RECONSIDERING ERADICATION TO ADDRESS THE GLOBAL INFECTIOUS DISEASE BURDEN

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ABSTRACT

The infectious disease burden is distributed unevenly worldwide, disproportionately affecting people in low-income countries. For certain diseases, eradication offers an equitable and cost-effective means of lowering disease burdens and benefits all parties involved—decreasing the human cost of illness while saving high-income countries the financial costs of indefinite disease control programs. This Article argues that the prospect of disease eradication, which offers a permanent solution to the issue of infectious disease control, should be reconsidered by policymakers and the public health establishment at large. Specifically, the Article argues for the creation of disease-specific, voluntary, multinational treaties dedicated to the eradication of diseases for which effective interventions already exist.

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I. Introduction

At the dawn of the twentieth century, infectious disease was the single largest cause of mortality in the United States, accounting for roughly one-third of all deaths.[1] From 1800 to 1893, epidemics of yellow fever periodically struck cities from New Orleans to New York City, killing an estimated 65,000 people with a case fatality rate of 28.6%.[2] Between 1900 and 1920, smallpox cases averaged between 15,000 and 111,000 each year, killing a total of nearly 12,000 people.[3] Numerous other common diseases, such as polio, tuberculosis, measles, and typhoid, contributed to an average life expectancy of 47.3 years.[4]

More than 100 years later, the epidemiological outlook regarding infectious diseases has changed dramatically, thanks to cultural shifts in hygiene, sanitation, and the development of effective vaccines and antimicrobial agents.[5] Between 1980 and 2014, infectious diseases were responsible for only 5.4% of all deaths in the

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[1] *See Leading Causes of Death, 1900-1998*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/nchs/data/dvs/lead1900_98.pdf (last visited July 13, 2020) (using 1900-1940 tables ranked in National Office of Vital Statistics from Dec. 1947).

[2] *See* K. David Patterson, *Yellow Fever Epidemics and Mortality in the United States, 1693-1905*, 34 SOC. SCI. MED. 855, 859 (1992) (discussing that some contemporary estimates give a yellow fever death count of approximately 65,000 between the years 1800-1893); Lauren E. Blake & Mariano A. Garcia-Blanco, *Human Genetic Variation and Yellow Fever Mortality During 19th Century U.S. Epidemics*, 5 MBIO, May-June 2014, at 1, 2 (providing case fatality rates for Caucasians and non-Caucasians in the United States between 1808-1878). Race-stratified case fatality rates allow for calculation of estimated overall case fatality rate by: (1) multiplying the deaths per/100 cases (58.6 and 8.4 for Caucasians and non-Caucasians, respectively) by number of cases recorded (9,049 and 13,325) to calculate deaths in each group, (2) summing total deaths (6,402) and total cases (22,374), and (3) dividing total deaths by total cases to reach the overall case fatality rate (28.61%). This estimate is based on available data from select cities during a slightly different period of time (1808-1878) than that (1800-1893) cited by the Patterson article and represents an approximation of yellow fever's case fatality rate at the time.

[3] *See* C. C. Dauer, *Smallpox in the United States: Its Decline and Geographic Distribution*, 55 PUB. HEALTH REPS. 2303, 2306 (1940).

[4] *See Mortality Trends in the United States, 1900-2018*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/nchs/data-visualization/mortality-trends/index.htm#references (last visited March 28, 2020); Gregory L. Armstrong et al., *Trends in Infectious Disease Mortality in the United States During the 20th Century*, 281 J. AM. MED. ASS'N 61, 62 (1999); CTRS. FOR DISEASE CONTROL & PREVENTION, U.S. DEP'T OF HEALTH & HUM. SERVS., *Table 004*, *in* HEALTH, UNITED STATES, 2018 (2018).

[5] *See* Mitchell L. Cohen, *Changing Pattern of Infectious Disease*, 406 NATURE 762, 762 (2000).

United States.[6] Furthermore, children born in 2017 in the United States had an average life expectancy of 78.6 years.[7]

Unfortunately, there is no guarantee that trends toward reduced infectious disease burden will continue. Indeed, substantial success creates a risk of complacency that could lead to resurgence, posing a serious public health threat. The decrease in infectious disease-related mortality has shifted public attention and funding to non-infectious diseases, social determinants of health,[8] and other emerging public health needs.[9] As attention shifts,[10] increasing reluctance to vaccinate has enlarged the population most susceptible to infectious diseases. For example, following a 1974 report from a London children's hospital ostensibly linking thirty-six cases of serious neurological conditions to DTP (diphtheria, typhoid, and pertussis) vaccinations, nationwide immunizations rates in the United Kingdom plunged from 77% to 33% by 1977.[11] Three major pertussis epidemics soon followed, with death tolls at least equivalent to, but possibly exceeding, the number of children purportedly hurt by the vaccine.[12]

Complacency can also manifest as reduced or insufficient funding. Of the twenty-one research-oriented institutes established within the National Institutes of Health (NIH) since 1937, only one—the National Institute of Allergy and Infectious Diseases (NIAID)—focuses on infectious diseases,[13] while seventeen deal primarily with

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[6] Victoria Hansen et al., *Infectious Disease Mortality Trends in the United States, 1980-2014*, 316 J. AM. MED. ASS'N 2149, 2149 (2016).

[7] *See* ELIZABETH ARIAS & JIAQUAN XU, U.S. DEP'T OF HEALTH & HUM. SERVS., UNITED STATES LIFE TABLES, 2017, 68 NAT'L VITAL STATS. REPS. 1 (2019).

[8] Indicated by Google Trend data for the search term "social determinants of health" from 2004-2020. *See Social Determinants of Health,* GOOGLE TRENDS, https://trends.google.com/trends/explore?date=all&geo=US&q=social%20determinants%20of%20health20diseases (last visited Aug. 15, 2020).

[9] *See generally, e.g.*, Theodore H. Tulchinsky & Elena A. Varavikova, *What Is the "New Public Health"?*, 32 PUB. HEALTH REVS. 25 (2010) (discussing "existing, evolving and re-emerging health threats and risks . . . in a complex world").

[10] Google Trend data for the search term "infectious diseases" from 2004-2020 shows a steady downward trend. *See Infectious Diseases*, GOOGLE TRENDS, https://trends.google.com/trends/explore?date=all&geo=US&q=infectious%20diseases (last visited Aug. 3, 2020).

[11] *See* Eve Dubé et al., *Vaccine Hesitancy, Vaccine Refusal and the Anti-vaccine Movement: Influence, Impact and Implications*, 14 EXPERT REV. VACCINES 99, 104 (2015).

[12] *See id.*

[13] *See NIAID Role in Research*, NAT. INST. ALLERGY & INFECTIOUS DISEASES, https://www.niaid.nih.gov/research/role (last visited Feb. 19, 2021).

non-infectious diseases and social determinants of health.[14] Excluding funding for HIV/AIDS, NIAID's share of the NIH's total appropriations has decreased from 9.2% in 1970 to 6.3% in 2019.[15] NIH research funding correlates modestly with current disease burden, meaning that as the domestic infectious disease burden decreases, relative funding decreases can be expected to continue even as the threat of resistance becomes more urgent.[16] And while private industry plays an important role in bringing new drug products to the market, companies have become increasingly reluctant to pursue infectious disease research, focusing instead on more lucrative therapeutic areas.[17]

Implementing such research is the domain of the Centers for Disease Control and Prevention (CDC), the federal agency tasked with "developing and applying disease prevention and control."[18] Funding for infectious disease has evolved for the CDC as well. From 2005 to 2019, the inflation-adjusted budget of the CDC shrunk from $10.5 to 7.4 billion dollars.[19] In 2005, the CDC expended $5.1 billion

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[14] *See generally List of NIH Institutes, Centers, and Offices*, NAT'L INSTS. OF HEALTH, https://www.nih.gov/institutes-nih/list-nih-institutes-centers-offices (last updated Aug. 22, 2019).

[15] In 1970, NIAID was appropriated $97 million (9%) of the total NIH budget of just over $1 billion. *See Appropriations*, NAT'L INSTS. OF HEALTH, https://www.nih.gov/about-nih/what-we-do/nih-almanac/appropriations-section-1 (last updated Mar. 4, 2020). In 2019, NIAID was appropriated $5.52 (14%) billion of the total NIH budget of $39.31 billion. *Id.* However, in 2019, $3 billion in NIH spending was devoted to HIV/AIDS research—a disease which was unknown until the early 1980s. *See Estimates of Funding for Various Research, Condition, and Disease Categories (RCDC)*, NAT'L INSTS. OF HEALTH (Feb. 24, 2020), https://report.nih.gov/categorical_spending.aspx. Excluding HIV/AIDS spending, NIAID's adjusted funding for 2019 was $2.49 billion, or 6.32% of the total NIH budget; this represents a significant decrease from the 1970 rate (9.17%). *See id.* Recent expenditures on COVID-19 are also not reflected in these figures. *See id.*

[16] *See* Leslie A. Gillum et al., *NIH Disease Funding Levels and Burden of Disease*, PLOS ONE, Feb. 24, 2011, at 1, 1, e16837.

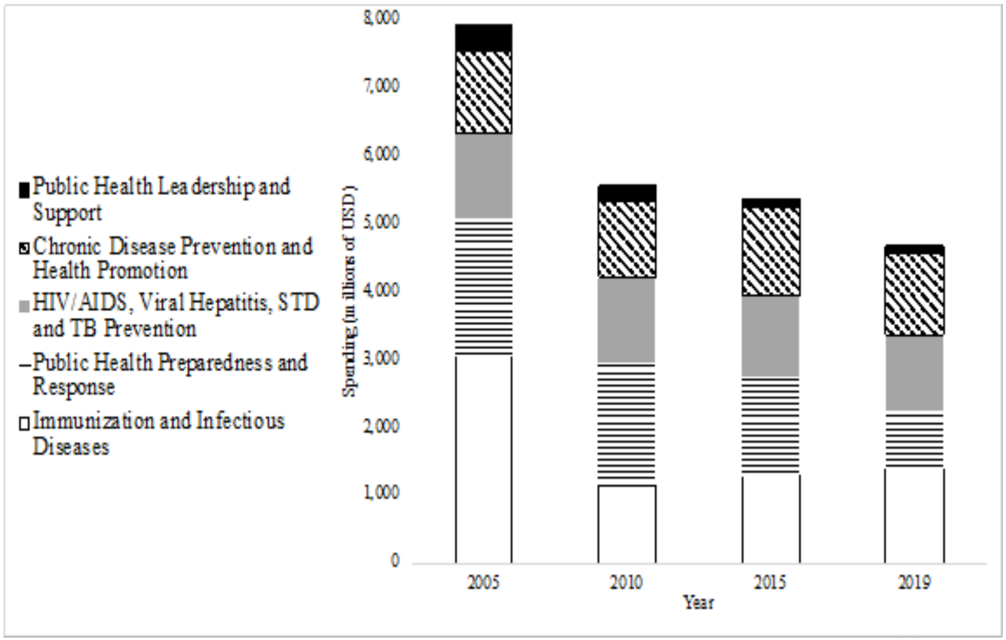
[17] *See* E. Ray Dorsey et al., *Financing of U.S. Biomedical Research and New Drug Approvals Across Therapeutic Areas*, PLOS ONE, Sept. 11, 2009, at 1, 1, e7015.

[18] *CDC Mission Statement*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/about/organization/cio-orgcharts/pdfs/CDCfs-508.pdf (last visited Aug. 16, 2020).

[19] Spending data were gathered from the actual outlay sections of CDC and HHS operating plans. *See Operating Plans*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/budget/operating-plans/index.html (last visited Aug. 16, 2020); *Budgets in Brief and Performance Reports*, DEP'T OF HEALTH & HUM. SERVS., https://www.hhs.gov/about/agencies/asfr/budget/budgets-in-brief-performance-reports/index.html (last updated Feb. 28, 2016). The HHS and CDC websites have taken down budgets from before 2009. Actual outlays from 2005 and 2010 were therefore gathered from archived versions of the above websites. *See Fiscal Year 2005 Budget in Brief*, DEP'T OF HEALTH & HUM. SERVS., http://wayback.archive-it.org/3920/20130927190336/http://archive.hhs.gov/budget/05budget/centers.html (last updated Mar. 4, 2004); *Fiscal Year 2011 Operating Plan Table*, CTRS. FOR DISEASE CONTROL & PREVENTION,

(approximately 50% of its total budget) on either “Immunization and Infectious Diseases” or “Public Health Preparedness and Response” (Exhibit 1).[20] Accounting for inflation, CDC spending in 2019 in those categories declined by more than 50% in absolute terms, totaling just $2.26 billion, or about 30% of its total budget (Exhibit 2). By contrast, over the same 2005-2019 time period, “Chronic Disease Prevention and Health Promotion Spending” stayed consistent at roughly $1.18 billion and increased from 11% to 16% of the CDC’s total budget.

