CHAPTER 2

# THE ECONOMICS OF HEALTH INNOVATION: LOOKING BACK AND LOOKING FORWARD

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Technological progress is widely recognized as a source of long-run economic growth. Some forms of progress, however, are not captured by standard growth statistics. Health improvements are one example. The Nobel-Prize winning economist William Nordhaus has calculated that the economic value of increases in longevity in the last 100 years is as large as measured economic growth *in all other sectors*. He illustrates the basic point with the following thought experiment:[1]

> Consider the improvements to both health and non-health technologies over the last half century (say from 1948 to 1998). Health technologies include a variety of changes such as the Salk polio vaccine, new pharmaceuticals, joint replacement, improved sanitation, improved automotive safety, smoke-free workplaces. Over this period, life expectancy at birth increased from a little above 68 years to a little less than 76 years. Non-health technologies were also wide-ranging and included the jet plane, television, superhighways, VCRs, and computers....
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> Now consider the following choice. You must forgo either the health improvements over the last half-century or the non-health improvements. That is, you must choose either (a) 1948 health conditions and 1998 non-health living standards or (b) 1998 health conditions and 1948 non-health living standards. Which would you choose?

If you choose (b) or have difficulty choosing, you basically agree with the idea that improvements in health are as valuable as improvements in all other sectors combined. While these estimates were based on data from the United States of America (U.S.), similar health improvements were observed in other high-income countries over the past half century. Lower income countries also saw significant improvements in standard indicators of health status during the 1950s, 1960s, and 1970s.[2]

## Looking back: the role of innovation in health improvement

Nordhaus and others have suggested that the creation and diffusion of new medical knowledge and technologies—medical innovation—were important sources of these health improvements.

What is medical innovation? While this is a more complicated question than it may seem, our focus here is on the incorporation into practice of new drugs, diagnostic methods, procedures, and devices that improve healthcare, as well as of new medical knowledge that shapes individual health behaviors, clinical practices, and informs public health policies and interventions.

Over the first half of the twentieth century, with some important exceptions,[3] new physical technologies had a limited role in improving health. Indeed, one influential scholar has argued that most historical improvements in health had little to do with healthcare or medical interventions at all, instead reflecting broader socioeconomic factors such as higher incomes, improved nutrition, and better sanitation.[4]

The antibiotics and sulfa drugs developed during the 1930s and 1940s were the first miracle medical technologies.[5] The diffusion of these drugs, first in rich countries and then globally, led to sharp decreases in morbidity and mortality in the 1940s and 1950s. Many new antibiotics and other new drugs, vaccines, and treatments were introduced in the two decades after World War II—often considered the "golden age" of medical innovation. By about 1960, antibiotics and vaccines virtually eliminated known infectious diseases as a major source of mortality in developed countries.

There has been continued improvement in health since that time. In most high-income countries, the main source of these gains has been a reduction in cardiovascular disease mortality.

Even though cardiovascular disease remains a leading cause of death, mortality fell sharply in the second half of the twentieth century. In the U.S., mortality from heart disease has fallen by about two-thirds since 1950, leading to a 5-year increase in life expectancy for the average 45-year-old.[6] Much of this has come through new knowledge of risk factors, which led to behavioral changes—such as less smoking and better diets—and disease prevention. Estimates suggest that about one-third of the gains are due to drug innovation, one-third to prevention, and the final third to high-tech medical treatments such as cardiac catheterization, bypass surgery, angioplasty, and others.[7] In reducing cardiovascular mortality, both medical technologies and new medical knowledge play an important role.

Another major source of morbidity and mortality is cancer. Cancer deaths have not declined in most countries in the postwar era, despite billions of dollars spent globally on the "war on cancer." One reason that deaths have not declined is competing risks: with fewer people dying of cardiovascular disease, more develop cancer. However, despite decades of frustration, there have been recent signs of progress in reducing mortality from some cancers, driven by screening technologies, such as mammography for breast cancer and colonoscopy, and by behavioral changes. In addition to better prevention, there have been new treatments as well, including surgeries, radiation, chemotherapy, and new drugs.[8] In an approach similar to Nordhaus, economists have found that improvements in cancer survival generated social benefits valued around US$1.9 trillion in the U.S. between 1988 and 2000.[9]

The HIV/AIDS epidemic threatened to negate some of the improvements in global life expectancy in the 1980s. For this disease, new technologies—especially antiretroviral therapy and follow-on drugs—have been crucial to making it a treatable disease. Economic estimates suggest that, by the end of the last century, new HIV/AIDS drugs generated US$1.4 trillion in economic value in the U.S.—a figure that would be significantly higher if global gains were included.[10] As with cancer and cardiovascular disease, more needs to be done to reduce the toll of HIV in developing countries in particular, yet the response to the HIV/AIDS epidemic presents perhaps the strongest recent example of the benefits from new medical technologies.

The basic empirical approach in many of the assessments above is to put an economic value on improvements in individual health outcomes, such as mortality and/or quality of life, that are linked to medical innovation. But there are other benefits from medical innovation as well. A study of AIDS treatment in sub-Saharan Africa shows that beyond the health benefits, these drugs helped improve labor force participation, childhood schooling, and other economic outcomes that influenced productivity and economic growth.[11] Beyond the value of reduced mortality and improved productivity, new medical technologies also improve the quality of life. Depression treatments and hip replacement, for example, have dramatically reduced morbidity and improved quality of life. Some new medical technologies, such as birth control pills, have completely revolutionized the labor force and social dynamics.[12]

In many cases, these advances have not come cheap. New medical technologies are widely recognized as major drivers of healthcare costs, perhaps because of the unique demand for improved health—in medicine invention may be the mother of necessity. There is now a large body of literature on whether the "technological imperative" in medicine is worthwhile and sustainable.[13] Overall, medical innovations seem to be cost-effective, and the social value of the technologies surveyed above—HIV treatments, cardiovascular improvements, infectious disease interventions— are orders of magnitude larger than their measured costs.[14] But there are many treatments where cost and value are out of line, which may account for a large share of health expenditures by patients and insurers.[15] Even technologies that are valuable from a clinical perspective can create budgetary pressures and affordability problems for governments and patients. The recent policy debate about high-cost prescription drugs is but one vivid illustration of the tension between new technologies, prices/access, and budgetary impact.

## Unevenness and potential

While medical knowledge and technology have been essential to generating valuable health improvements, progress has been uneven.[16] Many cancers remain untreated and diseases—from Alzheimer's to neglected tropical diseases and mental health disorders—lack effective prevention, treatment, and/or management and continue to drive morbidity and mortality globally. Perhaps worse, antibiotic resistance, rising obesity, and emerging infectious diseases could reverse some benefits of the past.

The potential economic benefits from new approaches to preventing and treating disease are significant. In a framework similar to that used by Nordhaus, economists have estimated that in the U.S., a 10% reduction in mortality from heart disease would generate US$6 trillion in value to current and present generations.[17] Reductions in morbidity and mortality from other major diseases would yield benefits of similar orders of magnitude. Economists have also calculated that delaying aging by 20% would generate social benefits of over US$7 trillion in the U.S.—even as it would create serious fiscal challenges due to the need for supporting a growing, elderly population.[18] Economically valuable health gains and productivity improvements could also come from reducing the burden of neglected tropical diseases, continuing progress in HIV/AIDS, combating antibiotic resistance, and improving the efficiency of healthcare delivery.

## Can future medical innovation match the gains from the past?

It is important to remember that innovations in medical care are not the only route to improving health status and achieving potential gains, and in some contexts, they may not even be the most productive. Promoting broader economic development, reducing income disparities, and improving educational attainment could also generate health improvements, independent of medical care. As discussed above, these "social determinants" have been extremely important in the past, and poverty,

education, and diets continue to be associated with health outcomes today. Even as we focus on new technologies, the diffusion and adaptation of existing technologies and practices may also pay large dividends.

