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The economics of vaccination

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Abstract

Since the end of the 18th century, vaccines against several infectious diseases have been developed. Having gone through a long process of technology improvements, traditional vaccination represents one of the most significant and cost-effective public health measures nowadays. Although many infectious diseases are vaccine-preventable, vaccines are generally still under-valued and under-utilized, resulting in a high burden of infectious diseases worldwide. Vaccination coverage rates are often used as a quality indicator of healthcare systems and are an important measure for reducing child mortality as outlined in Millennium Development Goal (MDG) number 4. However, there are challenges to deploying vaccinations as preventive measure to their full extent. For manufacturers, a high level of know-how is required as well as high upfront investments and fixed costs, which leads to there being only relatively few manufacturers for vaccines. At individual and societal level, there are problems of uncertainty and the phenomenon of time preference (for short-term benefits) when it comes to investigating the under-usage of vaccines. Despite these challenges, public health initiatives leading to higher vaccination coverage are likely to play an important role for controlling infectious diseases globally.

Key words: vaccination coverage, economics

Introduction

Immunization counts as a collective activity as vaccinations do not only reduce the incidence of a disease in those immunized but also indirectly protect susceptible individuals without vaccination (Brisson 2003) [1]. Therefore, increasing the immunization the coverage to a level of herd-immunity produces extra benefits or so-called positive externalities, and millions of infections can be avoided. Vaccinations are considered as one of the most significant public health interventions nowadays (Ehreth 2003a; 596 f.)[2].

The history of vaccines and immunization began with the development of the world's first vaccine for smallpox in the 1790s. During the last two centuries, effective vaccines for other relevant infectious diseases such as tuberculosis, rabies, diphtheria, measles, mumps and rubella have been developed. Technology improvements in the vaccine production lead to higher quality and safety (Stern and Markel 2005; 612) [3]. Overall, at least 26 diseases can be prevented, or their incidence reduced, by vaccination (Ehreth 2003b; 4107) [4]. Additionally, vaccinations are regarded as one of the most cost-effective health policy intervention (OECD 2011; 124) [5]. Being "cost-effective" is occasionally defined as "buying" a full year of healthy life at less than the per-capita gross domestic product of the country under study. In case of most vaccinations, the costs per healthy live-year saved are less than US$ 50 (Ehreth 2003a; 599) [2].

Global Burden of (infectious) Diseases

However, infectious diseases still count as a major threat to human life and health. In 2008, more than 8.7 million people died of infectious diseases worldwide; many of them were children under the age of five (WHO 2012a; 12) [6]. Globally, six infectious diseases are responsible for about 20 percent of total deaths (WHO 2008a; 11) [7]. In high-income countries, lower respiratory infections are the only infectious disease among the ten leading causes of death, being responsible for only four percent of mortality. Conversely, in low- and middle income countries, lower respiratory diseases represent the third leading cause of death; diarrheal diseases, HIV/AIDS and tuberculosis are also among the ten leading causes of death (WHO 2008b)[8].

Considering child mortality, even 58 percent of under-five deaths were caused by infectious diseases (WHO 2012c) [9]. Children in developing countries face a higher mortality risk for infectious diseases; the chance of dying of a vaccine-preventable disease is 10-fold greater than for children in industrialized countries (Ehreth 2003b; 4107) [4]. With routine vaccination programs, nearly 1.5 million deaths of children younger than five years could have been prevented, which is equal to 17 percent of the under-five mortality (WHO 2012b) [10].

In order to take into account premature mortality, a metric considering both the frequency of death as well as the age at which death occurs has been devised, namely the years of life lost (YLL) (sometimes also referred to as potential years of life lost or PYLL) (WHO 2008b; 21)[8]. Infectious diseases mostly lead to deaths at younger age. Worldwide, more than 386 million life-years are saved annually because of vaccination programs (Ehreth 2003a; 599) [2].

The aforementioned infectious diseases carry various levels of severity causing different kinds of symptoms, and might lead to several disabling effects (WHO 2008b; 31) [8]. To account for disabling effects, the measure Years Lost due to Disability (YLD) has been developed. It considers of the number of years lived with a disability, the latter being weighted with a factor between 0 (perfect health) and 1 (death) to express the severity of the disability. YLD and YLL are subsequently added up to obtain Disability Adjusted Life Years, or DALYs (Van Lier et. al. 2007) [11]. One Disability-Adjusted Life Year is equivalent to one life year of full health lost. The DALY concept allows for comparisons between the burden of diseases which causes premature death but no disability, and diseases that are not fatal, but lead to severe, often long-standing, disabilities (WHO 2008b; 40)[8].

In low-income countries, six infectious diseases were responsible for 31.5 percent of the DALY burden in 2004, whereas there were no infectious diseases among the ten leading causes of DALY burden in high-income countries (WHO 2008b; 44) [8].