Exhibit 1: CDC Spending by Five Largest Program Categories in 2005, 2005-2019



Sources: Centers for Disease Control and Prevention,[21] Department of Health and Human Services[22]

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https://wayback.archive-it.org/3920/20140402145447/http://www.hhs.gov/about/budget/fy2011/fy2011bib.pdf (last visited Apr. 4, 2021). The inflation adjustment rate calculations were made using an online inflation calculator. *See* U.S. INFLATION CALCULATOR, https://www.usinflationcalculator.com/ (last visited Aug. 16, 2020).

[20] *See* sources cited *supra*, note 19.

[21] Review the operating plan summaries and tables for fiscal years 2005-2019 at *Operating Plans*, *supra* note 19.

[22] *See id.*

While attention is centered elsewhere, infectious diseases continue to circulate globally, creating opportunities for acquired mutations, drug-resistance, and reintroduction or increased incidence.[23] This article examines the extent to which disease eradication—a once-mainstream idea that has been largely abandoned by many public health experts in the United States—could provide a permanent means of addressing certain aspects of the global infectious disease burden. Despite well-known challenges,[24] a changing environment motivates a renewed consideration of the value and feasibility of eradication for certain diseases. We discuss the financial, biological, technological, and ethical dimensions to disease eradication, and evaluate the feasibility of achieving eradication through one or more international treaties.

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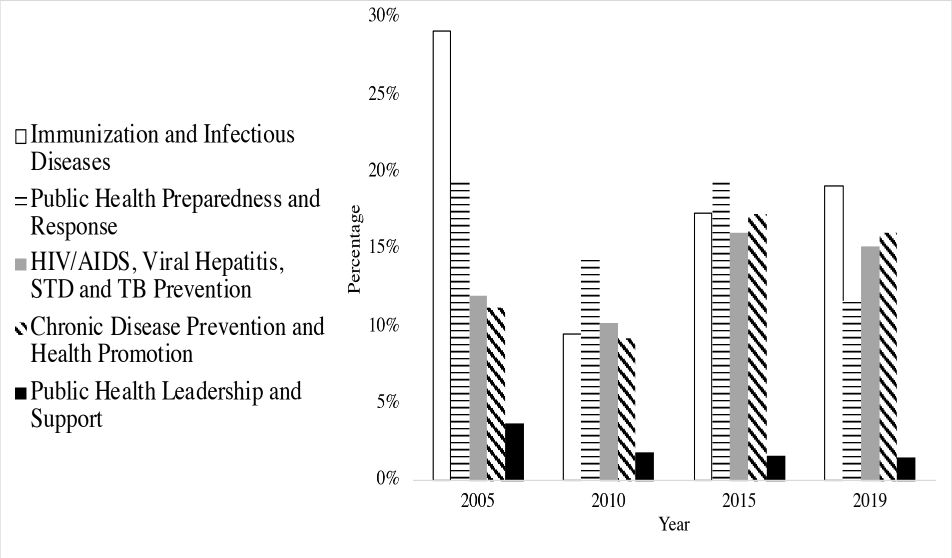
[23] *See generally* Murray E. Alexander et al., *Emergence of Drug Resistance: Implications for Antiviral Control of Pandemic Influenza*, 274 PROC. ROYAL SOC'Y 1675 (2007) (modeling the risks of antiviral mutations in circulating influenza strains).

[24] *See* Petra Klepac et al., *Six Challenges in the Eradication of Infectious Diseases*, 10 EPIDEMICS 97, 100 (2015).

Exhibit 2: CDC Spending as Percentage of Total Budget by Five Largest Program Categories in 2005, 2005-2019



Sources: Centers for Disease Control and Prevention,[25] Department of Health and Human Services[26]

II. Past Successes Demonstrate Feasibility of Eradication

As human populations proliferated and established themselves into dense urban areas, the capability of infectious diseases to sustain transmission from person-to-person increased exponentially.[27] Prior to 1800, "less than 2% of the European population lived in cities of 100,000 or more."[28] By 1850, certain regions of New York City housed more than 200,000 people per

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[25] Review the operating plan summaries and tables for fiscal years 2005-2019 at *Operating Plans*, *supra* note 19.

[26] *See id.*

[27] *See* Andrew P. Dobson & E. Robin Carper, *Infectious Diseases and Human Population History*, 46 BIOSCIENCE 115, 118 (1996).

[28] *Id.* at 121.

square mile.[29] As population shifts facilitated transmission within cities, advances in technology such as the railroad and steamship connected distant cities with regularly scheduled transport, allowing local epidemics to quickly become matters of national or international concern.[30] These and other factors contributed to repeated epidemics of cholera,[31] typhus,[32] smallpox,[33] yellow fever,[34] malaria,[35] and polio[36] in the late 1800s and early 1900s.[37]

The tremendous burden to human health caused by these epidemics motivated new approaches to mitigate their effects. The science of epidemiology, for example, is often traced to an 1854 London cholera epidemic, when John Snow meticulously mapped patterns of behavior and illness to uncover the source of the disease.[38] The emergence of the germ theory of disease in the 1860s and 1870s led to the discovery of the microorganisms underlying several

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[29] Sonia Shah, *Pandemic: Tracking Contagions*, FROM CHOLERA TO EBOLA AND BEYOND 81 (2016).

[30] *See generally* A.J. McMichael, *Environmental and Social Influences on Emerging Infectious Diseases: Past, Present, and Future*, 359 PHIL. TRANS. R. SOC. LOND. 1049 (2004) (describing various environmental, technological, political, agricultural, and demographic factors that affect disease transmission).

[31] *See* J. Glenn Morris & Robert E. Black, *Cholera and Other Vibrioses in the United States*, 312 NEW ENG. J. MED. 343, 343 (1985) (briefly listing and describing the major 18th century cholera epidemics in the United States).

[32] *See* Theodore E. Woodward, *Typhus Verdict in American History*, 82 TRANSACTIONS AM. CLINICAL & CLIMATOLOGICAL ASS'N 1, 6 (1971).

[33] *See* Alasdair M. Geddes, *The History of Smallpox*, 624 CLINICS DERMATOLOGY 153, 154-55 (2006).

[34] *See* Patterson, *supra* note 2, at 859.

[35] *See* Ernest C. Faust, *Clinical and Public Health Aspects of Malaria in the United States from an Historical Perspective*, 25 AM. J. TROP. MED. 185, 185 (1945) ("From the time of early Colonial history until the present day malaria has constituted a disease of more or less major importance in the United States . . . .").

[36] *See* Lauro S. Halstead, *A Brief History of Postpolio Syndrome in the United States*, 92 ARCHIVES PHYSICAL MED. & REHABILITATION 1344, 1344-45 (2011).

[37] *See generally* McMichael, *supra* note 30.

[38] STEVEN JOHNSON, THE GHOST MAP: THE STORY OF LONDON'S MOST TERRIFYING EPIDEMIC—AND HOW IT CHANGED SCIENCE, CITIES, AND THE MODERN WORLD 97-100 (2006).

common diseases in the 1880s,[39] and between 1885 and 1898, vaccines were developed for rabies, typhoid, cholera, and plague.[40]

The germ theory's new approach to infectious disease allowed local governments to take concrete steps in the battle against illness. In 1892, New York City established the Division of Pathology, Bacteriology, and Disinfection, becoming the first bacteriological laboratory to routinely diagnose diseases such as cholera and diphtheria.[41] Two years later, the city's Board of Health issued an order prohibiting physicians from discharging potential diphtheria patients unless the laboratory's tests showed a negative result—an attempt to minimize asymptomatic spread of the disease.[42] In addition to purely diagnostic testing, the lab began to manufacture and evaluate diphtheria antitoxin, and by 1895 it was able to halt a nascent diphtheria epidemic in the New York Infant Asylum by administering this treatment to the children who resided there.[43]

Collectively, advancements like these helped lower infectious disease burdens, even in the face of a population that continued to grow and move into even larger urban areas.[44] Following the devastation of the 1918 Flu Pandemic, science steadily beat back the tide of infectious diseases.[45] The influenza virus was isolated in 1933, and by 1943, large-scale production of an effective live-attenuated vaccine had begun.[46] The 1920s witnessed the development of

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[39] *See* Henry Gradle, *Bacteria and the Germ Theory of Disease: Eight Lectures Delivered at the Chicago Medical College* 2 (1883) ("Daily, almost, new facts are discovered, which substantiate more and more this *germ theory of disease*."); Nancy Tomes, *The Private Side of Public Health: Sanitary Science, Domestic Hygiene, and the Germ Theory, 1870-1900*, 64 BULL. HIST. MED. 509, 528 (1990); WILLIAM T. SEDGWICK, PRINCIPLES OF SANITARY SCIENCE AND THE PUBLIC HEALTH WITH SPECIAL REFERENCE TO THE CAUSATION AND PREVENTION OF INFECTIOUS DISEASES 55-56 (1902).

[40] Susan L. Plotkin & Stanley A. Plotkin, *A Short History of Vaccination*, PLOTKIN'S VACCINES 1, 8 (Stanley A. Plotkin et al. eds., 7th ed. 2017).

[41] *See* JOHN DUFFY, A HISTORY OF PUBLIC HEALTH IN NEW YORK CITY 1866-1966, at 94-95 (1974).

[42] *See id.* at 99.

[43] *Id.* at 100-01.

[44] These advances occurred in conjunction with other critical public health measures, notably clean water. *See* David Cutler & Grant Miller, *The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States*, 42 DEMOGRAPHY 1, 1 (2005); see also UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME, State of the World's Cities 2012/2013, AT 25 (2012); POPULATION DIVISION, UNITED NATIONS DEP'T OF ECON. & SOC. AFFS., WORLD URBANIZATION PROSPECTS: THE 2018 REVISION 9, 56 (2019) (55% of the world's population resided in urban areas in 2018).

[45] *See* PETER WASHER, EMERGING INFECTIOUS DISEASES AND SOCIETY 32 (2010).

[46] *See id.*

effective vaccines against tetanus, diphtheria, and yellow fever.[47] By 1943, the viral causes of measles, mumps, poliomyelitis, dengue fever, and the common cold had been discovered.[48]

The progress against infectious disease was not limited to new vaccines. In 1940, Oxford scientists discovered how to produce penicillin in quantities sufficient for human treatment, a timeline accelerated by the military realities of World War II.[49] Over the next several decades, a succession of antibiotics—bacitracin, tetracyclines, nitrofurans, polymixins, and cephalosporins—were discovered and developed for clinical applications.[50] Such advances made diseases like syphilis, which previously had been treated with toxic mercury-based medicines, safely treatable with an effective remedy.[51] Antibiotic combination therapies treated tuberculosis, another disease with no known cure, so effectively that the World Health Organization (WHO) proposed global tuberculosis eradication in 1960.[52] Polio and measles, two other serious diseases that regularly plagued countries in the early twentieth century, became rare in the United States following the widespread deployment of effective vaccines in 1955 and 1963, respectively.[53]

Progress against infectious disease was made even in the absence of effective treatments or vaccines. Indeed, although improvements in water sanitation often occurred alongside other public health interventions, an analysis of thirteen major American cities' clean water interventions in the early twentieth century found that joint filtration and chlorination of city water supplies alone "reduced typhoid fever mortality by 25%, total mortality by 13%, infant mortality by 46%, and child mortality by 50%."[54] Mortality rates in major United States cities dropped by 30% between 1900 and

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[47] *See id.*

[48] *Id.*

[49] *Id.* at 33-34.

[50] *See generally* William Kingston, *Antibiotics, Invention and Innovation*, 29 RESEARCH POL'Y 679, 682-89 (2000) (describing the discovery, invention, and development of modern antibiotics); *see also Antibiotic*, ENCYC. BRITANNICA, https://www.britannica.com/science/antibiotic (last visited Feb. 19, 2021).

[51] *See* WASHER, *supra* note 5, at 34.

[52] *Id.* at 34, 36.

[53] *Id.* at 35.

[54] Cutler & Miller *supra* note 44, at 11-12.

1936;[55] 13 percentage points—43% of the total decline—were attributable to clean water.[56] In 1906, the discovery of *Aedes aegypti* as the primary vector of dengue fever paved the way for future effective vector-control campaigns.[57] By the early 1940s, ambitious malaria eradication goals led to the elimination of two non-native malaria-carrying mosquito species from Brazil and Bolivia, drastically lowering the malaria burden, although native mosquito species remained as vectors.[58]

With the successful eradication of the last case of smallpox in 1977, infectious diseases seemed poised to become a tragic footnote in medical history. Dr. Anthony Fauci, the long-time head of the National Institute of Allergy and Infectious Diseases, shared his fears at the start of his infectious disease fellowship in 1967 that "I was entering a subspecialty of clinical medicine and an area of biomedical research that was disappearing at the same time that I was training for it."[59] As late as 1985, noted infectious disease expert Dr. Robert Petersdorf opined that "the millennium where fellows in infectious disease will culture one another is almost here,"[60] a sardonic reference to an expected vanishing of patients with infectious disease.

But even as optimism was reaching its zenith, novel infectious diseases had already begun to emerge as newly identified challenges, including Marburg virus (1967), Lyme disease (1975), Legionnaire's disease (1976), Ebola (1976), HIV (1983), Nipah virus (1998), and SARS (2003). Failures to bring past eradication campaigns to successful completion also weighed heavily, including those against

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[55] *Id.* at 13.

[56] *Id.*

[57] *See generally* NORMAN G. GRATZ & A. BRUCE KNUDSEN, WORLD HEALTH ORG., THE RISE AND SPREAD OF DENGUE, DENGUE HAEMORRHAGIC FEVER AND ITS VECTORS: A HISTORICAL REVIEW (UP TO 1995) (1996) (detailing the history of dengue fever and past interventions against the disease); Thomas L. Bancroft, *On the Etiology of Dengue Fever*, 25 AUSTRALASIAN MED. GAZ. 17, 17 (1906) (discussing the 1905 epidemic of dengue fever in Queensland which allowed researcher to "make some observations on the etiology of the disease").

[58] *See generally* Randall M. Packard & Paulo Gadehla, *A Land Filled with Mosquitoes: Fred L. Soper, the Rockefeller Foundation, and the Anopheles Gambiae Invasion of Brazil*, 17 MED. ANTHROPOLOGY 215 (1997) (detailing the vector control campaign and placing it in its historical and social context).

[59] Anthony S. Fauci, *Infectious Diseases: Considerations for the 21st Century*, 32 CLINICAL INFECTIOUS DISEASES 675, 675 (2001).

[60] Robert G. Petersdorf, *Whither Infectious Diseases? Memories, Manpower, and Money*, 153 J. INFECTIOUS DISEASES 189, 191 (1986).

older diseases such as malaria, yellow fever, polio, yaws, and guinea worm.[61] In 1952, the WHO launched a campaign to eradicate the endemic disease *Treponema pallidum pertenue* (yaws)—a disease primarily affecting skin, bones, and cartilage.[62] Although prevalence of yaws decreased 95% (from an estimated 50 million to 2.5 million cases worldwide) by 1964, efforts to eradicate the last 5% of cases failed and, by the end of the 1970s, yaws had begun to reemerge as a significant public health burden.[63] Similarly, the Global Malaria Eradication Programme, which ran from 1955-1969, initially achieved great successes including large-scale regional elimination, but drug resistance, economic crises, and fading public interest eventually ended the campaign in quiet failure.[64] Eradication campaigns against yellow fever (active from 1915-1977), yaws (1952-1967), and malaria (1955-1969) were diminished or abandoned.[65]

These and other failures gave rise to a growing disillusionment with eradication. It had long been recognized that smallpox was particularly suited to eradication in that it: (1) always resulted in clinical symptoms, (2) was not contagious until patients were symptomatic, (3) did not recur in previously infected individuals, (4) only had one serotype (meaning one vaccine provided protection against all smallpox strains), (5) fluctuated seasonally, and (6) had no natural animal reservoir.[66] By the 2000s, chided by failures

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[61] *See* Robert Keegan et al., *Comparing Measles with Previous Eradication Programs: Enabling and Constraining Factors*, 204 J. INFECTIOUS DISEASES S54, S54 (2011); R. Bruce Aylward et al., *When Is a Disease Eradicable? 100 Years of Lessons Learned*, 90 AM. J. PUB. HEALTH 1515, 1516 tbl.1 (2000).

[62] Kingsley Asiedu et al., *Yaws Eradication: Past Efforts and Future Perspectives*, 86 BULL. WORLD HEALTH ORG. 499, 499 (2008).

[63] *Id.*

[64] *See* Jose A. Najera et al., *Some Lessons for the Future from the Global Malaria Eradication Programme (1955-1969)*, PLOS MED., Jan. 25, 2011, at 1, 1, e1000412.

[65] Aylward et al., *supra* note 61, at 1516 tbl.1.

[66] *See* Frank Fenner, *Global Eradication of Smallpox*, 4 REVS. INFECTIOUS DISEASES 916, 917 (1982) (listing criteria that made smallpox uniquely susceptible to eradication efforts); *see also* Isao Arita et al., *Eradication of Infectious Diseases: Its Concept, Then and Now*, 57 JAP. J. INFECTIOUS DISEASE 1, 1 (2004); *cf.* William J. Moss & Peter Strebel, *Biological Feasibility of Measles Eradication*, 204 J. INFECTIOUS DISEASES S46, S46 (2011) (noting that three biological criteria are deemed important for disease eradication, including: "(1) humans are the sole pathogen reservoir; (2) accurate diagnostic tests exist; and (3) an effective, practical intervention is available at a reasonable cost."); *see generally* Peter Strebel et al., *Group Report: Assessing the Feasibility of an Eradication Initiative*, *in* DISEASE ERADICATION IN THE 21ST CENTURY: IMPLICATIONS FOR GLOBAL HEALTH 89, 91-92 (Stephen L. Cochi

to eradicate malaria, polio, measles, yaws, and yellow fever, observers began to argue that smallpox eradication was possible only because of an irreproducible perfect storm of biological and epidemiological factors and that eradication of most other diseases was unlikely.[67] Even the director of the successful smallpox eradication program, Donald Henderson, stated that "[p]rospects for eradication appear far more optimistic from . . . an office in a university ivory tower" and noted the "practical and political complexities of a targeted programme at national and international levels."[68] Some commentators argued for the reconsideration of the concept of eradication as a whole, arguing that the "complete extinction of a target pathogen both in the human population and in nature" was unrealistic in a globalized world filled with "socio-political unrest."[69]

But these characteristics, although making smallpox ideally suited for eradication, do not preclude eradication of other diseases.[70] The regional elimination of many diseases not possessing ideal characteristics demonstrates that eradication is possible. For example, rabies can infect all mammals and is commonly carried by dogs and non-domesticated wildlife.[71] Even so, coordinated vaccination programs have eliminated rabies from nine countries in Western Europe.[72] Measles can be infectious prior to onset of rash. Nevertheless, although the disease was once endemic in the Western

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& Walter R. Dowdle eds., 2011) (dividing the fundamental feasibility of a disease's eradication into biological and technical components and discussing each).

[67] *See* Arita et al., *supra* note 66, at 1-2 (discussing that a definition of eradication as "extinction of the pathogen [in nature]" is unrealistic, that "[s]mallpox eradication was a rare event," and that the concept of eradication should be reviewed "to determine whether it should continue to be based on eradication as complete as that of smallpox").

[68] Donald A. Henderson & Petra Klepac, *Lessons from the Eradication of Smallpox: An Interview with D. A. Henderson*, 368 PHIL. TRANSACTIONS ROYAL SOC'Y 1, 6 (2013). Interestingly, Dr. Henderson became a vocal critic of disease eradication shortly after the successful eradication of smallpox in 1980. *See id.*

[69] Arita et al., *supra* note 66, at 5-6.

[70] *See* Rik L. de Swart et al., *Rinderpest Eradication: Lessons for Measles Eradication?*, 2 CURRENT OPINION VIROLOGY 330, 333 (2012) (discussing the 2011 eradication of rinderpest, which shares many biological properties with measles, and noting that eradication of measles would not eliminate the need for measles vaccinations to continue, unlike smallpox) .

[71] *See* Thomas Müller et al., *Rabies Elimination in Europe–A Success Story*, *in* RABIES CONTROL: TOWARDS SUSTAINABLE PREVENTION AT THE SOURCE, COMPENDIUM OF THE OIE GLOBAL CONFERENCE ON RABIES CONTROL, INCHEON-SEOUL 31, 32 (Anthony R. Fooks & Thomas Müller eds., 2012).

[72] *See id.* at 37.

hemisphere, it was eliminated in the United States in 2000 and in the rest of the Americas by 2002.[73] Other successes have been even more dramatic. Poliomyelitis has three serotypes and is asymptomatic in most affected individuals, yet a WHO eradication campaign has reduced its prevalence by more than 99.9%, from roughly 600,000 people per year in the 1950s to only 175 polio cases reported in two countries (Afghanistan and Pakistan) in 2019.[74] Similarly, there is no medicine or vaccine against dracunculiasis (guinea worm disease), yet global efforts have reduced the prevalence of this disease from an estimated 3.5 million people in twenty-one African and Asian countries in 1986, when the WHO passed a resolution targeting the elimination of Guinea worm,[75] to only fifty-four laboratory-confirmed cases in three countries in 2019, a reduction of more than 99.99%.[76]

III. An Evolving Environment Favors Eradication

Skepticism of eradication is understandable in light of the difficulties past efforts have encountered, but the technological and social environment has changed dramatically since the 1980s in ways that create more favorable circumstances for the eradication of at least some diseases. A longer-term view of health care costs also suggests reconsideration. We explore four relevant factors: the financial costs

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[73] Moss & Strebel, *supra* note 66, at S49.

[74] *See* Neal Nathanson & Olen M. Kew, *From Emergence to Eradication: The Epidemiology of Poliomyelitis Deconstructed*, 172 AM. J. EPIDEMIOLOGY 1213, 1213 (2010). The mortality rate for paralytic polio depends on patient age and ranges from 2-5% in children to 15-30% in adults depending on age. CTRS. FOR DISEASE CONTROL & PREVENTION, *Poliomyelitis*, *in* EPIDEMIOLOGY AND PREVENTION OF VACCINE-PREVENTABLE DISEASES 297, 299 (2015).

[75] World Health Org. [WHO], Assembly Res. WHA39.21, *Elimination of Dracunculiasis*, Hbk Res., Vol. II (1985), 1.14.2; 1.16.3.3 (May 16, 1986), https://www.who.int/neglected_diseases/mediacentre/WHA_39.21_Eng.pdf. Dracunculiasis is a large parasite endemic to tropical areas that can cause "crippling disease" in its human hosts. It is closely associated with unclean drinking water and, before its near eradication, was found primarily in impoverished communities. *See* Ralph Muller, *Dracunculus and Dracunculiasis*, 9 ADVANCES PARASITOLOGY 73, 118 (1971); Brett Sutton & Deon Canyon, *The Tortoise and the Hare: Guinea Worm, Polio and the Race to Eradication*, PLOS CURRENTS OUTBREAKS, Aug. 31, 2015, at 7, 9.

[76] *See* Susan J. Watts, *Dracunculiasis in Africa in 1986: Its Geographic Extent, Incidence, and At-Risk Population*, 37 AM. J. TROPICAL MED. & HYGIENE 119, 119 (1987); WHO COLLABORATING CENTER FOR DRACUNCULIASIS ERADICATION, CDC, GUINEA WORM WRAP-UP #267, at 6 tbl.2 (2020) (providing a country-by-country report of recent guinea worm conditions); *see also* *Dracunculiasis (Guinea-worm Disease)*, WORLD HEALTH ORG. (Mar. 16, 2020), https://www.who.int/en/news-room/fact-sheets/detail/dracunculiasis-(guinea-worm-disease).

of eradication compared to ongoing surveillance and treatment; technological advances related to disease tracking and vaccine creation; a rising public awareness of resistance and the potential for pandemic; and the ethics of failing to put an end to diseases that likely could be eradicated.

A. Changing Cost Considerations

Disease eradication is defined as the "[p]ermanent reduction to zero of the worldwide incidence of infection caused by a specific agent."[77] The ability to achieve this outcome often depends in part on vaccination and containment strategies that become more costly as populations expand and become more mobile. Researchers estimate that the global human population, currently around 7.8 billion, will grow to between 8-10 billion by the year 2050.[78] Already, the United Nations Children's Fund procured 2.4 billion doses of vaccines in just one year.[79] More than 4 billion passengers take off and land at airports around the world each year, and net human mobility is estimated to have increased over 1,000-fold in high-income countries since 1800.[80] As population and mobility trends continue, costs will rise further.

Once achieved, eradication not only avoids vaccination costs but also the costs of medical care, surveillance, and related disease control efforts, such as tracking and tracing.[81] The entire smallpox eradication campaign, for example, is estimated to have cost $2.43 billion dollars between 1967 and 1980 (adjusted to 2020 US

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[77] David H. Molyneux et al., *Disease Eradication, Elimination and Control: The Need for Accurate and Consistent Usage*, 20 TRENDS PARASITOLOGY 347, 347 (2004).

[78] Wolfgang Lutz & Samir K.C., *Dimensions of Global Population Projections: What Do We Know About Future Population Trends and Structures?*, 365 PHIL. TRANSACTIONS ROYAL SOC'Y 2779, 2787 (2010).

[79] UNICEF USA, 2019 FOR EVERY CHILD: UNICEF USA ANNUAL REPORT 9 (2019).

[80] *See The World of Air Transport in 2018*, INT'L CIV. AVIATION ORG., https://www.icao.int/annual-report-2018/Pages/the-world-of-air-transport-in-2018.aspx (last visited July 13, 2020); A. J. Tatum et al., *Global Transport Networks and Infectious Disease Spread,* 62 ADVANCES PARASITOLOGY 293, 295 (2006).

[81] *See* Scott Barrett & Michael Hoel, *Optimal Disease Eradication*, 12 ENV'T & DEV. ECON. 627, 627, 645-46 (2007).

dollars).[82] By contrast, researchers have estimated that the costs avoided by no longer needing to vaccinate or hospitalize smallpox patients is valued at over $2 billion per year, or about $13.5 billion dollars if these perpetual annual savings are discounted to 2020 at a 10% discount rate.[83] Rinderpest, a cattle disease with a 95% mortality rate in naïve populations, was declared eradicated in 2011 after a series of regional campaigns with costs totaling around $300 million,[84] and by one calculation is estimated to save $1 billion annually for the African continent alone.[85] Guinea worm, a potentially debilitating human parasitic disease with a one-year course, had only twenty-five cases reported in 2016, and researchers report that eradication will likely be more cost-effective than control by the year 2030.[86]

Eradication campaigns can be cost-effective even before they achieve their goal, thanks to high levels of disease control that reduce treatment costs.[87] For example, researchers estimate that polio control efforts have saved the United States more than $180 billion since the start of widespread vaccinations in the 1950s.[88] On a global scale, it is estimated that polio eradication will save $14 billion in direct costs alone by the year 2050 compared to a permanent disease control strategy.[89] The savings accrued by disease control generally, and

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[82] This reflects the campaign's original $315 million cost adjusted to 2020 dollars. *See* Ann M. Nelson, *The Cost of Disease Eradication: Smallpox and Bovine Tuberculosis*, 894 ANNALS N.Y. ACAD. SCIS. 83, 85 (1999).

[83] Based on $2 billion in costs in the year 2000, when the calculation was first made, and assuming a 10% discount value. *See* Jennifer Ehreth, *The Global Value of Vaccination*, 21 VACCINE 596, 598 (2003).

[84] *See* Félix Njeumi et al., *The Long Journey: A Brief Review of the Eradication of Rinderpest*, 31 REV. SCI. TECH. 729, 729 (2012). There were four major rinderpest elimination campaigns from the 1960s until the eradication of rinderpest in 2011. *See* K. Tounkara et al., *Rinderpest Experience*, 36 REV. SCI. TECH. 569, 574-76 (2017).

[85] *See* Dennis Normile, *Driven to Extinction,* 319 SCIENCE 1606, 1609 (2008)..

[86] *See* Christopher Fitzpatrick et al., *The Cost-Effectiveness of an Eradication Programme in the End Game: Evidence from Guinea Worm Disease,* PLOS NEGLECTED TROPICAL DISEASES, Oct. 5, 2017, at 1, 1, e0005922.

[87] *See* Scott Barrett*, Economic Consideration for the Eradication Endgame*, PHIL. TRANSACTIONS ROYAL SOC'Y, Aug. 5, 2013, at 1, 1, 20120149.

[88] *See* Kimberly M. Thompson & Radboud J. D. Tebbens, *Retrospective Cost-Effectiveness Analyses for Polio Vaccination in the United States*, 26 RISK ANALYSIS 1423, 1431 (2006).

[89] *See* Marita Zimmerman et al., *Projection of Costs of Polio Eradication Compared to Permanent Control*, 221 J. INFECTIOUS DISEASES 561, 564 (2019). This approach, which only accounts for direct costs (e.g., immunization, treatment, surveillance), likely underestimates the total economic impact of an eradication strategy. *See id.* at 561.

eradication in particular, are best maximized by quick action—costs will rise and savings will be delayed as the global population grows.

When diseases are regionally eliminated rather than globally eradicated, resurgence can occur with associated financial and human costs. For example, in 2005, a measles outbreak traced to a single unvaccinated individual on a church mission trip infected thirty-four people in Indiana.[90] Although it was eventually contained, it cost public health officials $167,685 in 2005 dollars to track and trace over 500 people.[91] A review of eleven measles outbreaks in the United States, in which a total of just 129 people were confirmed to be infected, revealed that investigation and response measures consumed an estimated $233 per contact, $32,805 per case, and up to 10,054 personnel hours per outbreak.[92]

Some scholars have asserted that eradication is not a responsible use of finite, public health resources,[93] arguing that eradication campaigns unduly burden poor countries by requiring them to divert scarce public health funds to the detriment of other programs that have greater public health impacts.[94] Of course, shortly before eradication is achieved, the immediate public health burden of the nearly-eradicated disease will, by definition, be small in comparison to other health objectives—dramatic reduction in disease burden is the very purpose of eradication. But dousing a conflagration until the remaining flames are small and produce little heat is a resource intensive strategy for fire management, requiring that firefighters remain forever vigilant at the scene. Opponents of eradication recommend exactly that by assuming that reductions in prevalence could be sustained indefinitely through global surveillance and containment efforts. This is costly and, over the course of generations in a constantly changing global environment, unrealistic. For some diseases, any easing of disease control

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[90] Amy A. Parker et al., *Implications of a 2005 Measles Outbreak in Indiana for Sustained Elimination of Measles in the United States,* 355 NEW ENG. J. MED. 447, 451-52 (2006).

[91] *Id.* at 447.

[92] Jamison Pike et al., *A Review of Measles Outbreak Cost Estimates from the United States in the Postelimination Era (2004-2017)*, 71 CLINICAL INFECTIOUS DISEASES 1568, 1569-70 (2020).

[93] *See* Isao Arita et al., *Is Polio Eradication Realistic?*, 312 SCIENCE 852, 853 (2006).

[94] *See id.* at 853 (referencing the smallpox eradication program in particular; while $100 million in aid was provided by other countries, recipient countries spent $200 million of their own resources towards eradication).

programs—even when prevalence is very low—can lead to costly and dispiriting resurgences.[95] Indefinite control also effectively shifts costs to future generations and condemns them to forever live with the threat of resurgence. Many of critics' zero-sum arguments appear to assume that poor countries would necessarily bear an excessive share of eradication costs, but nothing prevents payment arrangements from considering the reasonable financial capacities and health care needs of all affected countries.[96]

Eradication also reduces the need for a continual pipeline of costly new drugs. The development of a new antibiotic is estimated to cost from $500 million to $3.9 billion.[97] Based on these estimates, the fifty-seven antimicrobial new molecular entities approved by the FDA between 2008 and 2018 would have cost society between $28.5 and $163.6 billion dollars.[98] Because the current rate of drug

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[95] *See* Justin M. Cohen et al., *Malaria Resurgence: A Systematic Review and Assessment of Its Causes*, MALARIA J., Apr. 24, 2012, at 1, 1.

[96] *See* A. R. Hinman & Donald R. Hopkins, *Lessons from Previous Eradication Programs*, *in* THE ERADICATION OF INFECTIOUS DISEASES 19, 19 (Walter R. Dowdle & Donald R. Hopkins eds., 1998) (explaining alternative payment arrangements for funding eradication programs); Justin M. Andrews & Alexander D. Langmuir, *The Philosophy of Disease Eradication*, 53 AM. J. PUB. HEALTH 1, 6 (1963) (hypothesizing that eradication campaign failures are more likely to be caused by "logistics . . . than from purely technical considerations"); Aylward et al., *supra* note 61, at1519 (characterizing the primary challenge to eradication as "securing societal and political commitment"); *see also* Andrea Rinaldi, *Free, At Last!*, 10 EUR. MOLECULAR BIOLOGY ORG. 215, 220 (2009) (discussing that in some cases the "best buy" for the world is to eradicate instead of continuing with control measures).

[97] Although individual estimates are widely cited, there is considerable controversy over the actual cost of drug development. *See* Steve Morgan et al., *The Cost of Drug Development: A Systematic Review*, 100 HEALTH POL'Y 4, 4 (2011) (estimating the range of drug development costs from 1963-2010 in 2009 dollars to be between $161 million and $1.8 billion capitalized); Christopher P. Adams & Van V. Brantner, *Estimating The Cost Of New Drug Development: Is It Really $802 Million?*, 25 HEALTH AFFS. 420, 425 (2006) (establishing a range for the cost of new drug development based on type of therapy and firm, while noting that expenditures are primarily driven by the cost of clinical trials); Joseph A. DiMasi et al., *Innovation in the Pharmaceutical Industry: New Estimates of R&D Costs*, 47 J. HEALTH ECON. 20, 31 (2011) (discussing comprehensive analyses of the cost of new drug development); *cf.* Matthew Herper, *The Truly Staggering Cost of Inventing New Drugs*, FORBES (Feb. 10, 2012), https://www.forbes.com/sites/matthewherper/2012/02/10/the-truly-staggering-cost-of-inventing-new-drugs/#43068abc4a94 (dividing R&D costs by new drug approvals to conclude that the average cost per new drug, including failures, is over $4 billion); Bernard Munos, *Lessons from 60 Years of Pharmaceutical Innovation*, 8 NATURE REV. DRUG DISC. 959, 963 (2009) (adjusting the success rate of DiMasi et al. to conclude that actual per drug development costs are around $3.9 billion). *But see* Aaron S. Kesselheim et al., *The High Cost of Prescription Drugs in the United States: Origins and Prospects for Reform*, 316 J. AM. MED. ASS'N 858, 863 (2016) (highlighting controversy over the methodology of determining the cost of new drug development); Jerry Avorn, *The $2.6 Billion Pill – – Methodologic & Policy Considerations*, 372 NEW ENG. J. MED. 1877, 1877 (2016) (critiquing flaws in the methodology of DiMasi et al.).

[98] Author Jonathan Darrow maintains a database of all new molecular entities approved by the FDA, part of which has been published. *See, e.g.*, Jonathan J. Darrow & Aaron S. Kesselheim, *Drug*

development is considered insufficient to keep up with antimicrobial resistance, policymakers have proposed an additional market entry reward of $800 million to $1.5 billion as a prize paid to pharmaceutical companies for developing and shepherding through the approval process a new antibiotic drug,[99] increasing already-high societal costs.[100] Unfortunately, the nature of microbial resistance means that the effectiveness of these treatments is time-limited,[101] and any containment strategy will therefore require not only indefinite surveillance and vaccination, but also a perpetual stream of billions of dollars of limited health care funds to be devoted to treatments the full effectiveness of which is inherently temporary (**Exhibit 3**). Minimum revenues for the pharmaceutical industry would thus be assured, while the public faces never-ending costs and continues to suffer, even if infrequently, from disease.

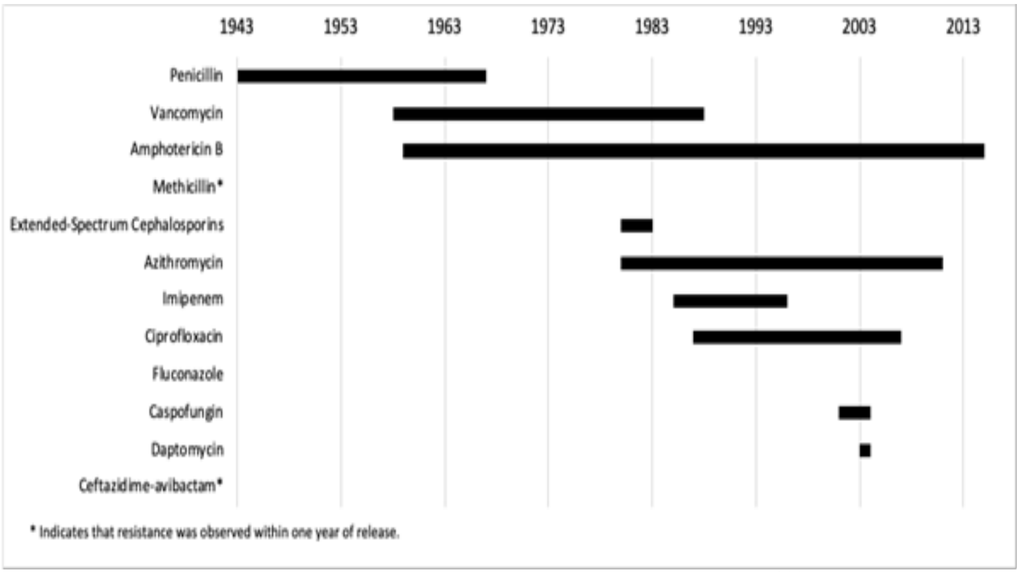
Development and FDA Approval, 1938-2013, 370 NEW ENG. J. MED. 2465 (2014), http://www.nejm.org/doi/full/10.1056/NEJMp1402114?query=featured_home; Jonathan J. Darrow, Michael S. Sinha & Aaron S. Kesselheim, *When Markets Fail: Patents and Infectious Disease Products*, 73 FOOD & DRUG L. J. 361, 363 fig.1 (2018).

