The Value of Vaccination

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Abstract Vaccination is most often studied from a scientific, clinical, or epidemiological perspective, and rightly so, for vaccines are meant to improve health outcomes. But these are not the only lenses through which the effects of vaccination programs can be understood. This chapter provides an economic perspective on vaccination programs, detailing in particular a new line of inquiry that makes a case for the importance of vaccination to achieving national economic aims. Research has shown that national spending on childhood vaccination programs does more than just reduce morbidity and mortality in a country: it also promotes national economic growth and poverty reduction. The chapter begins with a look at recent research that demonstrates powerful links that run from population health to economic well-being. Second, it discusses how knowledge of the economic benefits of health fundamentally transforms how we understand the value of vaccination. And third, it provides evidence for the scale of the returns that countries receive when they invest in immunization programs – returns that have not been fully captured by traditional economic analyses.

1 Population Health and Economic Well-Being

Since 1950, many parts of the world have seen remarkable health gains. Life expectancy has increased by more than two decades, and the global infant mortality rate has been reduced by two-thirds over the same time period. Smallpox has been eradicated, and polio nearly so. These health improvements are examples of what one might consider truly extraordinary achievements. By defining what might be possible, they can – and should – make us even more ambitious about what can be achieved in the future.

But these have also been accompanied by a colossal set of failures in the health arena, failures that indicate the extent and severity of human misery and insecurity

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on the planet. In particular, there has been a demonstrated reversal of health gains in some countries. Largely as a consequence of the HIV and AIDS epidemics, life expectancy in several sub-Saharan African countries has fallen, in some cases by roughly 15 years, beginning in the 1990s [1]. As another example, two-thirds of the roughly 9 million deaths of children under the age of 5 worldwide that will occur this year will be due to causes that could be easily prevented or cured with existing knowledge [2].

Even more troubling than these health deficits are the gross health disparities between rich and poor nations. In 2005, 86% of the world's health expenditure took place in the OECD countries – which are home to but 15% of the world's population [3]. At least 20% of the world's children are still not immunized with DTP3, with research in *The Lancet* suggesting that this number is likely to be closer to 26% [4]. Child mortality is currently an order of magnitude higher in developing countries than it is in the wealthy industrial countries. Significant disparities also prevail in infant mortality and life expectancy (see Table 1). Large disparities also exist not only between but also within countries, typically between urban and rural populations, racial and ethnic groups, and income classes.

Most of the financial resources for improving population health – for addressing these failures and disparities – will have to come from the public sector. There are four classic arguments in support of devoting public resources to the promotion and protection of health. The first set of arguments has moral, ethical, and humanitarian roots – i.e., devoting resources to health is fair and just. The second argument is that health is a "fundamental human right," a legal claim to which all human beings are entitled. The third argument is that health is essential to building strong societies. In this view, improved health is a key ingredient in the formation of social capital and societies that are cohesive, peaceful, equitable, and secure. A fourth argument has to do with the character of health and of health services, from an economic standpoint. For a number of reasons, unregulated markets do a poor job of achieving socially

Table 1 Health disparities between developed and developing countries [5]

	1950–1955			2005–2010		
	World	Developed countries	Developing countries	World	Developed countries	Developing countries
Infant mortality rate (deaths per 1,000 live births)	152	59	174	47	6	52
Child mortality rate[a] (deaths per 1,000 live births)	109	18	122	71	8	78
Life expectancy (years)	47	66	41	68	77	66

[a]Child mortality rate is for 1980–1985 and 2005–2010

desirable levels of health provision. This means that governments have a natural (and essential) role to play in the health sector.

These four arguments on behalf of devoting public resources to health are each logical and coherent. However, neither individually nor collectively have governments or other institutions been able to use them to mobilize the resources necessary to make a significant dent in the world's health deficits and disparities. It is evident that more is needed to make a persuasive case.

