and acellular pertussis vaccine (DTP or DTaP), hepatitis A vaccine (Hep A), hepatitis B vaccine (Hep B), haemophilus influenza type b vaccine (Hib), HPV vaccine, meningococcal conjugate vaccine (MenACWY), measles-mumps-rubella vaccine (MMR), oral poliovirus vaccine or inactivated poliovirus vaccine (OPV or IPV), pneumococcal conjugate vaccines (PCV7 or PCV13), rotavirus vaccine (Rota), tetanus and diphtheria toxoids vaccine or tetanus and reduced diphtheria toxoids and acellular pertussis vaccine (Td or Tdap), and varicella vaccine (Var). The purchase cost was only based on non-combination vac-

cines. The price trends of combination vaccines are discussed separately in later sections.

The vaccine recommendations also specify dose series for each vaccine. In the calculation, we multiplied the price per dose by the number of doses recommended from age 0 through 18 years. We used 5 doses for DTP/DTaP, 2 doses for Hep A, 3 doses for Hep B, 3 or 4 doses for Hib (3 for Pedvax®), 3 doses for HPV, 4 doses for OPV/IPV, 1 dose for MenACWY before year 2011 and 2 doses afterwards (due to recommendation change), 2 doses for MMR, 1 dose for Td/Tdap, 4 doses for PCV7/PCV13, 2 or 3 doses for Rota (2 for Rotarix®), and 1 dose for Var before year 2006 and 2 doses afterwards (due to recommendation change).

2.3. Changes in vaccine recommendations

Among the 12 vaccine types listed above, the majority were introduced after 1996: PCV7 was recommended in 2000, IPV was recommended to completely replace OPV in 2000; MenACWY was introduced in 2005; Hep A, Tdap and Rota were added in 2006; HPV was first recommended for girls in 2007 and later for boys in 2011; PCV13 replaced PCV7 in 2010.

Other changes in recommended vaccine schedules started in 2006, the recommended doses for Var increased from 1 to 2; MenACWY had 1 more dose added in 2011. These dose changes have been included in purchase costs for corresponding years.

In addition, DTaP was first licensed to be used as 2 booster doses following a DTP dose, and then approved to be used for all 5 doses in 1997. Thus, the price of DTP/DTaP was the average of the DTP and DTaP prices in 1996 and only the DTaP price in later years. Similarly, IPV was purchased in all sample years but only completely replaced OPV in 2000, thus the price for OPV/IPV was based on both OPV and IPV vaccines before 2000 and on only IPV vaccines afterwards. The situation was slightly different for Td/Tdap and PCV7/PCV13. The purchase of Tdap and PCV13 did not begin until after their ACIP recommendations. The price for Td/Tdap was averaged only among Td vaccines before Tdap was recommended in 2006 and among only Tdap vaccines afterwards. The price for PCV7/PCV13 was based on PCV7 vaccines only before 2010 and on PCV13 vaccines only from 2010 to 2014.

Since the purchase costs were based on recommended vaccines, updates in vaccine recommendations directly changed the purchase costs. We estimated this change by calculating the additional cost of newly recommended vaccines or/and added doses.

Another event that affected vaccine purchase cost occurred during 1999–2003. During this time, Td purchase was discontinued in the CDC contracts, so the purchase cost did not count Td price during those years. As a consequence, the purchase cost tended to be lower in 1999 compared to 1998 and higher in 2004 compared to 2003, as Td was excluded in 1999 and included again in 2004. After isolating the changes due to these reasons, we devoted the rest of the yearly changes in purchase costs as the changes attributable to price variation.

2.4. Combination vaccine prices

The calculation of purchase costs discussed above was based on non-combination vaccines. In order to show the trend in prices of combination vaccines, we (1) calculated the annual growth rate in adjusted prices of each combination vaccine, and (2) compared prices of selected combination vaccines with those of their component vaccines, such as the price of measles-mumps-rubella-varicella vaccine (MMRV) versus the sum of prices of MMR and Var vaccines. Again, when multiple brands and packaging types were available at different prices, the quantity-weighted average prices were used. For (1), we considered DTP-Hib, DTaP-Hib, DTaP-IPV, DTaP-IPV-Hep B, DTaP-IPV-Hib, Hep B-Hib, and MMRV.

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