[99] *See* CHRISTINE ÅRDAL ET AL., DRIVE-AB, REVITALIZING THE ANTIBIOTIC PIPELINE, 6 (2018); Christopher Okhravi et al., *Simulating Market Entry Rewards for Antibiotics Development*, 46 J. L. MED. & ETHICS 32, 32 (2018).

[100] *See* Gregory W. Daniel et al., *Implementation of a Market Entry Reward within the United States*, 46 J. L. MED. & ETHICS 50, 51 (2018).

[101] *See About Antibiotic Resistance*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/drugresistance/about.html (last updated Mar. 13, 2020).

Exhibit 3: Introduction of Antibiotics and Time Until First Resistant Strains Observed



Source: Centers for Disease Control and Prevention[102]

The estimated costs needed to see eradication efforts through to completion are in the billions of dollars and have been criticized by some commentators as prohibitive.[103] In 2020 dollars, the entire cost of the global smallpox eradication program was $2.43 billion.[104] The estimated, inflation-adjusted costs of eradicating various diseases are substantial, including yaws ($396 million),[105] guinea worm disease ($467 million, including past expenditures),[106] poliomyelitis

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[102] *Id.*

[103] *See* Arita et al., *supra* note 94, at 853.

[104] *See* Nelson, *supra* note 82, at 85 (discussing the original $315 million cost between 1967 and 1980).

[105] Fitzpatrick et al. estimate $362 million in 2014 dollars, comparable to $396.2 million in 2020 after adjusting for inflation. Christopher Fitzpatrick et al., *Where the Road Ends, Yaws Begins? The Cost-effectiveness of Eradication Versus More Roads*, PLOS NEGLECTED TROPICAL DISEASES, Sept. 25, 2014, at 1, 1, e3165. Inflation adjustment data gathered from an online inflation calculator. *See* U.S. INFLATION CALCULATOR, https://www.usinflationcalculator.com/ (last visited Aug. 16, 2020).

[106] Fitzpatrick et al. estimates $432 million in 2015 dollars. $467 million is the value adjusted for inflation. *See* Christopher Fitzpatrick et al., *The Cost-Effectiveness of an Eradication Programme in the End Game: Evidence from Guinea Worm Disease,* PLOS NEGLECTED TROPICAL DISEASES, Oct. 5, 2017, at 1, 13, e0005922.

($22.77 billion),[107] and malaria ($90-120 billion).[108] Nevertheless, these global expenditures—which total approximately $150 billion—pale in comparison to the nearly $5.2 trillion spent in the United States alone to address the economic costs associated with the ongoing COVID-19 pandemic (**Exhibit 4**).[109] This disconnect in expenditures and public focus between COVID-19 and potentially eradicable diseases cannot be justified based on morbidity and mortality: COVID-19 is estimated to have killed approximately 2.5 million people worldwide during the approximately one-year period from its emergence through February 21, 2021,[110] while other infectious diseases, many of which are potentially eradicable, kill approximately 8.5 million people annually, year after year.[111] For example, pertussis, measles, hepatitis B, and malaria—all diseases for which effective treatments or preventions are available—kill an estimated 10, 91, 111, and 446 thousand people, respectively, each year.[112]

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[107] This total was made by adding past expenditures (adjusted for inflation) to the GPEI's estimated $3.27 billion endgame strategy from 2019-2023. *See Contributions and Pledges to the Global Polio Eradication Initiative, 1985-2019*, GLOB. POLIO ERADICATION INITIATIVE, http://polioeradication.org/financing/donors/historical-contributions/ (last visited July 13, 2020); WORLD HEALTH ORG., POLIO GLOBAL ERADICATION INITIATIVE: 2019 ANNUAL REPORT 24 (2020).

[108] *See* BILL GATES & RAY CHAMBERS, BILL & MELINDA GATES FOUNDATION, FROM ASPIRATION TO ACTION: WHAT WILL IT TAKE TO END MALARIA? 45 (2015).

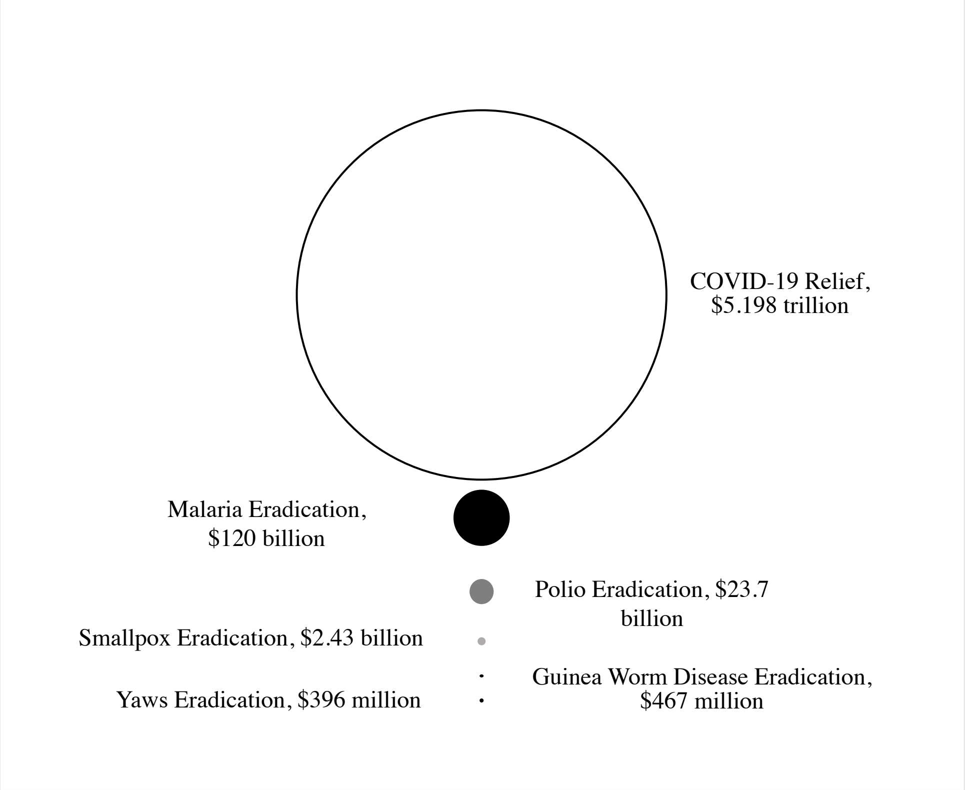
[109] There have been five primary federal COVID-19 relief bills. The Family First Coronavirus Response Act, which was enacted on March 18, 2020, provided $192 billion in public relief. The Congressional Budget Office estimates that the Coronavirus Aid, Relief, and Economic Security Act ("CARES Act"), which became law on March 27, 2020, will cost the federal government a total of $1.7 trillion over the 2020-2030 time period. The Paycheck Protection Program and Health Care Enhancement Act ("PPP Act"), signed into law on April 24, 2020, will cost an estimated $484 billion. In December 2020, the Consolidated Appropriations Act, 2021, was passed with an estimated cost of $2.3 trillion. And on March 11, 2021, President Biden signed the $1.9 trillion American Rescue Plan. The combined costs of these five COVID-19 response bills sum to nearly $5.2 trillion. *See* Families First Coronavirus Response Act, Pub. L. No. 116-127, 134 Stat. 178 (2020); PHILLIP L. SWAGEL, CONG. BUDGET OFF., CBO-56334, REVISED PRELIMINARY ESTIMATE OF THE EFFECTS OF H.R. 748, THE CARES ACT 1 (2020); CARES Act, Pub. L. No. 116-136, 15 U.S.C. § 116 (2020); PPP Act, Pub. L. No. 116-139, 134 Stat. 622 (2020); Consolidated Appropriations Act, 2021, Pub. L. No. 116-260 (2020); American Rescue Plan Act of 2021, Pub. L. No. 117-2 (2021).

[110] *COVID-19 Coronavirus Pandemic: Coronavirus Cases*, WORLDOMETERS, https://www.worldometers.info/coronavirus/ (last visited Feb. 21, 2021).

[111] *Global Health Estimates 2016 Summary Tables: Global Deaths by Cause, Age and Sex, 2000-2016*, WORLD HEALTH ORG. (Apr. 2018), https://www.who.int/healthinfo/global_burden_disease/GHE2016_Deaths_Global_2000_2016.xls?ua=1.

[112] *Id.*

Exhibit 4: Cost of US-only COVID-19 Relief Compared to Global Disease Eradication Programs



Sources: COVID-19 Relief,[113] Malaria,[114] Polio,[115] Smallpox,[116] Guinea Worm Disease,[117] Yaws[118]

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[113] *See* CARES Act; PPP Act.

[114] *See* GATES & CHAMBERS, *supra* note 109, at 45.

[115] *See Contributions and Pledges to the Global Polio Eradication Initiative, 1985-2019*, *supra* note 107. Past expenditures, adjusted for inflation, have been added to projected future expenditures to reach the polio eradication total.

[116] *See* Nelson, *supra* note 82, at 85. Totals adjusted to 2020 dollars.

[117] *See* Fitzpatrick et al., *supra* note 106, at 15. Totals adjusted to 2020 dollars.

[118] *See* Fitzpatrick et al., *supra* note 105, at 6. Totals adjusted to 2020 dollars.

B. New Technologies Increase Feasibility

New and emerging technologies have created an environment where disease eradication is more feasible than ever before.[119] Artificial intelligence and advanced computer modeling have become more powerful, helping to accelerate the discovery of more effective vaccines.[120] Tools that were unavailable during the smallpox eradication program, including GPS and smartphone cameras, are now ubiquitous and can be used to track and contain disease transmission in real time. Improvements in environmental surveillance technologies have normalized techniques such as sewage sampling to track poliovirus transmission, in many countries.[121] These tools, in conjunction with the increasing number of individuals working from home, allow for physical distancing to reduce transmission with less hardship on both individuals and the economy, reducing factors that might otherwise engender public opposition to eradication efforts. The use of Internet search terms and other "big data" to identify outbreaks even before patients present at medical centers can accelerate the deployment of resources to quickly extinguish emerging hot spots.[122]

Such technology has already been implemented on a large scale in response to the COVID-19 pandemic.[123] In South Korea, Taiwan, Singapore, Iceland, and Israel, government investigators

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[119] Not all innovations are dramatic. Donald Henderson, the director of the smallpox eradication campaign, stated that one of the key contributors to eradication was the development of a heat-stable smallpox vaccine that did not require refrigeration. *See* Donald A. Henderson*, The Miracle of Vaccination*, 51 NOTES & RECS. ROYAL SOC'Y LONDON 235, 237-38 (1997).

[120] *See* Ann L. Oberg et al., *Systems Biology Approaches to New Vaccine Development*, 23 CURRENT OP. IMMUNOLOGY 436, 441-42 (2011).

[121] Such testing is routinely employed in the Czech Republic, Egypt, Estonia, Finland, India, Israel, Japan, Latvia, the Netherlands, New Zealand, Pakistan, Russia, Slovakia, and Switzerland. *See* T. Hovi et al., *Role of Environmental Poliovirus Surveillance in Global Polio Eradication and Beyond*, 140 EPIDEMIOLOGY & INFECTION 1, 10 (2012).

[122] *See* Min Kang et al., *Using Google Trends for Influenza Surveillance in South China,* PLOS ONE, Jan. 2013, at 1, 1, e55205; Shweta Bansal et al., *Big Data for Infectious Disease Surveillance and Modeling*, 214 J. INFECTIOUS DISEASES S375, S376 (2016); John S. Brownstein et al., *Surveillance Sans Frontières: Internet-Based Emerging Infectious Disease Intelligence and the Health Map Project*, 5 PLOS MED. 1019, 1019 (2008); Zoe Schlanger, *An Algorithm Spotted the Ebola Outbreak Nine Days Before WHO Announced It*, NEWSWEEK (Aug. 8, 2014) https://www.newsweek.com/algorithm-spotted-ebola-outbreak-9-days-who-announced-it-263875.

