Jeroen Luyten ans Philippe Beutels

The social value of vaccination programs: beyond cost-effectiveness

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VIEWPOINT

The Social Value Of Vaccination Programs: Beyond Cost-Effectiveness

Abstract

In the current global environment of increased strain on health care budgets, all medical interventions have to compete for funding. Cost-effectiveness analysis has become a standard method to estimate how much value an intervention offers relative to its costs, and it has become an influential element in decision making. However, the application of cost-effectiveness analysis to vaccination programs fails to capture the full contribution such a program offers to the community. Recent literature has highlighted how cost-effectiveness analysis can neglect the broader economic impact of vaccines. In this article, we also argue that socioethical contributions such as effects on health equity, sustaining the public good of herd immunity, and social integration of minority groups are neglected in cost-effectiveness analysis. Evaluations of vaccination programs require broad and multidimensional perspectives that can account for their social, ethical and economic

impact as well as their cost-effectiveness.

Edward Jenner, at the time a physician in the English countryside, scientifically demonstrated the principle of vaccination in 1796 (using cowpox pus against smallpox). The ensuing gradual wide-scale use of this principle in Europe and later in the rest of the world, made a phenomenal contribution to human well-being.[1,2] For instance, in the United States, vaccines were shown to have prevented 103 million cases of selected infectious diseases, including forty million cases of diphtheria (since 1924) and thirty-five million cases of measles (since 1963).[3] Currently, an estimated 80–90 percent of the world's children receive the basic package of vaccines from the World Health Organization's (WHO's) Extended Program on Immunization (up from 15 percent initially in the 1980s).[4,5] Smallpox was eradicated in 1977, and rinderpest, a cattle disease, in 2011.[6] Polio has been eliminated from the United States and Europe.[2]

Despite these historical successes, vaccination is not just a story from the past. Stanley Plotkin and colleagues enumerated twenty-two diseases and infections for which effective vaccines exist but also forty-seven

others for which sufficiently effective vaccines are currently not available.[7] Infectious diseases, many of which are vaccine preventable, remain a leading cause of worldwide mortality.[8] For instance, approximately 6.3 million children under 5 die each year, and about half of these deaths are due to pneumonia (often caused by influenza or pneumococcus), diarrhea (often caused by rotavirus) or other diseases caused by potentially vaccine-preventable infections such as measles, tetanus, tuberculosis and malaria.[2,8] Current realities such as global warming, globalization, and increased urbanization all facilitate disease transmission. Global warming changes environments and allows for organisms to flourish in previously inhospitable environments.[9] Populations are more mobile, and globalization and increased urbanization allow for greater movement of people and microbes, thus contributing to disease transmission. Perhaps an even greater issue is antibiotic

resistance, which reduces the ability to cure many common acute infections compounded by a lack of having real alternative treatments in development.[10] Wider and inappropriate use of antibiotics promotes antibiotic resistance. The prevention of infections through vaccination reduces the need to treat infections with antibiotics. Such treatment can be appropriate when these

infections are caused by bacteria (eg, *Streptococcus pneumoniae*, *Bordetella pertussis;* both vaccine-preventable). Antibiotic treatment is often inappropriate when it is used against infection with viruses (eg, influenza).

Given their continued importance in reducing the global infectious disease burden and curtailing antibiotic resistance, there is little doubt that vaccination will remain a pillar of public health. It is essential to have adequate policy environments in place that can guarantee a timely and steady supply of vaccines along with well-established pathways to enable their widespread uptake in the population. A key for success is to secure sufficient financial resources for vaccination. In the current context of rising pressure worldwide on health care budgets, where all medical interventions have to compete for funding, success can only be guaranteed by correctly understanding the value vaccination offers to the community. When policy makers only see part of the benefits of a vaccine but all of its costs, they are likely to underinvest. Not only would this lead to suboptimal use of existing vaccines, it would also adversely affect the supply of new vaccines as their development and production is very expensive and risky. In addition, since their production occurs predominantly

in a private market, it is important that vaccines remain an attractive business opportunity with a sufficient return on investment.[7]

