Pediatric vaccine procurement policy: The monopsonist’s problem

Matthew J. Robbins a, *, Sheldon H. Jacobson b

a Department of Operational Sciences, Air Force Institute of Technology, 2950 Hobson Way, Wright-Patterson AFB, OH 45433-7765, United States
b Department of Computer Science, University of Illinois at Urbana-Champaign, United States

1. Introduction

Vaccination against infectious disease is an extremely important public health endeavor. Yet, in the past 40 years, the manufacture of pediatric vaccines has become less profitable due to rising costs and limited demand, inducing many pharmaceutical companies to exit the market. To ensure the safe, secure, and reliable provision of vaccines, the economic interests of the vaccine industry must be considered by public health policy makers. The monopsonistic market power of the federal government uniquely positions it to significantly influence the pediatric vaccine market by negotiating contractual agreements that increase the vaccine manufacturers’ financial incentives to remain in the market. The Monopsonist Vaccine Formulary Pricing and Purchasing Problem (MVFP3P) is introduced, which seeks pediatric vaccine prices and purchase quantities that ensure a birth cohort is fully immunized according to the recommended childhood immunization schedule at an overall minimum system cost while also ensuring that vaccine manufacturers each attain a reservation profit level. The practical value of MVFP3P is demonstrated by analyzing and assessing pricing and purchasing policies that the Centers for Disease Control could adopt in attempting to actively manage the long-term provision of pediatric vaccines.
vaccine manufacturers' financial incentives to enter or remain in the market. Pediatric vaccines purchased at the public-sector price, as negotiated by federal government officials at the Centers for Disease Control and Prevention (CDC), account for approximately 57% (by volume) of total pediatric vaccine purchases [11,20]. In the United States, the CDC acts as the primary federal public health organization responsible for setting pediatric immunization policy. Based on recommendations from the Advisory Committee on Immunization Practices (ACIP), the CDC annually publishes a Recommended Childhood Immunization Schedule (RCIS) (see Fig. 1 from [4]) that provides specific guidance regarding the effective control of vaccine-preventable diseases, to include the appropriate periodicity and dosage requirements for each pediatric vaccine. The RCIS serves as the fundamental force driving market demand [6]; vaccine purchasers buy vaccines in order to fully immunize children in accordance with the RCIS. The CDC also maintains a list of acceptable pediatric vaccines (i.e., licensed by the Food and Drug Administration (FDA) [7]) and negotiates discounted prices at which federal, state, and local governments can purchase the vaccines. A model that addresses the short term need to satisfy the RCIS at minimum economic cost while accounting for long-term concerns regarding the vaccine industry's viability provides value to the public health community (specifically, the CDC) and is the focus of this research.

Operations research methods have been applied to the analysis of the United States pediatric vaccine market. Prior research has mostly addressed the selection of an optimal vaccine formulary (i.e., a set of vaccines stocked to satisfy the immunization needs for a population cohort, as defined by a given set of immunization requirements) that satisfies a RCIS at minimum cost [10,15,27] (from the perspective of a vaccine purchaser) or the determination of optimal vaccine prices [14,16,23–25] (from the perspective of a vaccine manufacturer). Weniger et al. [27] introduce an integer program (IP) model to aid health care decision makers in determining a vaccine formulary that minimizes the cost to fully immunize a child according to a given childhood immunization schedule. Jacobson et al. [15] present a full technical description of the model introduced by Weniger et al. [27]. Hall et al. [10] introduce the general vaccine formulary selection problem, providing fundamental insights into the structure of problems concerning minimum cost satisfaction of a childhood immunization schedule. Sewell et al. [25] adopt a “reverse engineering” scheme involving a bisection algorithm to compute a vaccine’s maximum inclusion price (i.e., the maximum price at which a vaccine is selected to be part of the lowest overall cost formulary). Sewell and Jacobson [24] present a full technical description of the methods in Sewell et al. [25]. Similar efforts are seen in Jacobson et al. [14,16]. Robbins et al. [23] present a method to optimally price a pediatric vaccine so as to maximize a vaccine manufacturer's expected revenue given an uncertain cost parameter. While these efforts provide analysis tools to help one group of stakeholders in the pediatric vaccine market make decisions, no study has presented a comprehensive approach in which the interests of all stakeholders in the market are simultaneously considered.

This research effort addresses the issue of the pediatric vaccine industry’s continuing viability from the perspective of the monopsonistic federal government. The fundamental premise of the analysis is the supposition that the altruistic CDC desires to negotiate pediatric vaccine prices and determine purchase quantities in order to minimize the vaccine system's delivery costs while ensuring that the pharmaceutical companies manufacturing the pediatric vaccines each earn a profit that induces them to remain in the market. The operations research approach presented in this paper defines the Monopsonist Vaccine Formulary Pricing and Purchasing Problem (MVF3P) mixed integer nonlinear program (MINLP) model, which minimizes the weighted sum of the cost to fully immunize a birth cohort according to a given childhood immunization schedule. The model determines optimal vaccine prices and purchase quantities while ensuring that each vaccine manufacturer earns at least a particular amount of profit, with vaccine production quotas, capacities, and price caps respected. The MVF3P MINLP model can be used to design a pricing and purchasing policy for the CDC that establishes a sustainable and stable capital investment environment in which the reliable provision of the pediatric vaccines (so essential to public health) can occur.

The paper is organized as follows. Section 2 presents the MINLP model formulation for the optimization problem MVF3P that determines the set of pediatric vaccine formularies and attendant component vaccine prices and quantities that should be used to satisfy a given childhood immunization schedule for an entire birth cohort. The model minimizes overall system cost while ensuring a sustainable market environment for vaccine manufacturers. Section 3 presents the computational complexity of MVF3P. Section 4 reports the computational results of applying the MVF3P MINLP model to the analysis of CDC pricing and purchasing policies; optimal pediatric vaccine prices and purchase quantities for the current United States pediatric vaccine market are reported. Section 5 provides concluding comments and directions for future research.
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی

امکان دانلود نسخه ترجمه شده مقالات

پذیرش سفارش ترجمه تخصصی

امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله

امکان دانلود رایگان ۲ صفحه اول هر مقاله

امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب

دانلود فوری مقاله پس از پرداخت آنلاین

پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات