Chapter 19

Technological Fixes and Antimicrobial Resistance

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Abstract A ‘technological fix’ reduces the negative impact of a problem without addressing its underlying political, economic, or social causes. This chapter examines antimicrobials’ central role in both the modern faith in technological fixes in medicine, and critiques of over-reliance on technological interventions that produce unintended consequences. The enduring appeal of technological fixes is rooted in their promise to provide simple, efficient, measurable, and effective solutions to complex problems; but this practically is purchased at the price of eliding important distributive concerns.

Keywords Ethics · Public health · Infectious diseases · Social policy · History of science

19.1 Introduction

In October, 2003, The Bill and Melinda Gates Foundation (BMGF) announced the first 14 ‘Grand Challenges in Global Health,’ as part of an initiative to stimulate scientific research on diseases affecting less-developed nations. Grand Challenge #10 asked for applications that would help “discover drugs and delivery systems that minimize the likelihood of drug resistant microorganisms.” In the intervening years, combatting antimicrobial resistance has continued to be a priority for the BMGF, with at least 50 grants funded through initiatives aimed at ‘Creating Drugs and Delivery Systems to Limit Drug Resistance,’ and identifying ‘Novel Approaches to Characterizing and Tracking the Global Burden of Antimicrobial Resistance.’ Funded projects include efforts to crowdsource surveillance of antimicrobial resistance (AMR), investigating the role of metabolic pathways in *M. tuberculosis*

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bacteria as a target for drug therapy, and identifying chemical entities that would act as ‘selection inverters’ to limit or reverse the development of AMR.

Given the problem’s scale and complexity, the importance of developing technological solutions to improve surveillance and response to AMR might seem unsalvageable. However, soon after the initial announcement of the BMGF Grand Challenges, historian Anne-Emanuelle Birn published a sharp critique in *The Lancet*. Birn argued that, “in calling on the world’s researchers to develop innovative solutions targeted to ‘the most critical scientific challenges in global health’, the Gates Foundation has turned to a narrowly conceived understanding of health as the product of technical interventions divorced from economic, social, and political contexts” (Birn 2005, p. 515). In the area of AMR, Birn argued that:

Three more Grand Challenges addressing drug resistance and the development of cures for latent and chronic infections are also short-sighted. While access to effective immunotherapies for HIV/AIDS, tuberculosis, and other ailments has been appropriately termed a human right, integration of treatment with the well-established social and economic components of prevention surely merits at least one Grand Challenge. Here what deserves careful consideration are the factors associated with both HIV and multiple drug resistant tuberculosis: typically a combination of deprived social conditions—poor nutrition, overcrowded and unsanitary housing, economic insecurity, and inadequate health-care services—which lead to disease and can inhibit the taking of a complete course of medication (Birn 2005, p. 516).

Noting that “it is easy to be seduced by technical solutions” (Birn 2005, p. 516), Birn questioned the BMGF’s assumption that the most pressing global health problems can be solved through the application of innovative scientific and technological solutions that target proximate causes of disease, while ignoring more distal political, economic, or social determinants of health. She concluded with a call for integrating both narrow technological and wider social interventions, and cautioned that “the longer we isolate public health’s technical aspects from its political and social aspects, the longer technical interventions will squeeze out one side of the mortality balloon only to find it inflated elsewhere” (Birn 2005, p. 518).

Birn’s general argument is commonplace in contemporary public health. These arguments frequently employ a critique of ‘technological fixes’ (or in Birn’s language, ‘technical solutions’) – attempts to solve problems through technological innovations or interventions, without attending to the social, economic, or political factors that may have contributed to the development of the problem in the first place. Over-reliance on the promise of technological fixes has long been controversial in public health, particularly since the widespread recognition of the importance of the social determinants of health. Critics contend that too much emphasis is placed on ‘downstream’ technical solutions to health problems whose root ‘upstream’ causes are not amenable to technological intervention.

In this chapter, I will use the idea of a ‘technological fix’ as a window into the moral economy of responses to AMR, paying special attention to questions of distributive justice. Responding to antimicrobial resistance – which results from both a lack of appropriate medical technology and a complex web of behavioral, social, political, and economic factors – invites but also troubles the easy distinctions at the

heart of the technological fix idea, and confronts us with difficult decisions regarding how best to distribute social and economic resources.

19.2 Technological Fixes

The idea of a technological fix arose within a context of postwar optimism that advances in science and technology could provide cheap and effective solutions to seemingly intractable social problems. While there were important precursors, one of the most important early popularizers of this view was Alvin Weinberg, a physicist and longtime director of the Oak Ridge National Laboratory. Weinberg had long advocated philosophical reflection and social awareness among scientists, particularly about the implications of ‘Big Science.’ During the 1960s, in a series of conversations with colleagues, he developed the idea that at least some pressing problems that were largely seen as intrinsically social might be amenable to simple technological interventions (Johnston 2018), culminating in an influential 1966 speech, “Can Technology Replace Social Engineering?” which was printed in a number of periodicals, including the *Bulletin of the Atomic Scientists*.

Weinberg argued that the causes of many pressing social problems of the day were intractably complex, and interventions targeting those causes are infeasible or impossible. He thus advocated remedies that can reduce or eliminate the harms generated by these problems, without addressing those causes:

There is a more basic sense in which social problems are much more difficult than are technological problems. A social problem exists because many people behave, individually, in a socially unacceptable way. To solve a social problem one must induce social change – one must persuade many people to behave differently than they behaved in the past. One must persuade many people to have fewer babies, or to drive more carefully, or to refrain from disliking blacks. By contrast, resolution of a technological problem involves many fewer individual decisions (Weinberg 1991, p. 42).

Weinberg identified technologies that had already ‘fixed’ social problems, including the intra-uterine device (a ‘one-shot’ form of birth control which requires a minimum of individual motivation), development of safer cars (which reduces traffic deaths without having to improve driver competence), and even the hydrogen bomb (a strong disincentive to war that does not require greater tolerance or understanding). He proposed additional fixes, such as providing air conditioning to low-income households (to improve immediate personal comfort and potentially reduce rioting during hot summer months, without having to address the underlying social or economic causes of riots), and employing nuclear-powered desalination (which would eliminate water shortages without changing water consumer behavior).

While Weinberg was an admitted optimist and a tireless promoter of technological fixes, in his 1966 speech he struck a conciliatory note with potential critics: Noting that “technological solutions to social problems tend to be incomplete and metastable, to replace one social problem with another,” he conceded that “we technologists shall not satisfy our social engineers, who tell us that our Technological

Fixes do not get to the heart of the problem; they are at best temporary expedients; they create new problems as they solve old ones” (Weinberg 1991, pp. 47–8). Answering the question posed in his title, Weinberg concluded that “technology will never *replace* social engineering...It is only by cooperation between technologist and social engineer that we can hope to achieve what is the aim of all technologists and social engineers – a better society, and thereby, a better life” (Weinberg 1991, p. 48).

Weinberg’s hedging notwithstanding, his ideas about technological fixes met with immediate and sustained criticism; as early as 1970 the Oxford English Dictionary included wholly negative or ironic definitions of the term (Rosner 2004). Critics have mounted both practical and ideological objections. On the practical side, technological fixes provide at best short-term relief from the deleterious symptoms of social problems, but fail to address their root causes; at worst, they oversimplify intrinsically complex problems which they then fail to solve, and may introduce side effects that are worse than the problems they intend to solve. In a larger sense, the search for technological fixes is fundamentally reactionary in nature, encouraging society to seek cheap, quick, and partial solutions to holistic problems, while turning a blind eye to fundamental social and distributive injustices.

The transparent pursuit of technological fixes has had few defenders as vocal as Weinberg, and many detractors. This does not mean that the idea has fallen out of favor. Indeed, continued criticism is a sign of the enduring appeal of the idea of a technological fix, even if the term itself is not commonly used. For example, Evgeny Morozov’s 2013 book, *To Save Everything, Click Here: The Folly of Technological Solutionism*, criticizes the ‘there’s an app for that’ mentality of technological ‘solutionism’ in the internet age. Echoing earlier criticisms, Morozov argues that efforts to use internet-based technology to solve complex social problems – such as combating obesity through exercise-tracking apps rather than food regulation – encourage us to define problems in terms of the technologies that might solve them, and discourage broader consideration of macro-level interventions (Winograd 2013).