Another powerful justification for devoting public resources to health has recently come to the fore, one that will perhaps add to the collective power of the above justifications for health spending. This argument has to do with the relationship between health and the macroeconomy. Essentially, it argues that a healthy population is an important engine of economic growth [6].

Figure 1 shows one of the best established patterns in the field of global health – the positive association between health and wealth. Each point is a country, with the location of the point reflecting the country's income per capita and the life expectancy of its people. The basic pattern shown on the chart is that countries with higher incomes tend to have healthier populations. This pattern holds for different income and health measures and at different points in time [7].

Another key feature of the chart is the arrangement of the variables on the horizontal and vertical axes. Income is placed on the horizontal or *X* axis, which means it is the independent variable. This is a clear suggestion that the variable income affects the dependent variable on the vertical or *Y* axis, in this case, health. In other words, the centerpiece of this very famous scatterplot is a causal link that runs from income to health.

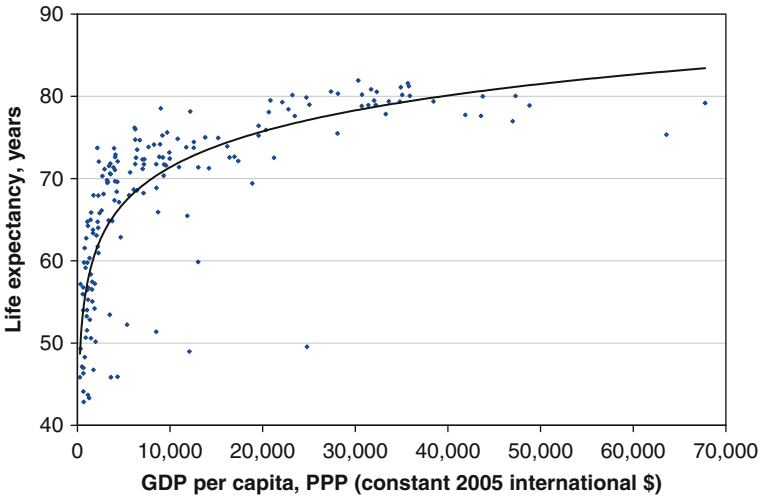

Fig. 1 Life expectancy and income [8]

This is not a startling idea. When people have more money, they tend to have better nutrition, better access to safe water and sanitation, access to more and better health care, and better psychosocial resources like community recreation facilities. These mechanisms allow one to conceptualize population health as a consequence of economic growth, which has been the dominant view on the health–income nexus going back to the birth of modern economics over two centuries ago.

However, the reverse causal link – from health to income – may be equally plausible, for several reasons [9]:

First, a healthier workforce tends to be a more productive workforce, with more energy, better mental health, and less absenteeism.

Second, economic outcomes can be improved through better education, which is in turn improved by health. Healthy children tend to stay in school longer and have better cognitive development. Thus, educational investments in healthy children yield high returns, which will naturally lead to an expansion of those investments. Education is virtually undisputed among economists as being one of the most powerful instruments of economic growth and poverty alleviation.

Third, health and longevity affect savings and investment. Healthy populations have higher savings rates as people save more in anticipation of longer periods of retirement. Savings lead to investment, which results in the accumulation of physical and human capital, and technological progress. These are, of course, the classic drivers of economic growth. It is also worth noting that healthy populations are better able to attract foreign direct investment [10], which often carries with it new technology, job creation, and increased trade.

Finally, demographic change provides yet another casual link from health to economic improvement, a link that was vitally important to the so-called economic miracles experienced in a number of countries in East Asia and Ireland. Essentially, the idea is that health improvements trigger a process of demographic change, beginning with lower fertility rates, that promotes an age distribution that is increasingly favorable to economic growth. This demographically induced boost to economic growth has come to be known as the demographic dividend.

The reverse link from health to income has been the subject of much statistical and econometric analysis in the past few years. There are different ways of looking at the link and at data pertaining to the link – varying time periods, control variables, data sets, statistical tools, theoretical frameworks, etc. For the purposes of this chapter, it is enough to say simply that population health is an exceedingly robust and powerful predictor of economic growth.