Cost-Effectiveness And Broader Economic Impact

Cost-effectiveness analysis has become a standard framework for evaluating health care interventions in terms of value for money, by comparing their incremental costs with their incremental health effects (usually expressed as a cost per quality-adjusted life-year [QALY] gained).[11] Although official guidelines and regulations stipulate that funding decisions should not be based on cost-effectiveness alone, it has become an important predictor of funding decisions.[12] Cost-effectiveness is often referred to as the "fourth hurdle" a health program has to take in order to qualify for funding, after having demonstrated safety, quality, and efficacy.[13] Many countries have made evidence of cost-effectiveness mandatory in decision making on subsidized health care, including vaccines (for example, Australia, Finland, Norway, Canada, Portugal, Sweden, the Netherlands, and the United Kingdom).[14] In other countries such as the United States, cost-effectiveness analysis is not mandatory and its role is more limited. However, its implementation is nonetheless a subject of

discussion,[15,16] and in the context of infectious disease prevention cost-effectiveness analysis is often used as a means to make informed decisions.[17,18]

Vaccination is in several ways a special health care intervention.[14] Vaccines work preventatively, are usually administered to otherwise healthy individuals, often at a very young age, but give a (small) risk of serious adverse effects in vaccine recipients. Ideally, vaccination programs are rolled out with a long term population-wide public health goal in mind, taking account of its often substantial-- mostly positive and protective -- indirect effects in unvaccinated groups of the population (eg, neonates, immunosuppressed and elderly) through the population-wide reduction in the circulation of vaccine-preventable pathogens . Some of these properties may also be present in other forms of health care (for example, smoking cessation programs are preventative and may yield health effects in non-smokers), but their concentration in one intervention is unique to vaccination. A relevant question is, therefore, whether a one-size-fits-all evaluation method such as cost-effectiveness analysis manages to adequately take into account these particular characteristics.

During the past decade, several researchers have indeed argued that cost-effectiveness analysis can

misrepresent the real economic value of vaccines.[14,19-27] These scholars argue that cost-effectiveness analysis wrongly restricts itself to a "narrow" focus, underestimating the longer-term and broader economic effects of vaccines by only measuring short-term health care and productivity costs during the illness and its sequelae and by only considering effects on the vaccinated individual and closely related individuals (such as caregivers) instead of larger populations.

Recently, efforts have been made to develop economic frameworks that adopt a "broader" focus than cost-effectiveness analysis and that can consider the full economic impact of vaccines (e.g. 21,23,27). The broader benefits that are considered in these frameworks typically involve longer-term effects and wider externalities beyond the vaccinated individuals or their caregivers, such as increased lifetime productivity because of enhanced capabilities that are not easily measured, for example, improved cognition and educational attainment as a result of absence of infection and disease at a young age; ecological effects, such as reduced antibiotic usage and resistance; programmatic synergies, such as the development of delivery platforms that could be used for other purposes than vaccination, for example, health or social care communication; or

macroeconomic effects. The latter includes changes in household consumption and foreign investments due to uncertainty and risk-aversion caused by infectious diseases, as well as large demographic changes that impact on labor supply.[28] Such extended frameworks may also be relevant for other public health programs or complex interventions with important consequences that are difficult to measure or value unambiguously.

Social Impact

When it comes to priority-setting decisions and health care budget allocation, few will argue that cost-effectiveness and economic welfare should be the only guiding principles. The societal value of a vaccination program beyond cost-effectiveness and economic welfare is also in part determined by its impact on other objectives of public policy, such as promoting health equity, sustaining public goods, and stimulating social integration. Depending on the specific context, vaccination programs can play an important positive or negative role in achieving these goals.

Promoting Health Equity

In the most recent decades, health equity--fairness in the distribution of health within a population--has

become an increasingly important social policy objective. Vaccination programs can affect equity on two levels: between socioeconomic groups and between generations.

Both across and within country borders, along several axes of social stratification (e.g. education, income, occupation), it is systematically observed that the better-off population have better health prospects than the worse-off population.[29] There is a wide consensus that addressing this "social gradient" in health status should be a policy priority. However, affecting the social gradient presents obstacles, since it can be hard to identify the specific areas where action is most needed. First, from an effectiveness point of view: What *can* be done? In many instances, such as when trying to address disparities in cancer rates, the causal pathway to achieving more equality can be difficult to uncover. Second, from an ethical point of view, it can be difficult to single out areas where action *should* be undertaken. Not all health inequalities are necessarily inequities. For instance, inequalities between different income groups can be the result of complex social mechanisms beyond individual control, but they can also be the consequence of autonomous individual choice (for example risky lifestyle choices), which will--at least to some--be a morally relevant distinction to

make. From a health equity perspective such distinctions between avoidable and unavoidable and between fair and unfair inequalities matter, and only those that are both avoidable and unfair imply an undisputable call for policy measures and additional public resources.