19.3 Technological Fixes and Health

Technological fixes have been the subject of intense and sustained debate in the areas of public health and medicine. Advances in medical technology (e.g. vaccines, therapeutic drugs, surgical techniques, medical devices such as x-rays) play an undeniable role in diagnosing and curing disease, relieving suffering, increasing life expectancy, and improving population health. This fact alone would seem to justify continued investment of the BMGF Grand Challenges variety. Yet, beginning around the same time that Weinberg began evangelizing for technological fixes, critics began to question a similar logic underlying increasing investment in medical technology.

First, critics questioned whether medical advances played as great a role in health improvements as commonly believed. The classic statement of this critique is

Thomas McKeown's 1976 book, *The Role of Medicine: Dream, Mirage, or Nemesis?* McKeown argued that changes in political economy – including rising standards of living and better sanitation and nutrition – rather than specific therapeutic or preventive efforts, were responsible for the massive mortality declines of the nineteenth and early twentieth centuries (McKeown 1979). While the McKeown thesis has been hotly contested (Szreter 1988; Fairchild 1998; Colgrove 2002), it is now widely accepted that the contribution of technological innovation to historical improvements in health and longevity has been greatly overstated.

Critics also pointed to the unintended consequences of medical technology. The classic statement (and the 'Nemesis' of McKeown's title) is Ivan Illich's 1975 book, *Medical Nemesis: The Expropriation of Health*. Illich criticized medicine's role in the production of 'iatrogenic' illness, side effects of medical interventions that might often be worse than the original pathology they were intended to treat. He lamented the progressive "medicalization of life," which left individuals and societies ill-equipped to contend with normal aspects of human life including birth, pain, and death, as anything other than technologically-mediated pathology. And he objected to modern medicine's "radical monopoly" on all aspects of health and disease, diverting economic and intellectual resources from other attempts to improve the human condition.

Finally, critics contended that the pursuit of medical technology promoted a narrow approach to health and illness, rather than the environmentally and socially holistic approach that is actually necessary. In his 1959 book, *Mirage of Health: Utopias, Progress, and Biological Change*, René Dubos – a microbiologist who as early as 1942 had predicted the emergence of bacterial resistance (Moberg 1996) – argued that attempts to create a world free of disease are bound to fail, "because paradise is a static concept while human life is a dynamic process" (Dubos 1996, p. 281). Modern medical technology is ill-equipped to address the evolutionarily dynamic biological and social worlds, and single-minded pursuit of technological innovation is a fool's errand.

In the years since, the arguments mounted by McKeown, Illich, and Dubos have resonated with a wide variety of critics of technological fixes in clinical care, modern medicine, and public health. They have found most purchase among proponents of the social determinants of health, who contend that the majority of the world's inequalities in health result from political, economic, environmental, and social injustices, rather than lack of technological innovation. As the World Health Organization's 2008 report, *Closing the Gap in a Generation*, argues:

Traditionally, society has looked to the health sector to deal with its concerns about health and disease. Certainly, maldistribution of health care – not delivering care to those who most need it – is one of the social determinants of health. But the high burden of illness responsible for appalling premature loss of life arises in large part because of the conditions in which people are born, grow, live, work, and age. In their turn, poor and unequal living conditions are the consequence of poor social policies and programmes, unfair economic arrangements, and bad politics. Action on the social determinants of health must involve the whole of government, civil society and local communities, business, global fora, and international agencies. Policies and programmes must embrace all the key sectors of society not just the health sector (WHO Commission on Social Determinants of Health 2008, p. 1).

19.4 Technological Fixes in the Context of Antimicrobial Resistance

It is no accident that Dubos developed his theories of microbial ecology, and his broader critique of the ‘mirage’ of modern medicine, within the context of his early work on bacterial resistance (Moberg 1996). Antimicrobials appear at first glance to be a technological fix par excellence, in the sense that they are a simple and effective technical solution to a complex problem with biological, social, political, and economic determinants. Indeed, a recent article critiquing the pursuit of technological fixes in dementia cited antibiotics as the classic case of a technological fix with unintended consequences (Jongsma 2017).