[123] *See* Bruno Macacs, *Only Surveillance Can Save Us*, FOREIGN POL'Y (Apr. 10, 2020) https://foreignpolicy.com/2020/04/10/coronavirus-pandemic-surveillance-privacy-big-data/.

utilized smartphone data to track potential coronavirus patients and, in conjunction with physical distancing and mask-wearing precautions, were able to successfully minimize the disease's spread.[124] Public officials in South Korea, for example, used closed circuit surveillance cameras and smart phone location data to trace the route of infected individuals and were able to minimize deaths to just 281 as of June 24, 2020,[125] compared to the United States' staggering toll of 121,979 by the same date.[126]

Vaccine technology has also improved. Recent developments in synthetic, nucleic acid-based (DNA and mRNA) vaccine technology have allowed for the rapid and targeted creation of effective viral vectors without many of the risks inherent in conventional vaccines,[127] potentially helping to reduce vaccine hesitancy.[128] Although nucleic acid vaccines have not yet been licensed for human use, DNA vaccines have been extensively evaluated in human clinical trials and found to be both safe and effective.[129] Structural biology research has also begun to identify new biological targets for vaccines by analyzing antigen structure at the nucleic acid level, enabling custom-built epitopes to bind targets

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[124] *See* Liza Lin & Timothy W. Martin, *How Coronavirus Is Eroding Privacy*, WALL STREET J. (Apr. 15, 2020), https://www.wsj.com/articles/coronavirus-paves-way-for-new-age-of-digital-surveillance-11586963028; Elizabeth Kolbert, *How Iceland Beat the Coronavirus*, NEW YORKER (June 1, 2020) https://www.newyorker.com/magazine/2020/06/08/how-iceland-beat-the-coronavirus. Resurgence remains a possibility until eradication is achieved. For example, Israel successfully minimized the spread of COVID-19 until reopening its schools. *See* Isabel Kershner & Pam Belluck, *When Covid Subsided, Israel Reopened Its Schools. It Didn't Go Well.*, N.Y. TIMES (Aug. 4, 2020), https://www.nytimes.com/2020/08/04/world/middleeast/coronavirus-israel-schools-reopen.html.

[125] *The Updates On COVID-19 in Korea as of 24 June*, KOREAN CENTER FOR DISEASE CONTROL (June 24, 2020), https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030 (search in Title bar for the name of the document); *see also* Derek Thompson, *What's Behind South Korea's COVID-19 Exceptionalism?*, THE ATLANTIC (May 6, 2020) https://www.theatlantic.com/ideas/archive/2020/05/whats-south-koreas-secret/611215/.

[126] *See COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)*, JOHNS HOPKINS UNIV. (June 24, 2020) https://www.arcgis.com/apps/opsdashboard/index.html?fbclid=IwAR2QQUQhUkQfrE-HMW63kZvUX7SOj8X6-m7AYo0pWUBBcVWTIZ-w40i8tqs#/bda7594740fd40299423467b48e9ecf6.

[127] *See generally* Mariana C. Castells et al., *Maintaining Safety with SARS-CoV-2 Vaccines*. 384 NEW ENG. J. MED. 643, 643-49 (2020) (discussing the side effect profile of the COVID-19 mRNA vaccines).

[128] *See* Raquel P. Deering et al., *Nucleic Acid Vaccines: Prospects for Non-Viral Delivery of mRNA* Vaccines, 11 EXPERT OP. DRUG DELIVERY 885, 885-86 (2014).

[129] *See Id.*

with greater degrees of specificity—a development that should result in fewer adverse events.

Additionally, "platform vaccines" are being investigated to serve as a "chassis" to efficiently build targeted vaccines collectively addressing whole classes of microbes.[130] According to this approach, once a new pathogen is observed, it is sequenced and "loaded" onto the chassis—making it possible to complete a "bespoke vaccine in a matter of weeks."[131] Traditional vaccines, which deliver inactivated or attenuated antigens to create immunity in the patient,[132] can be difficult to create and manufacture.[133] Using existing technology, the development of a new vaccine candidate can cost in excess of $500 million.[134] Establishing suitable production facilities and equipment can add an additional $50-$700 million in expenses, depending on the plant's location and other external factors.[135] Although estimates of the savings flowing from modular vaccine facilities do not exist, there is widespread consensus that they will be substantially cheaper than existing facilities.[136] New research has begun to identify potential targets for such platform vehicles,[137] including viruses such as influenza that continually evolve to create a need for new vaccines each year.[138]

Some scientists have even begun cautiously investigating the development of transmissible viral vaccines, which could

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[130] *See* Michael Specter, *How Anthony Fauci Became America's Doctor*, NEW YORKER (Apr. 10, 2020), https://www.newyorker.com/magazine/2020/04/20/how-anthony-fauci-became-americas-doctor.

[131] *Id.*

[132] Ronald W. Ellis et al., *Technologies for Making New Vaccines*, *in* VACCINES 1182, 1189 (Stanley A. Plotkin et al. eds., 6th ed. 2013).

[133] *See* Susanne Rauch et al., *New Vaccine Technologies to Combat Outbreak Situations*, 9 FRONTIERS IN IMMUNOLOGY, Sept. 19, 2018, at 1, 2-3 (2018); Haley K. Charlton Hume & Linda H. L. Lua, *Platform Technologies for Modern Vaccine Manufacturing*, 35 VACCINE 4480, 4481, 4483 (2017).

[134] *See* Stanley Plotkin et al., *The Complexity and Cost of Vaccine Manufacturing—An Overview*, 35 VACCINE 4064, 4067 (2017).

[135] *Id.*

[136] *See* Alain Pralong et al., *Paradigm Shift for Vaccine Manufacturing Facilities: The Next Generation of Flexible, Modular Facilities*, 14 ENG'G LIFE SCIS. 244, 246 (2014); Charlton Hume & Lua, *supra* note 133, at 4481, 4483.

[137] *See* Leo van der Pol et al., *Outer Membrane Vesicles as Platform Vaccine Technology*, 10 BIOTECHNOLOGY J. 1689, 1689 (2015) (discussing the novel use of membrane vesicles as targets for platform vaccine development).

[138] *See* Nani Wibowo et al., *Modular Engineering of a Microbially-produced Viral Capsomere Vaccine for Influenza*, 103 CHEM. ENG'G SCI. 12, 12 (2013).

permanently shift the ecological landscape of infectious diseases.[139] Traditional, live-attenuated vaccines work by establishing a subdued infection of a weakened variant of a virus in patients; the infection must be strong enough to elicit immunity, but weak enough to avoid causing disease.[140] A transmissible, viral vaccine would be a live-attenuated form of a virus considered contagious, thereby providing others the benefits of immunity without the need for traditional inoculation. While this area has not been highly studied, the phenomenon has been observed with the oral polio vaccine,[141] and holds the potential to dramatically decrease costs and rapidly expand immunity.[142]

Traditionally, it has been assumed that optimal targets for eradication were limited to diseases with exclusively human vectors, such as poliomyelitis and smallpox.[143] Technologies such as gene drive, which preferentially favors the inheritance of genetically modified genes, could be adapted to generate immunity in animal vectors and change the calculus of vector-borne diseases.[144] Researchers have already reported successful, limited deployment of a synthetic gene in *Anopheles gambiae*, the main vector for malaria.[145] The gene, which renders female mosquitos sterile if two copies are present, is passed down to over 90% of progeny and–if released in the wild–would rapidly suppress mosquito populations to levels that do not support malaria transmission.[146] Plans are currently underway to release 750 million of these altered mosquitos in the

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[139] *See* James J. Bull et al., *Transmissible Viral Vaccines*, 26 TRENDS MICROBIOLOGY 6, 6 (2018).

[140] *See* Rauch et al., *supra* note 133, at 3.

[141] *See* Philip Minor, *Vaccine-derived Poliovirus (VDPV): Impact on Poliomyelitis Eradication*, 27 VACCINE 2649, 2649 (2009).

[142] *See* Bull, *supra* note 139, at 6-7.

[143] *See* R. Bruce Aylward et al., *When Is a Disease Eradicable? 100 Years of Lessons Learned*, 90 AM. J. PUB. HEALTH 1515, 1515-16 (2000).

[144] *See generally* Steven P. Sinkins & Fred Gould, *Gene Drive Systems for Insect Disease Vectors*, 7 NATURE REV. GENETICS 427 (2006) (describing the concept and implications of gene drive technology); Jennifer Kahn, *The Gene Drive Dilemma: We Can Alter Entire Species, But Should We?*, N.Y. TIMES (Jan. 8, 2020), https://www.nytimes.com/2020/01/08/magazine/gene-drive-mosquitoes.html (discussing the ethical dimensions of gene dive technology).

[145] *See* Andrew Hammond et al., *A CRISPR-Cas9 Gene Drive System Targeting Female Reproduction in the Malaria Mosquito Vector Anopheles gambiae*, 34 NATURE BIOTECH. 78, 78 (2016) (reporting the effects of experimental gene drive technologies in malaria-hosting mosquito species).

[146] *See id.*

Florida Keys in 2021 and 2022.[147] These and similar advances in vector-control and molecular biology technologies make possible the eradication of diseases once thought too difficult to accomplish.

C. <u>Public Concern with Infectious Disease Has Increased</u>

In 2020, the rapid spread of the SARS-CoV-2 virus and the disease it causes, COVID-19, gripped public attention and increased interest in addressing infectious disease. This attention created a window of opportunity for increased support for eradication of infectious diseases. COVID-19 is a highly contagious airborne disease transmitted by casual contact.[148] If such a formidable contagion can be tamped down in more than 170 countries through mostly uncoordinated international efforts, and virtually eliminated in some even before the availability of a vaccine, then the public may have enough confidence to recognize that, with a concerted effort, it would be possible to eradicate the last few dozen cases of polio or guinea worm in the few countries where those diseases remain.

Even before the coronavirus pandemic, antibiotic resistance was attracting increasing media and public attention, raising public awareness of infectious disease threats.[149] In 2019, the US Centers for Disease Control and Prevention issued a report estimating that more than 2.8 million Americans are infected with antibiotic-resistant bacteria every year and that more than 35,000 die from these infections.[150] The WHO estimates that 700,000 people worldwide die

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[147] *See Heath Highlights: Aug. 19, 2020*, U.S. NEWS & WORLD REP. (Aug. 19, 2020, 9:00 AM), https://www.usnews.com/news/health-news/articles/2020-08-20/health-highlights-aug-19-2020.

[148] *How COVID-19 Spreads*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html (last updated Oct. 28, 2020).

[149] *See* Andrew Jacobs, *Crisis Looms in Antibiotics as Drug Makers Go Bankrupt*, N.Y. TIMES (Dec. 25, 2019), https://www.nytimes.com/2019/12/25/health/antibiotics-new-resistance.html (last updated Dec. 26, 2019); Editorial, *Antibiotic Resistance Is a Severe Health Threat. But There's a Glimmer of Hope.*, WASH. POST (Nov. 27, 2019, 10:01 PM), https://www.washingtonpost.com/opinions/antibiotic-resistance-is-a-severe-health-threat-but-theres-a-glimmer-of-hope/2019/11/27/9ce6d5bc-0652-11ea-ac12-3325d49eacaa_story.html; Matt Richtel, *Urinary Tract Infections Affect Millions. The Cures Are Faltering*, N.Y. TIMES (July 13, 2019), https://www.nytimes.com/2019/07/13/health/urinary-infections-drug-resistant.html.

[150] *See* CTRS. FOR DISEASE CONTROL & PREVENTION, U.S. DEP'T OF HEALTH & HUM. SERVS., ANTIBIOTIC RESISTANCE THREATS IN THE UNITED STATES, at vii (2019). Indeed, a recent

every year from anti-microbial resistant organisms.[151] Alarmingly, the WHO forecasts that this number may grow to more than 10 million annually by 2050, with potentially severe disruptions to people and the world economy.[152]

D. A Technological Window of Opportunity

The COVID-19 pandemic has demonstrated that substantial disease control can be achieved even in the absence of medicines and vaccines, helping to inspire confidence that even highly transmissible diseases can be eliminated with sufficient public cooperation and political will. Nevertheless, eradication campaigns can best be mounted when a full range of effective tools is available. Although antibiotic resistance has occurred most frequently in microorganisms not traditionally considered targets for eradication, waning effectiveness of antimicrobial interventions can mean that eradication of certain diseases may become more difficult over time.