Looking at the leading 20 causes of burden of disease at global scale, infectious diseases – namely lower respiratory and diarrheal diseases, HIV/AIDS, tuberculosis, neonatal infections and malaria – accounted for about 21 percent of the DALY burden, which is equal to 326 million DALYs (WHO 2008b; 43)[8]. Based on the DALY burden of the source year 2004, approximately 200 million DALYs could be vaccine-preventable (authors' own estimates). Annually, vaccination programs already save more than 96 million DALYs worldwide (Ehreth 2003a; 599) [2].

Due to the tremendous effect, vaccinations have on mortality and morbidity burden from infectious diseases, vaccination coverage is often considered to be a quality-of-care indicator (OECD 2011) [5].

Production and Pricing

Economic factors play a key role in the development and use of vaccines throughout the world. However, there are many barriers that hinder the optimal use of vaccines, starting at the development and production phase and continuing in distribution as well as uptake phases (Milstien 2006) [12].

The production of novel vaccines requires a high level of know-how as well as investment costs for research and development. Fixed costs also play an important role in the manufacturing process as setting up production facilities will add to the upfront cost. Overall, vaccine production is a costly and high-risk enterprise, of comparatively modest economic value for the companies involved, taking the pharmaceutical market as a reference point. Vaccine products account for only two percent of the global pharmaceutical market, so relatively few suppliers feel attracted (GAVI) [13]. In addition, traditional vaccines are often products with a low margin, complex supply chain, short shelf-life, and single or limited (non-chronic) use. This, combined with the problem of uncertain demand when the product is available, further exacerbates the challenges to contain vaccine-preventable diseases (Milstein 2006) [12]. As a result, the number of major pharmaceutical companies producing traditional vaccines has gone down from over twenty in 1970 to four in 2005 (WTEC 2007)[14].

This reveals that many pharmaceutical manufacturers have not considered vaccinations to be a good business opportunity (Rappuoli 2002) [15]. Prices for the well-established traditional vaccines such as measles, diphtheria, pertussis, tetanus, oral polio and BCG tend to decrease over time (Tracy 2005) [16]. Fixed costs make up a significant part of the total cost of vaccine production, but high demand for these vaccines – e.g. through uptake into routine immunization programs around the globe – leads to economies of scale. Thereby, fixed costs are "diluted" by the increasing volume, which lead to a growth of the total revenue to the manufacturers, who in turn can offer these vaccines at a lower price (Milstein 2006) [12]. Another reason for the sinking prices are technology improvements in vaccine production. Gains in productivity and efficiency achieved through the learning curve as the product matures are important. These effects also introduce the possibility of expanding the product portfolio by leaning towards economies of scope, creating new products which will again enter the cycle of innovation and maturation.

Challenges to prevention

In addition to the particular aspects on the manufacturing side, there are also elements at the individual and societal level that often hinder the widespread use of vaccines as a primary preventive measure. Vaccines, just as most other preventive actions, face fundamental challenges. In contrast to people seeking treatment for an acute illness, individuals contemplating getting immunized do not face morbidity pressure. Moreover, there is considerable uncertainty linked to the potential future benefits for the individual. An individual can only draw upon estimates about the risk of actually contracting the disease, typically derived from incidence data (with and without vaccination). The above, combined with the natural human preference for immediate benefits, often leads to an under-utilization of available vaccines. Another aspect contributing to this problem is the preference for short-term benefits not only at the individual, but also at the societal level. While the costs of policy programs geared towards an increase in immunization coverage will occur instantly, the benefits mostly arise in the long term. However, as political business cycles are often limited to a few years, there is a "risk" of such positive public health effects being reaped by a respective political successor. This predicament further reinforces the preference for short term benefits and frequently a focus on "repairing" rather than preventive medicine.

Conclusion

Infectious diseases are responsible for a high morbidity and mortality burden worldwide. Several vaccines can be used to avoid infections and the resulting illness. However, there are various challenges to developing, manufacturing and using vaccinations to their full extent.

Despite the aforementioned problems, the long term benefits of vaccination would still appear to outweigh any such challenges. Vaccinations had a tremendous impact on households and national economies so far, for example by eradicating polio and smallpox. The eradication of the latter alone resulted in global savings of over US$ 2 billion annually (Ehreth 2003b; 4105) [4]. Some vaccinations are considered to "pay for themselves": By adopting widespread use of the MMR vaccine, for example, US$ 3.94 - 4.91 were saved per dollar spent (Ehreth 2003b; 4114) [4]. Protecting a child against the most important infectious diseases can be reached by spending only US$ 30 on vaccines and administration (Ehreth 2003a; 599) [2]. These numbers show that relatively low spending levels can result in reducing mortality and morbidity from infectious diseases enormously. Therefore, vaccinations can contribute significantly to meet MDG 4, namely the reduction of child mortality by two-thirds until 2015. The value of vaccination programs lies in their low risks, but a high proven impact at global scale. By expanding immunization coverage, millions of lives can be saved.

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