One could in fact argue that the apparent success of antibiotics is in large part responsible for a broader faith in technological fixes in medicine in the developed world. In 1967, during an oft-cited speech before American public health officials at the White House, U.S. Surgeon General William H. Stewart declared that it was time to close the book on infectious diseases and turn attention towards chronic health problems (Garrett 1994, p. 33). Stewart’s optimistic claim reflects a perennial American faith in the power of biomedical science to conquer disease, but it is also evidence of a significant transformation in the burden of disease during the past century. In what is often referred to as the “epidemiologic transition,” the proportion of deaths caused by infectious disease in the United States (and other industrialized nations) declined precipitously (Omran 1983). In 1900, infectious disease was responsible for 797 deaths per 100,000 population; by 1980, this figure had dropped to 36 deaths per 100,000 population. As mortality from infectious disease climbed, death rates for heart disease, various cancers, stroke, and accidents held steady or increased. In a dramatic reversal, chronic diseases replaced infectious ones as the leading killers in the United States. In 1900, 40% of deaths in the U.S. were caused by the eleven major infectious diseases (pneumonia, influenza, and tuberculosis alone accounting for more than 25% of all deaths), 16% by the three major chronic diseases (heart disease, cancer, and stroke), and 4% by accidents; by 1973, only 6% of deaths were caused by infectious diseases, 58% by chronic diseases, and 9% by accidents (Armstrong 1999).

The social and institutional ramifications of the epidemiologic transition were profound. Deluged with dramatic stories of patients snatched from the brink of death by antibiotics such as streptomycin and penicillin (dubbed “yellow magic” by Reader’s Digest in 1943), Americans increasingly credited biomedical science for reducing the threat of infectious disease. This accelerated the transformation (or “narrowing”), underway since the early part of the century, of the focus of public health, from broad preventive measures towards clinical medicine, screening and the early detection of disease (Rosenkrantz 1974; Tomes 1998). This transformation was accompanied by changes in federal health expenditures as well: between 1950 and 1959, federal grants-in-aid declined from \$45 million to \$33 million, while

funding for clinical and laboratory research jumped from \$28 million in 1947 to \$186 in 1957 (Fee 1994). The redirection of public and private funding from public health towards biomedical research would continue to accelerate into the 1980s, when it would be exacerbated by the dismantling of public health infrastructures in general under the pressure of Reagan-era budgetary constraints.

Even as much of the institutional apparatus for addressing infectious disease was being dismantled, the public and the medical profession increasingly mirrored Stewart's optimism regarding the threat of infectious disease. As historian Nancy Tomes notes, "With the array of drugs and vaccines available by 1965, the need to guard against contact infection understandably relaxed. Americans quickly came to believe that with a few soon-to-be-cured exceptions, modern medicine and public health had 'conquered' epidemic disease. Young physicians in the 1960s were advised, 'Don't bother going into infectious diseases,' and to concentrate on cancer or heart disease instead" (Tomes 1998, p. 254). Americans increasingly came to see infectious disease as a thing of the past, and they were bolstered in this confidence by the lack of significant epidemics of communicable disease – a confidence only briefly shaken by the HIV/AIDS epidemic, at least until the discovery of antiretroviral drugs.

Yet one can argue whether antibiotics truly 'fixed' the problem of infectious disease. As already noted, while they are often given full credit for the decline of infectious disease in Europe and North America, antibiotics were introduced after the majority of mortality declines that are more correctly attributed to rising standards of living, better nutrition, and basic public health preventive measures such as sanitation, vaccination, vector control, and provision of clean water (Szreter 1988; Cutler and Miller 2005). Moreover, social and economic factors continue to be major determinants of infectious disease (Semenza 2016). Even in high-income countries with well-functioning health care systems and access to a full range of antibiotics, poverty, social marginalization, and food and water quality continue to play a significant role in the incidence of infectious disease (King 2003; Semenza 2010). It remains to be seen whether, from a population perspective, investment in additional antimicrobials is the most effective or efficient way to reduce the burden of infectious disease.