For example, in 1955 the WHO (and others) began an eradication campaign against malaria, a parasitic infection transmitted by mosquitos.[153] The drug chosen as the cornerstone of the campaign was the antimalarial chloroquine, which was safe (even during pregnancy), effective against severe infection, and economical.[154] Chloroquine was the sole drug used by many national antimalaria programs and was extensively dispensed in suboptimal doses—in certain parts of the world it was even used as a table salt additive.[155] From its introduction in the 1940s until the early 1960s,

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survey of oncologists in the U.K. revealed that 46% believe that treatment-resistant microbes will make chemotherapy nonviable because its immunosuppressive effects leave patients at an increased risk of severe infection. *See* Kashmira Gander *Chemotherapy for Cancer Treatment Could Soon Be Unviable Because of Antibiotic-Resistant Superbugs, Doctors Fear*, NEWSWEEK (Feb. 18, 2020, 10:17 AM), https://www.newsweek.com/chemotherapy-cancer-treatment-resistant-superbugs-doctors-1487773.

[151] *See* Andrew Jacobs, *W.H.O. Warns That Pipeline for New Antibiotics Is Running Dry*, N.Y. TIMES, https://www.nytimes.com/2020/01/17/health/antibiotics-resistance-new-drugs.html (last updated Jan. 27, 2020).

[152] *See id.*

[153] Malaria is caused by several species of *Plasmodium* family parasites; the most severe disease comes from infection by *P. falciparum*. *See* Emilio J. Pampana & Paul F. Russell, *Malaria—A World Problem*, 9 WORLD HEALTH ORG. CHRON. 31, 31 (1955).

[154] *See* Donald J. Krogstad, *Malaria as a Reemerging Disease*, 18 EPIDEMIOLOGIC REVS. 77, 78 (1996).

[155] *Id.*

no nation reported chloroquine resistance.[156] By 1978, however, resistance was reported in the virulent *Plasmodium falciparum* species in South America, Southeast Asia, and Africa.[157] By 2000, hospitals around the African continent reported two- to three-fold increases in malarial death and admissions—presumably the result of chloroquine-resistant *P. falciparum*.[158] Since 2007, the WHO's Model List of Essential Medicines has indicated that chloroquine is "[f]or use only for the treatment of *P*[*lasmodium*] *vivax* infection."[159]

The endemic bacterial infection *Treponema pallidum pertenue* (yaws) also illustrates the potential for diseases to develop resistance against powerful antimicrobial agents. Yaws was successfully treated for decades with penicillin, resulting in a 95% reduction in the disease's incidence worldwide.[160] However, in the late 1990s, reports emerged of penicillin treatment failures resulting in relapse of the infection—possibly an early indication that the bacteria were beginning to develop resistance to the drug.[161] Since that time, azithromycin has become the standard treatment of choice, but it is described by the WHO as having "higher resistance potential," and its continued effectiveness is not certain.[162] Treatment resistance has also emerged with tuberculosis,[163] HIV,[164] fungal diseases,[165] and others.[166]

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[156] *See id.*

[157] *Id.*

[158] *See* Jean-Francois Trape, *The Public Health Impact of Chloroquine Resistance in Africa*, 64 J. AM. TROPICAL MED. & HYGIENE 12, 12 (2001).

[159] WORLD HEALTH ORG., MODEL LIST OF ESSENTIAL MEDICINES 11 (15th ed. 2007); WORLD HEALTH ORG., MODEL LIST OF ESSENTIAL MEDICINES 24 (21st ed. 2019) [hereinafter *2019 Model List*].

[160] *See* Jack T. Stapleton et al., *Potential for Development of Antibiotic Resistance in Pathogenic Treponemes*, 7 REV. INFECTIOUS DISEASES S314, S314 (1985); Oriol Mitjà et al., *Yaws*, 381 LANCET 763, 763 (2013).

[161] *See* Josephine L. Backhouse et al., *Failure of Penicillin Treatment of Yaws on Karkar Island, Papua New Guinea*, 59 AM. J. TROPICAL MED. & HYGIENE 388, 388 (1998).

[162] *See 2019 Model List*, *supra* note 159, at 8, 12; *see also* Mitjà, *supra* note 160, at 768.

[163] Juan Carlos Palomino & Anandi Martin, *Drug Resistance Mechanisms in Mycobacterium Tuberculosis*, 3 ANTIBIOTICS 317, 317 (2014).

[164] Luc Perrin & Amalio Telenti, *HIV Treatment Failure: Testing for HIV Resistance in Clinical Practice*, 280 SCIENCE 1871, 1871 (1998).

[165] *See* Matthew W. McCarthy et al., *Novel Agents and Drug Targets to Meet the Challenges of Resistant Fungi*, 216 J. INFECTIOUS DISEASES S474, S474 (2017).

[166] *See generally* Mirjam Schunk et al., *High Prevalence of Drug-Resistance Mutations in Plasmodium falciparum and Plasmodium vivax in Southern Ethiopia*, 5 MALARIA J. 1, 1 (2006) (describing drug-resistant, malaria-causing parasites).

Vaccine escape, the vaccine analogue to antimicrobial resistance, has also emerged as a potential concern. Although not yet a widespread public health issue, evidence has begun to emerge that the measles virus, which has been extremely rare since the development and global deployment of an effective vaccine roughly fifty years ago, can sometimes infect fully-vaccinated individuals.[167] In the well-publicized measles outbreak at California's Disneyland amusement park in 2014-2015, from the thirty confirmed cases, ten individuals were fully-vaccinated.[168] Additionally, increasing rates of whooping cough (pertussis) in countries with continuous high levels of vaccine coverage have also begun raising concerns that *B. pertussis* may be evolving antigenic variants leading towards vaccine escape.[169] Similar concerns have been expressed with hepatitis A and B,[170] pneumococcus,[171] and pertussis.[172]

E. Ethical Considerations

Dramatic declines in the infectious disease burden have not been evenly distributed worldwide (**Exhibit 6**), in part because low-income countries tend to have the lowest vaccination rates against vaccine-preventable illnesses.[173] In high-income countries in 2016, infectious diseases accounted for 6.1% of all deaths, while non-communicable diseases (NCDs) were responsible for 87.8%.[174] In

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[167] *See* Luojun Yang et al., *Measles Vaccine Immune Escape: Should We Be Concerned?*, 34 EUR. J. EPIDEMIOLOGY 893, 894 (2019).

[168] *Id.*

[169] *See* Andrew Preston, *The Role of B. Pertussis Vaccine Antigen Gene Variants in Pertussis Resurgence and Possible Consequences for Vaccine Development*, 12 HUM. VACCINES & IMMUNOTHERAPEUTICS 1274, 1274 (2016).

[170] *See* Unai Pérez-Sautu et al., *Hepatitis A Virus Vaccine Escape Variants and Potential New Serotype Emergence*, 17 EMERGING INFECTIOUS DISEASES 734, 734 (2011); William F. Carman et al., *Vaccine-induced Escape Mutant of Hepatitis B Virus*, 336 LANCET 325, 325 (1990).

[171] *See* Angela B. Brueggeman et al., *Vaccine Escape Recombinants Emerge after Pneumococcal Vaccination in the United States*, 3 PLOS PATHOGENS 1628, 1628 (2007).

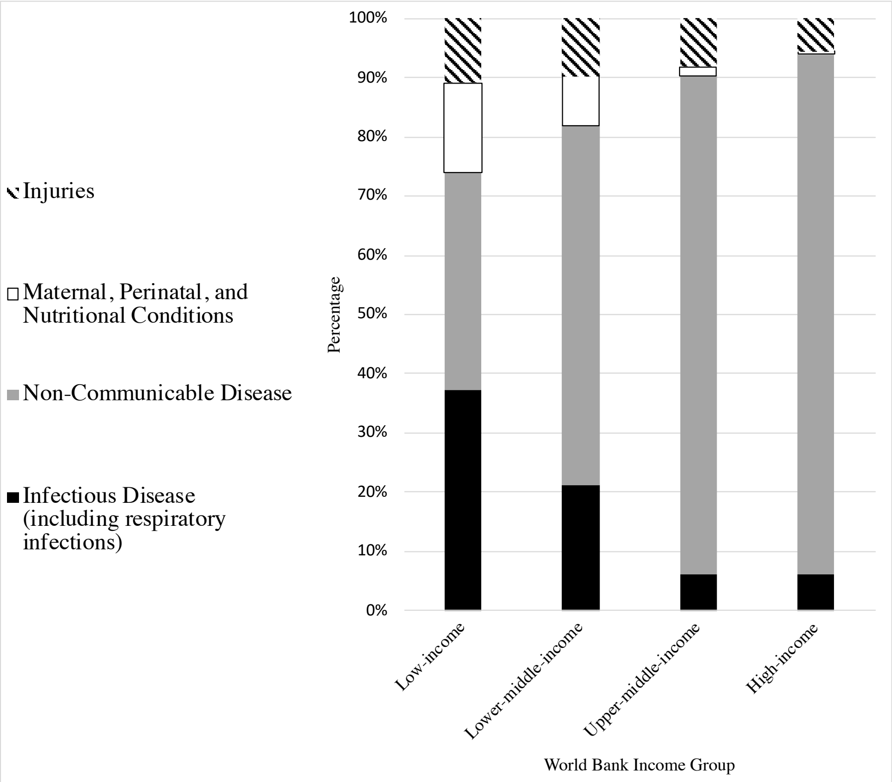
[172] *See* Duleepa Jayasundara et al., *Emergence of Pertactin-Deficient Pertussis Strains in Australia Can Be Explained by Models of Vaccine Escape*, EPIDEMICS, June 1, 2020, at 1, 1, No. 100388.

[173] *See* Charles H. King & Anne-Marie Bertino, *Asymmetries of Poverty: Why Global Burden of Disease Valuations Underestimate the Burden of Neglected Tropical Diseases,* PLOS NEGLECTED TROPICAL DISEASES e209, 1 (2008).

[174] The total percentage comes from combining the infectious disease and respiratory infections categories. *See Global Health Estimates 2016 Summary Tables: Deaths by Cause, Age and Sex, by World Bank Income Group, 2000-2015*, WORLD HEALTH ORG. (Apr. 2018), https://www.who.int/healthinfo/global_burden_disease/GHE2016_Deaths_WBInc_2000_2016.xls.

low-income countries, meanwhile, infectious diseases caused 37.1% of deaths while NCDs were responsible for only 36.8%.[175] Of the top ten causes of death in high-income countries in 2016, only one had an infectious origin; in low-income countries that same year, six of the top ten causes of death originated from infectious organisms.[176]

Exhibit 5: Cause-Specific Mortality by World Bank Income Group, 2016



Source: World Health Organization[177]

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[175] *See id.* The remaining 26.1% of deaths in low-income countries are caused by Maternal Conditions (2%), Neonatal Conditions (10.4%), Nutritional Deficiencies (2.8%), and Injuries (10.9%). *See id.*

[176] *See The Top 10 Causes of Death*, WORLD HEALTH ORG. (May 24, 2018), https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death.

[177] Total percentage equals 100.1% for high-income countries due to rounding. *See Global Health Estimates 2016 Summary Tables*, *supra* note 174.

Although the greatest percent decreases in vaccine-preventable illness deaths since 1990 have been in low-income countries, such countries continue to bear a disproportionate share of the global infectious disease burden. At the same time, low disease burdens in wealthy nations have diminished public investment in disease control programs. When measured in disability-adjusted life-years (DALYs), a standard means of comparing disease burden across populations, in 2016, low-income countries suffered from communicable disease rates more than nineteen-times higher than the rates of high-income countries.[178]

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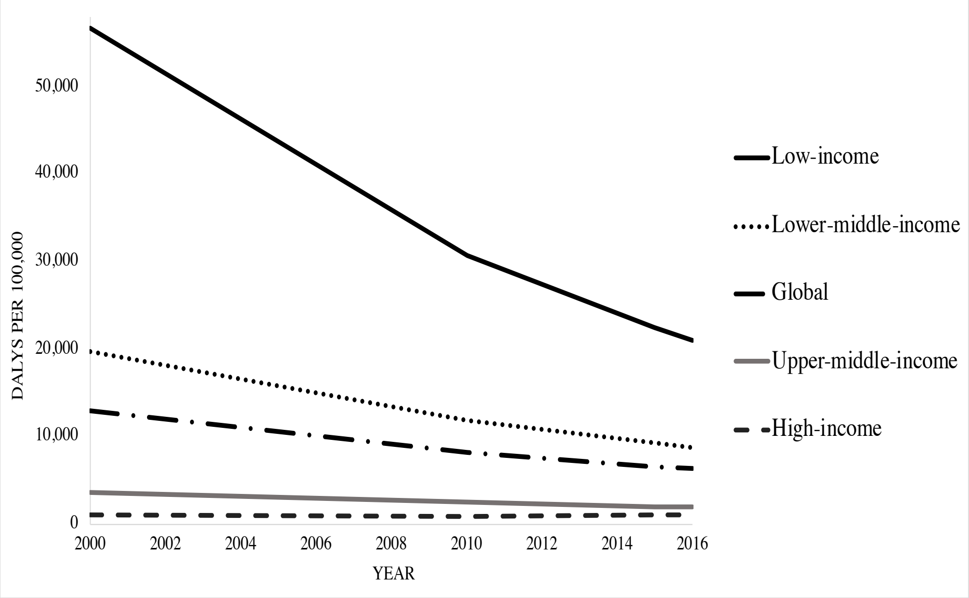
[178] In 2016, low-income countries' infectious disease burden was 20,937 (DALY per 100,000), while high-income countries' analogous burden was 1,076—19.5 times as high. *See Global Health Estimates 2016: Disease Burden by Cause, Age, Sex, by Country and by Region, 2000-2016*, WORLD HEALTH ORG., https://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html (last visited Aug. 8, 2020).