This premise can be illustrated through a thought experiment: Imagine two countries that are identical in all key dimensions pertinent to economic growth, except that the people in one are healthier than those in the other. The new finding tells us that the healthier country will increase its average income and reduce its poverty rate faster than the less healthy country. It also tells us that a 5-year advantage in life expectancy translates into between 0.3 and 0.5 additional percentage points of annual growth of income per capita [11].

A 1% point advantage may not sound like much, but in a world economy in which per capita income typically grows at 2–3% per year, it is quite meaningful.

A 1% point gain is also meaningful because a 10-year gain in life expectancy is well within the grasp of a very large number of countries. It corresponds roughly to the life expectancy improvement that developing countries – where average life expectancy is currently 66 years – would enjoy if they achieved the same life expectancy as today's developed countries – where it is currently 77 years. It also corresponds to the life expectancy improvement that many demographers project for the wealthy industrial countries during this century.

2 A New Paradigm for the Value of Vaccination

The new perspective outlined above has important implications for assessing the value of immunization programs. There are two standard approaches to conducting an economic evaluation of the desirability of a health intervention: cost-effectiveness analysis and benefit–cost analysis. Today, benefit–cost analysis is the economic tool of choice with respect to assessing the value of vaccination [12].

In carrying out a benefit–cost analysis, decisions must be made regarding what constitutes a cost and what constitutes a benefit. With respect to vaccination, there is nothing particularly tricky about measuring costs. These include the cost of the immunizing agent, the cost of administering that agent, and the value of time associated with getting a child to a medical practitioner, along with any associated transportation costs.

The calculation of benefits is less straightforward. Economists traditionally focus on a narrow range of implications of vaccination programs. They assume that with vaccinated children not getting sick, medical costs are avoided. In addition, they assume that parents may benefit by not having to miss work to look after sick children or take them to the doctor. These two benefits are correctly treated as benefits of a vaccination program. However, they are just two components of the much wider set of overall benefits that vaccination potentially confers on children, their parents, and their communities.

For example, healthy children have, as mentioned above, better records of school attendance. They also attend school for more years and learn more each year they are enrolled. Vaccinated children also tend to avoid the long-term sequelae associated with certain childhood diseases, such as neurological impairments, hearing loss, and a variety of other physical disabilities. Better educated and healthier than their peers, vaccinated kids will therefore tend to be more productive workers when they grow up.

Such benefits do not only accrue to children. With respect to parents and grandparents, they tend to be healthier themselves if their children and grandchildren are healthy. They also have lower rates of absenteeism, and they avoid the anxiety associated with having children and grandchildren who are ill.

Society also derives benefits from vaccinated, healthy children. These benefits relate first to herd immunity, where even individuals who are not immunized gain protection from disease when other members of the community are immunized.

Immunologists and clinicians express this herd immunity bonus in terms of additional numbers of effectively immunized people; economists focus on the monetary aspects, where those people who avoid illness because of herd immunity will tend to be more productive and require less resources for medical care. Societal benefits also include decreased antibiotic resistance. Because immunization means less need to treat diseases with antibiotics, it decreases the development of antibiotic resistance and the need to resort to what are often far more expensive second-line drugs. Finally, the expectation that children will grow up healthy leads naturally to families having fewer children, a benefit that helps trigger the demographic dividend described above.

The central premise, then, of the new paradigm for the economic evaluation of vaccination is a broad view of the benefits of vaccination, one that incorporates impacts on the many factors listed here, in addition to averted medical care costs and the cost of parental work loss [13]. In other words, if one accepts the argument that "healthier means wealthier," it stands to reason that a proper accounting of the benefits of vaccination must, at a minimum, include the future productivity gains of children who grow up healthier, smarter, and better educated, as well as the economic gains enjoyed by others in their families and communities.