In the case of infectious diseases, there is a strong presumption that inequalities indeed fall into the avoidable and unfair category and are amenable to interventions. First, disparities in infection rates are relatively easy to counter through more inclusive vaccination programs.[30,31] Moreover, infections are rarely reducible to lifestyle choices for which individuals could be held responsible. Few infections are related to chosen behaviors (infections transmitted by unsafe sex or injecting drug use might qualify), and, as most vaccines are offered during childhood, the choice to become vaccinated or not is rarely a decision for which an individual can be held personally accountable. Therefore, large-scale vaccination programs are essential instruments to promote health equity as they level the health risks that different socioeconomic groups face before issues of lifestyle and personal responsibility become relevant.

Moreover, there is substantial evidence that many other health conditions (or even inequalities in wealth

and well-being) later in life (part of which will again qualify as being inequitable) are related to a bad start in childhood,[32] for example, through experiencing a severe episode of an infection, such as childhood meningitis or congenital rubella syndrome. A general recommendation of the WHO's commission on social determinants of health is, therefore, to strengthen the role of prevention,[33] and several authors argue that vaccination should be a priority in this.[34]

But equity can also be relevant on an intergenerational level. The benefits, risks, and opportunity costs of a vaccination program are not necessarily fairly spread over different age groups and generations. Examples include disease-eradication programs where the benefits potentially extend to infinity, whereas risks and costs have to be incurred in the present;[35] "altruistic" vaccination (for instance, annual influenza vaccination in children that substantially decreases the risk of influenza in all age groups); and "egocentric" vaccination, which yields health gains in one generation but risks to induce health losses in another (for instance, childhood varicella-zoster virus vaccination, which may decrease chickenpox in children but simultaneously increase shingles in adults and the elderly[36,37]). Neglecting such

considerations can, depending on views about what different generations owe to each other, lead to inequitable vaccination policy and affect a general sense of intergenerational solidarity in preventing infectious diseases.

Such considerations of socioeconomic or intergenerational equity are not considered in cost-effectiveness analysis nor in frameworks for vaccines' broader economic impact. Health outcomes (such as QALYs) are given an equal value, regardless of whether they improve health equity, widen disparities even further (for example, by improving the health of better-off groups only), or harm the rightful interests of particular generations or age groups.

Sustaining The Public Good Of Herd Immunity

Herd immunity is the disease protection that those individuals in a population who are immune offer to the remaining susceptible ones. It arises as a consequence of the reduced circulation of a pathogen that is observed when more and more individuals become immune, either through having experienced an infection or through vaccination.[38]

This herd immunity is an important way of protecting two groups of individuals who are unable to protect

themselves. First, vaccines can only be effectively administered to those individuals with an immune system that is able to trigger an adequate antibody response. Young infants, the elderly, pregnant women, patients with chronic illness, or those with particular allergies often do not tolerate vaccination. Second, also to immunocompetent individuals, vaccination does not offer (on average) 100 percent protection. There is always a percentage of those who are vaccinated who are not protected against the disease (because of an ineffective vaccine or unsuccessful response from the immune system). No one can be 100 percent certain that a vaccine he or she receives will work for him or her. In other words, herd immunity is an important benefit to *everyone* at *any* time. As we have all been children, and we expect to be old one day, and as we cannot be certain about our protection in the lifetime in between, we all benefit from herd immunity at different stages in our lifetime. It should be seen as a safety net for unfortunate individuals, an essential second tier of infectious disease prevention.

This herd immunity should be considered as a "public good."[39,40] It offers a substantial benefit to the entire population, but establishing and maintaining it requires collective action. This dependence on collective

effort makes a public good vulnerable, difficult to establish, and demanding to sustain. In the case of herd immunity, it requires broad support and dedication from the population to collectively undergo short-run sacrifices (costs and possible adverse effects from vaccinations) for more long-term and less visible herd immunity benefits. At the same time, on an individual level, people will have an incentive to "free ride" on the efforts of others: Let others become vaccinated and risk adverse effects and then take advantage of their efforts.[40]

A key responsibility of public policy is to establish these public goods but also, once they are there, to manage the complex social dynamics that are involved in sustaining them.[41] Considerations of trust, goodwill, solidarity, and fairness are essential to long-term success. Vaccination programs have characteristics that can affect these values and that can consequently affect the public good of herd immunity.