Whether or not antibiotics 'fixed' infectious disease, their introduction generated the unintended consequence of antimicrobial resistance. While it might seem logical that a 'technological' problem (antimicrobials) demands a 'technological' solution (more antimicrobials), as the other chapters in this volume illustrate, the causes of and solutions to antimicrobial resistance are more complicated. As with infectious disease, the proximate cause of antimicrobial resistance is biological – pathogens develop resistance under the selective pressure exerted by use of antimicrobials – but underlying this proximate cause is a range of more distal determinants. These include, among others:

- Physician behavior – e.g., prescribing antibiotics for conditions caused by viruses (Sprenger 2015); engage in suboptimal practices such as use of monotherapy rather than combination therapy; and incorrect drug administration routes (Struelens 1998).
- Patient behavior – e.g., failure to complete full course of treatment; and self-medication, particularly in countries where antimicrobials are available over the counter.
- Poor hygiene, sanitation, and infection control in hospitals and other healthcare facilities, leading to cross-infection with multiple strains of bacteria (Aiello 2006; Struelens 1998).
- Widespread use – including misuse and overuse – of antimicrobials in agriculture (Levy 2014; Ventola 2015).
- Lack of development of new antimicrobials, which are less profitable than drugs for chronic conditions that are generally more expensive and used for much longer periods of time (Brown and Wright 2016).

Novel antibiotics will be introduced into the same social, political, and economic contexts that have contributed to the development of antibiotic resistance in the first place. Addressing these contexts would require, among other interventions: changing the behavior of physicians and patients to encourage appropriate stewardship of antimicrobials; instituting and enforcing new sanitation and infection control protocols at healthcare facilities across the globe; reforming an agricultural system dependent upon cheap antibiotics; and changing the incentive structure of the pharmaceutical industry to ensure that need rather than profit drives drug research.

Faced with a wide and seemingly insurmountable range of determinants, focusing on the development of new lines of antimicrobials through targeted research grants and incentive programs is attractive. Yet such a narrow pursuit would, ultimately, amount to little more than layering technological fixes on prior technological fixes. As Dubos noted a half-century ago, “Granted the obvious usefulness of sanitary practices, immunological procedures, and antimicrobial drugs, it does not necessarily follow that destruction of microbes constitutes the only possible approach to the problem of infectious disease, nor necessarily the best” (Dubos 1996, p. 53).

19.5 Technological Fixes and Distributive Justice

Technological fixes have an enduring appeal. Part of this is practical: they appear to provide simple, efficient, measurable, and effective solutions to complex problems. However, the presumed practicality of these fixes conceals underlying moral and political assumptions, with important ramifications for distributive justice.

One of Weinberg's precursors was Richard L. Meier, a chemist and technological optimist who advocated the use of technological systems as a means of eliminating poverty and other social ills (Johnston 2018). It is worth noting an important distinction between the little-known precursor and the widely-known successor: while Meier saw technology as a means of remedying distributive injustices, Weinberg saw it as a means for minimizing the harms of those injustices without addressing them. Indeed, in his influential 1966 essay, Weinberg's primary example of a successful technological fix is the advances in mass production of goods that "enable[d] our capitalistic society to achieve many of the aims of the Marxist social engineer without going through the social revolution Marx viewed as inevitable" (Weinberg 1991, p. 43).

The distinction between Meier and Weinberg illustrates an often-hidden ethical component of the technological fix approach. Technological fixes generally reward the rich. This is partially by design: fixes are appealing precisely because they avoid social engineering that might upset the status quo, including extant inequalities. They require no hard questions about the justness of current distributional procedures or outcomes, and they often expressly promise to reduce the negative consequences of extant inequalities without addressing the inequalities themselves.

The concentration of benefits among the rich is also a consequence of the global economy of health research. Health-related technological innovations are most likely to occur in wealthy institutions – top research universities, multinational pharmaceutical companies and medical device manufacturers, highly-capitalized biotechnology startup companies – concentrated in high-income countries. Initiatives that target technological innovation, from BMGF research grants to targeted incentives for pharmaceutical development, thus overwhelming benefit wealthy individuals and institutions in wealthy countries. While it is true that these investments may eventually benefit others, in the short-term they simply circulate resources from rich donors to rich institutions in the global north, often in the name of benefitting the least advantaged.

Technological fixes may thus be 'practical' insofar as they provide an easily identifiable, targeted, and efficient strategy for distributing resources; but this practically is purchased at the price of eliding important distributive concerns. In the context of antimicrobial resistance, we would do well to resist the urge to unthinkingly pursue technological fixes, lest they contribute to precisely the inequalities that underlie the spread of infectious disease and the continued generation of antimicrobial resistance.

Acknowledgments The author thanks Joy Tseng for research assistance in the preparation of this chapter.

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