That said, the scope for new medical knowledge and technology to improve health and generate value is tremendous. But this raises another question: Is medical innovation up to the task? While the demand for innovation is high, there is concern that the golden years may be behind us—whether measured by the decline in major medical advances by year,[19] drug approvals,[20] or research productivity.[21] There is no consensus explanation for these trends. They may reflect that scientific and technological opportunities have dried up, ideas are getting harder to find, or the "low hanging fruit" has been picked. Perhaps more troubling, they may also reveal fundamental structural problems with the biomedical innovation system and incentives facing both public and private sector researchers.[22]

It is interesting that, at the same time, there is also tremendous enthusiasm about the future of medical science and technology. In the past few years, we have seen the launch of new hepatitis C treatments that essentially cure the disease—for those who can afford them—and cures for some cancers.[23] New areas of science and technology—cancer immunotherapies, gene editing, improvements in imaging and diagnostics, and many others—could transform prevention and treatment of specific diseases or healthcare in general. At the same time, some believe these new approaches may ultimately have limited impact on population health and potentially high costs. For example, echoing the historical debates about the role of healthcare in health alluded to earlier, public health scholars have questioned whether current levels of investment and enthusiasm in personalized medicine are the best route forward for improving population health, as opposed to greater investment in known behavioral and structural interventions.[24] Some warn that over-enthusiasm and hype may surround the new fields of medical science and innovation, as is also common for emerging technologies.[25]

Interestingly, much of the discussion about innovation in health today—in both high- and low-income countries—is not about new pills or products, but instead about improving healthcare delivery.[26] There is also excitement about new technologies and organizational innovations that may "disrupt'' existing business models—and, in particular, reduce costs without sacrificing value—though, at the same time, concerns exist about the obstacles to developing and diffusing such innovations in existing healthcare systems.[27] These trends reveal not only widespread dissatisfaction with current healthcare delivery models in many countries but also demand for new technologies that lead to cost-effective care. Interestingly, many of these new technologies are enabled by advances from another sector—information and communication technology. Information technology (IT) could have particular relevance in developing countries and resource-poor locations. Beyond their impact on healthcare delivery, new IT approaches—in particular, artificial intelligence (AI), machine learning, and big data—may also reshape drug discovery, new treatment evaluations, and the medical innovation system itself.

Conceptually, for medical innovations to have major economic impact, one of several things will have to be true:

- innovations must help prevent or treat diseases with a high disease burden, or at least eventually spill over to diseases and health problems with broad prevalence;
- treatments or interventions focused on specific diseases would have a cumulative impact, such as when genetic therapies target individual diseases;
- beyond individual disease-specific interventions, the process of innovation would be transformed by new general-purpose technologies, such as AI, machine learning, gene editing, cell therapy, and synthetic biology that open up new areas of exploration and invention;[28] or
- new technologies (e.g., digital technologies) facilitate broad systemic improvements in healthcare delivery, lowering costs and/or improving outcomes.

Predictions are hard. History teaches us that "the vast majority of attempts at innovation fail."[29] Enthusiasts making strong statements that any technology will transform, revolutionize, or disrupt healthcare should keep this in mind. However, history has also demonstrated an "inability to anticipate the future impact of successful innovations, even after their technical feasibility has been established."[30] Nathan Rosenberg and other economic historians have emphasized that technological forecasting is very difficult, since the success and economic impact of individual technologies depend, among other factors, on the rate and direction of incremental innovation following introduction, improvements in complementary enabling technologies, the scope for learning by doing and using, and the state of broader technological systems.[31] History shows that new technologies, including general purpose technologies, can take a long time to generate economic impact, and their ability to do so is contingent on many broader socio-economic factors.[32] Technical advances are often enabled by complementary advances in other fields, some of which are completely unanticipated.[33] Complicating things further, whether a technology "works" is often not known until it is embedded in clinical practice for a large number of patients.[34]