First, although vaccines are generally considered to be safe, all vaccines can cause side effects, which are usually mild. Serious adverse events also occur, albeit rarely. But the occurrence of the latter can have an extraordinary and unpredictable impact on public perception and can disproportionally affect the

acceptance and success of a vaccination program, other vaccines, or any intervention co-administered with it. Public scares such as with the measles, mumps, and rubella vaccine in the United Kingdom, can have long-lasting effects on overall vaccine uptake that are costly and hard to counter.[42] There is a large symbolic or role-model dimension to the safety of a vaccination program, and the impact of serious adverse effects goes widely beyond their actual health consequences. Moreover, in the present context of internet and social media, where antivaccination lobbies are increasingly inflating such risks over the benefits, or spreading completely false allegations, harmful consequences may even be exacerbated . [43, 44]

A second element is the perceived extent of free-riding in a program. Once herd immunity is established, it is difficult to exclude free-riders from benefitting from it. If the public perception is that large groups of people free ride (either intentionally or unintentionally, such as in the case of religious vaccine refusers), then this can affect the willingness of others to contribute. But also, vice versa, if the perception is that those people who can become vaccinated overall do so, that sacrifices for the public good are generally fairly distributed, and that free-riding is a marginal

phenomenon, then this can establish a social norm to contribute to the creation of herd immunity. These norms signal appropriate behavior, reinforce it, and are influential determinants of success in establishing and maintaining public goods.[45]

This public good dimension of a vaccination program is not properly accounted for in cost-effectiveness analysis. Many analyses are based on static models that ignore the herd immunity benefits a program generates.[46] Increasingly, cost-effectiveness analyses use dynamic transmission models,[46-49] which do consider cases prevented indirectly through herd immunity but do not adequately take into account the complexity of positive values of herd immunity and the factors that sustain or undermine it. Adverse health effects are valued in a similar way as the positive effects from vaccination (for example, in QALYs gained versus lost and supplementary treatment costs) without considering their costly repercussions of losing trust and goodwill. Herd immunity benefits are valued by simply assigning QALYs to them, irrespective of whether those who receive them are in fact free-riders or vulnerable individuals who can't protect themselves, and no valuation is provided for social norms or contributing to the public good.

Social Integration Of Minorities

A third broader social objective in which vaccination can play an important positive or negative role is the social integration and inclusion of ethnic or cultural minorities. Both in the United States and in the European Union, policy makers acknowledge that this is a big and ongoing social challenge that requires positive action and targeted policies.[50] In the European Union, the current migrant crisis makes this objective especially poignant.

Vaccination can foster integration by countering social dynamics such as stigmatization that can be fueled by infectious disease transmission. Population subgroups with a sensitive public image often also have higher incidence of and more severe disease from infections.[51-54] Examples include measles in Europe’s Roma population; hepatitis A in men who have sex with men and in immigrant clusters in Europe among those from the (Maghreb) Northwest African countries of Morocco, Algeria, and Tunisia; hepatitis B in sex workers; and several infections, such as rotavirus, pneumococcus, hepatitis A, and hepatitis C in indigenous populations in Australia and North and South America. Arguably, these transmission patterns can hinder social mobility, integration, labor

market participation, or, worse, create an atmosphere of exclusion in the community at large.

On the other hand, the opposite is also conceivable.[55,56] Vaccination programs targeted specifically at these minorities could be perceived as discriminatory, by the target group who may feel unfairly singled out for vaccination or by the majority who has to pay more for the vaccine. Or, it could reinforce stigmatizing stereotypes that minority groups are responsible for the transmission of particular diseases in the community.

These subtleties affect the broader social impact of a program but are neglected in an appraisal based on cost-effectiveness or broader economic impact.

Conclusion

In a context of increasingly strained health budgets, in which cost-effectiveness analysis and comparative effectiveness research have become influential drivers of funding decisions (especially in Europe but increasingly in the United States as well), it is important to correctly understand the full contribution vaccination programs offer to the community and the extent to which this value is over- or underestimated in summary measures such as cost per QALY.

Several authors have argued that vaccines can have a broader economic impact than other health care interventions and that their value is underrepresented in cost-effectiveness analysis (14,19-27). In this article, we argued that vaccination programs also have a special relationship with particular objectives of social policy. An important but admittedly difficult challenge for health technology assessment and appraisal is to expand existing methods so that they manage to include these broader, complex, and often multidimensional effects.[57] However, in absence of more complete evaluation frameworks, decision makers should be aware of the social benefits and costs of vaccination that are excluded.

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Acknowledgment

AUTHOR BIOS

BIO 1: Jeroen Luyten (J.luyten@lse.ac.uk) is a fellow in the Department of Social Policy at the London School of Economics.

BIO 2: Philippe Beutels is a professor at the Centre for Health Economics Research and Modeling Infectious Diseases at the University of Antwerp, in Belgium.