3 Applications of the New Approach

A review of some recent research will demonstrate the kind of results that are produced via the new paradigm for conceptualizing, measuring, and accounting for the full benefits of childhood vaccination. Two studies serve to illustrate the change: one focuses on a Global Alliance for Vaccines and Immunisation (GAVI) program and the other analyzes some data from the Philippines [14].

The GAVI proposal aims to extend the use of a variety of vaccines to 75 low-income countries during 2005–2020, at a cost of US $13 billion. GAVI seeks to expand the traditional basic childhood vaccination package; to increase coverage of the under-used Hib, hepatitis B, and yellow fever vaccines; and to help finance the introduction of vaccines covering meningococcus, pneumococcus, and rotavirus. In principle, this ambitious program will save lives, save medical care costs, and encourage higher labor productivity by supporting the physical and mental development of children. GAVI's epidemiologists estimate that this program will reduce the child mortality rate in the 75 GAVI countries by 4 deaths per 1,000 live births initially (by 2005), and by 12 deaths per 1,000 live births (by the year 2020), a sizable decline.

In an initial, albeit somewhat crude, attempt to estimate the rate of return on this investment, a group of researchers calculated the likely effect of the program on worker productivity at the individual level. The headline result was striking, in which a conservative approach estimated the rate of return on investment in the GAVI immunization program to be 12% by 2005, rising to 18% by 2020. These rates of return compare favorably with rates of return on other highly regarded investments in economic growth and development.

A second study that took a relatively broad view of the benefits of vaccination examined data from the Cebu Longitudinal Health and Nutrition Survey on efforts to immunize children in the Philippines against DTP, TB, polio, and measles. The analysis focused on children's cognitive development and directly links vaccination experience in the first 2 years of life to cognitive function at age 10, as measured by test scores on language, math, and IQ tests.

Using a range of propensity score methods to deal with the problem of non-random assignment, the study found a significant positive effect of childhood vaccination on all three test scores. When international evidence was used to translate those test-score benefits into earnings gains as adults, and to compare those earnings gains to the $20 cost of the vaccine package, another striking result appeared: a 21% rate of return on the vaccine spending.

4 Two Calls to Action

The results of the GAVI study and the Philippines study are at best suggestive. But they both point toward the eminent economic sensibility of immunization programs by virtue of the handsome rate of return they deliver – a return that is higher than previously recognized and that is comparable to estimated rates of return on investments in education, the most exalted instrument of development.

Education economists have long understood that one compelling argument to justify incurring the out-of-pocket and foregone earnings costs of schooling today is the enhancements that schooling yields to productivity and earnings tomorrow.

What the above research suggests is that we acknowledge that the same reasoning applies to spending on vaccination research and coverage. Spending on immunization programs today promotes increased productivity and increased earnings tomorrow – and these increases need to be meaningfully, consistently, and comprehensively measured in the interest of better public and private policy decisions about resource allocation.

Thus, this research potentially provides more than just an incremental contribution to knowledge. It actually has transformative potential: it has the capacity to transform vaccination policy debates from discussions of vaccination programs as burdensome costs into discussions of vaccination programs as income-generating investments. Such a transformation is guaranteed to get the attention of economic policymakers because they are accountable for income growth and poverty reduction. And this can be very fortuitous, since economic policymakers also have the "power of the purse." The first call to action is thus that policymakers, in allocating resources to national vaccination budgets, acknowledge that the rate of return offered by vaccination is likely higher, perhaps considerably, than has been previously thought.

One other certain implication of this research is that the literature on the economic evaluation of vaccination needs to be reconsidered. Most books and articles on the benefits and costs of vaccination discuss only the reduction in healthcare costs

that stem from vaccination, while a few sources also make a passing nod to the benefits of reducing time away from work. As a result, there is much research to be done. The second call to action is directed toward economists and other researchers, who must conduct a new set of benefit–cost analyses, vaccine by vaccine and country by country, to widen and deepen the evidence base regarding the full benefits of vaccination programs.

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