Although predicting the impact of specific areas of medical innovation is difficult, the potential for new medical innovation to generate valuable gains going forward certainly seems high, given the large value of health improvements and the unevenness of progress to date. Whether these potential gains are realized will depend on factors such as whether investments in innovation are aligned with social value, the pool of scientific and technological opportunities for advancement in different fields, the scalability of individual technical advances, and the extent to which healthcare providers and healthcare systems are incentivized to adopt and diffuse valuable new technologies. The costs of these innovations will determine affordability and ultimate benefit to patients.

## Looking ahead: governing the future

Policymakers will face trade-offs in supporting and regulating new medical innovation. These include, among others:

- **Public funding:** How much should the government be spending on research? What is the right balance between spending on fundamental science and more clinical and applied activities? How should public funds be allocated across different diseases and fields, between new science and old approaches?
- **Human capital:** What kinds of educational and other investments are needed to enable the development and effective diffusion of new medical innovations?
- **Patents and intellectual property:** How should national patent laws and global governance regimes be designed to promote innovation and access/diffusion?
- **Regulation:** How strong should regulations on new health technologies be to balance risk, including potential ethical considerations, against benefits from innovation and incentives/costs of entrepreneurship?
- **Evaluation:** How and when should policymakers evaluate the cost and benefits of new medical technologies to enable the creation and diffusion of safe, effective, high-value care?
- **Costs:** What role should governments have in influencing prices? How should they do so, and how would these policies affect the rate and direction of health innovation and diffusion?
- **Diffusion:** How should health and health innovation systems be designed to promote broad diffusion of, and access to, valuable existing technologies and organizational models? How should systems be designed to encourage "disadoption" of technologies that don't work or are too costly?

The future of health innovation, and the role of medical innovation in improving health outcomes going forward, will depend on the policies and institutions created by national and global actors to support research and innovation. There are no easy answers to the questions above; they are the subject of considerable research by economists and others and in many cases involve starkly competing values and objectives. Nonetheless, they are important issues for policymakers and the public to consider carefully and deliberately—given the transformative economic, social, and health impacts that new medical technologies have had historically and the enormous potential value of further health improvements for current and future generations.

**Notes:**

1 Nordhaus, 2002.

2 Cutler et al., 2006.

3 Cutler et al., 2005.

4 McKeown, 1976; However even in the early twentieth century, new medical knowledge, including the germ theory of disease, helped buttress the sanitation and hygiene movements that contributed to reductions in infectious disease mortality that accounted for most of the global decline in mortality over this period; Mokyr, 1993.

5 World Intellectual Property Report (WIPO), 2015.

6 Cutler et al., 2003.

7 Cutler et al., 2003.

8 Cutler, 2008; Lichtenberg, 2013.

9 Lakdawalla et al., 2010.

10 Philipson et al., 2006

11 Thirumurthy et al., 2012.

12 Bailey, 2006.

13 Cutler et al., 2001

14 Cutler et al., 2006.

15 Cutler, 2005.

16 Nelson et al., 2011.

17 Murphy et al., 2006.

18 Goldman et al., 2013.

19 Casadevall, 2018.

20 Scannell et al., 2012.

21 Bloom et al., 2017.

22 Sarewitz, 2016; Casadevall, 2018; Gittelman, 2016; Scannell et al., 2012.

23 Casadevall, 2018.

24 Bayer et al., 2015.

25 Deyo et al., 2005.

26 Herzlinger, 2006.

27 Hwang et al., 2008; Cutler, 2011.

28 Mokyr, 2018.

29 Rosenberg, 1998.

30 Rosenberg, 1998.

31 Rosenberg, 1969.

32 David, 1989.

33 Rosenberg, 1969.

34 Gelijns et al., 2001.

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