Exhibit 6: Infectious Disease Burden by World Bank Income Group, 2000-2016



Sources: World Health Organization,[179] World Bank[180]
DALYs = Disability-Adjusted Life Years

A greater infectious disease burden, however, means that people in low-income countries will gain the greatest health benefits from successful eradication campaigns. Those regions are also likely to gain economically. While eradication funding will almost certainly be derived from global contributions, the day-to-day logistics of eradication will be carried out primarily by local workers, providing employment opportunities and effecting a transfer of wealth from rich to poor nations. Although wealthy nations will finance the bulk of any eradication campaign, up-front expenditures are also likely to

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[179] DALY burden (shown here as a rate per 100,000 individuals) combines the infectious disease and respiratory infections categories, listed separately by the WHO. DALYs per category were totaled, then divided by income group population size to arrive at the relevant rate. *See id.*

[180] *See generally World Bank Country and Lending Groups*, WORLD BANK, https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (last visited Aug. 8, 2020) (defining economy levels for countries throughout the world).

lead to lower long-term costs for those countries, as the costs of surveillance, diagnosis, prevention, treatment, and foreign assistance for particular diseases become no longer necessary.

Ethical concerns of perennial vaccination and containment programs are not limited to issues of wealth. Conventional vaccines, such as the yellow fever vaccine, can in rare cases actually cause death.[181] Annual global vaccination therefore will result in a small number of patients suffering serious injury or death from the vaccines themselves. For example, the smallpox vaccine caused sixty-eight deaths out of millions of vaccinations between 1959 and 1968.[182] In the United States, the 1986 National Childhood Vaccine Injury Act created a no-fault program to compensate people purportedly injured by vaccinations.[183] Since 2006, 5,317 adverse events have been compensated out of the 3.7 billion doses of vaccines dispensed—indicating an adverse event rate of 0.00014%.[184] Although there is widespread consensus that the overall public health benefits of vaccination far outweigh the costs at the societal level, these rare adverse events mean that an extremely small percentage of people bear severe health consequences, including death, in order to benefit billions of others. Eradication would avoid this disconcerting trade-off.

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[181] *See* A. Doblas et al., *Yellow Fever Vaccine-Associated Viscerotropic Disease and Death in Spain*, 36 J. CLINICAL VIROLOGY 156, 158 (2006) (demonstrating a rare but serious potential side-effect of a live-attenuated vaccine); *see also* Rauch, *supra* note 133, at 3 ("Live-attenuated vaccines generally bear the risk of reversion . . . ."). Examples of live-attenuated vaccines used in the U.S. include the MMR (measles, mumps, and rubella), rotavirus, smallpox, chickenpox, and yellow fever vaccines. *See Vaccine Types,* U.S. DEP'T HEALTH & HUM. SERVS., https://www.vaccines.gov/basics/types (last visited July 13, 2020). The oral polio vaccine is also live-attenuated, and polio reversion cases constitute a large number of polio cases reported to the WHO in recent years. *See This Week*, GLOB. POLIO ERADICATION INITIATIVE (Mar. 18, 2020), http://polioeradication.org/polio-today/polio-now/this-week/.

[182] *See* J. Michael Lane et al., *Deaths Attributable to Smallpox Vaccination, 1959 to 1966, and 1968,* 212 J. AM. MED. ASS'N 441, 441 (1970).

[183] *See History of Vaccine Safety*, CTRS. FOR DISEASE CONTROL & PREVENTION https://www.cdc.gov/vaccinesafety/ensuringsafety/history/index.html (last updated Sept. 9, 2020).

[184] *National Vaccine Injury Compensation Program Data Report*, HEALTH RESOURCES & SERVS. ADMIN, https://www.hrsa.gov/sites/default/files/hrsa/vaccine-compensation/data/data-statistics-report.pdf (last updated Jan. 1, 2021). Seventy percent of all compensation awarded was the result of negotiated settlement, meaning that the Department of Health and Human Services did not determine whether the vaccine caused the injury. *See id.*

IV. The "Last Mile" Problem

Disease eradication was once the centerpiece of twentieth century public health efforts, and the eradication of smallpox in 1980 one of its crowning achievements. Yet with the possible exception of SARS,[185] no additional human diseases have been eradicated. To the contrary, despite a broad range of technical advances in infectious disease control and continued interest at the international level,[186] disease eradication has largely fallen to the wayside among United States public health experts and academics. In its place, the policy focus has shifted to the prevention of non-infectious diseases, improving health care access and delivery, and the equitable balancing of social determinants of health.[187]

Although the causes of this stunning failure to achieve further eradications are complex,[188] there is a unifying theme known as the "last mile" problem, which refers to the common "set of shared barriers that emerge during the endgame or 'last mile'" of an eradication program.[189] As the prevalence of an infectious disease

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[185] Robert Smith, *Did We Eradicate SARS? Lessons Learned and the Way Forward*, 6 AM. J. BIOMED. SCI. & RES. 152, 154 (2019) ("[T]he 2003 SARS epidemic was permanently reduced to zero as a result of deliberate efforts, requiring no further intervention efforts."); *see also SARS (10 Years After)*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/dotw/sars/index.html (last updated Mar. 3, 2016).

[186] *See, e.g.*, MARCEL TANNER ET AL., MALARIA ERADICATION: BENEFITS, FUTURE SCENARIOS AND FEASIBILITY: A REPORT OF THE STRATEGIC ADVISORY GROUP ON MALARIA ERADICATION, at xv (2020) ("Almost 50 years later, the world has once again begun to consider the feasibility of eradicating malaria."); Richard G.A. Feachem et al., *Malaria Eradication within a Generation: Ambitious, Achievable, and Necessary*, 394 LANCET 1056, 1056 (2019) (describing the conclusion of the Lancet Commission on Malaria Eradication that eradication by 2050 is an "attainable goal"). The Global Fund, with a stated goal of ending AIDS, tuberculosis, and malaria by 2030, raised $14 billion in its 2019 replenishment—33% of which came from the U.S. Congress. *Global Fund Donors Pledge US$14 Billion in Fight to End Epidemics*, THE GLOB. FUND: NEWS & STORIES (Oct. 10, 2019) https://www.theglobalfund.org/en/news/2019-10-10-global-fund-donors-pledge-usd14-billion-in-fight-to-end-epidemics/.

[187] *See* Tulchinsky & Varavikova, *supra* note 9, at 25; Mark G. Embrett & Glen E. Randall, *Social Determinants of Health and Health Equity Policy Research: Exploring the Use, Misuse, and Nonuse of Policy Analysis Theory*, 108 SOC. SCI. & MED. 147, 147 (2014); Michael Marmot, *Social Determinants of Health Inequities*, 365 LANCET 1099, 1103 (2005); Carlyn M. Hood et al., *County Health Rankings: Relationships Between Determinant Factors and Health Outcomes*, 50 AM. J. PREVENTATIVE MED. 129, 133-34 (2016).

[188] *See* Petra Klepac et al., *Six Challenges in the Eradication of Infectious Diseases*, 10 EPIDEMICS 97, 100 (2015).

[189] Sarah Wondmeneh, *The Last Mile: Endgame Challenges in Disease Eradication*, INST. PUB. HEALTH (Feb. 27, 2017), https://publichealth.wustl.edu/last-mile-endgame-challenges-disease-eradication/.

approaches zero,[190] some members of the public and even public health experts may begin to view the disease as "largely conquered."[191] Vaccine refusal rates can spike as the general public's memory of the disease fades and risk tolerance of vaccine-related adverse effects decreases.[192] Disease control efforts continue to consume resources as fewer individuals are affected, thus creating an impression of diminishing returns. For example, in 2014, there were 359 cases of wild polio virus reported in nine countries, but estimated costs of completing the eradication program were $5.5 billion.[193] This is a tremendous cost per person if the possibility of resurgence is ignored.[194] Just when public will and dedication are most important to finish the campaign—necessary support is lost.[195] Eradication programs, in other words, can fall victim to their own success, a problem that potentially worsens the longer an unfinished campaign languishes.

V. Challenges and Solutions: Disease-specific Eradication Treaties

Because infectious diseases do not respect national boundaries, international cooperation is indispensable to any communicable disease control program. As a United Nations-affiliated body with more than seven decades of experience in

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[190] *See id.*

[191] *See* Joshua Lederberg, *Infectious History*, 288 SCIENCE 287, 289 (2000).

[192] Robert T. Chen et al., *The Vaccine Adverse Event Reporting System (VAERS),* 12 VACCINE 542, 542 (1994). The tendency to forget the severity of diseases when they occur only rarely is not new. In 1885, a vaccine refuser named J.F. Banton argued that smallpox, a highly contagious disease with a mortality rate around 30%, was "a disease not so much to be dreaded as we are wont to believe, leaving the system in a much healthier condition than most other diseases . . ." *See* Martin Kaufman, *The American Anti-Vaccinationists and Their* Arguments, 41 BULL. HIST. MED. 463, 475 (citing J. F. Banton, *Vaccination Refuted* (1882)). This dilemma is also known as "vaccine hesitancy" and is extensively addressed in immunotherapeutic literature. *See generally* Eve Dube et al., *Vaccine Hesitancy: An Overview*, 9 HUM. VACCINES & IMMUNOTHERAPEUTICS 1763, 1763-64 (2013) (illustrating a conceptual model to understand vaccine hesitancy at the individual level). Here, we use the term "vaccine refusal" to refer to the problem eradication campaigns face when individuals affirmatively decline vaccination, as opposed to generally questioning their efficacy. *See* Diane S. Saint-Victor & Saad B. Omer*, Vaccine Refusal and the Endgame: Walking the Last Mile First*, 368 PHIL. TRANSACTIONS ROYAL SOC'Y 1, 2 (2013).

[193] *See* Julie R. Garon, Stephen L. Cochi & Walter A. Orenstein, *The Challenge of Global Poliomyelitis Eradication*, 29 INFECTIOUS DISEASE CLINICS 651, 655, 662 (2015).

[194] *Id.* at 662.

[195] *See id.*

coordinating global health initiatives, the WHO is best positioned as a forum to guide eradication efforts. Yet past efforts led by the WHO to eradicate malaria, polio, measles, yaws, and yellow fever have either failed or proceeded more slowly than expected. We consider the structural challenges under which the WHO must operate, and we evaluate diseases-specific eradication treaties for their potential to overcome the obstacles faced by past eradication campaigns.

A. WHO Institutional Challenges

In part, disappointing outcomes of past campaigns have been the result of a lack of institutional focus. The WHO appropriately seeks to take account of the interests of all its member countries, but the desire to comprehensively address global health problems led to an original remit that was expansive in scope. The 1946 WHO Constitution listed "eradicat[ing]. . . diseases" as just one of twenty-two stated objectives, which promoted ends as diverse as nutrition, housing, sanitation, recreation, working conditions, accident reduction, mental health, and teaching standards, among others.[196]

Over time, the goals of the WHO have become even more diverse and ambitious.[197] Since its inception, the WHO has taken on projects related to tobacco control, climate change, pharmaceutical packaging, electromagnetic fields, and poverty.[198] In 2011, the Director-General of the WHO conceded that the intergovernmental agency was overextended and unable to respond with speed and agility to modern global health needs.[199] She went on to elaborate that "[p]riority setting is neither sufficiently selective nor strategically focused."[200] Of the nine new goals established by the WHO in

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[196] WORLD HEALTH ORG. CONST. art. 2.

[197] The stated goal of the WHO is "the attainment by all peoples of the highest possible level of health." *See* WORLD HEALTH ORG. CONST. art. 1.

[198] *Programmes and Projects*, WORLD HEALTH ORG., https://www.who.int/entity/en (last visited July 13, 2020).

[199] *See* Devi Sridhar & Lawrence O. Gostin, *Reforming the World Health Organization*, 305 JAMA 1585, 1585 (2011) (citing World Health Org. [WHO], *The Future of Financing for WHO*, WHO Doc. EB128/21 (Dec. 15, 2010).

[200] World Health Org. [WHO], *The Future of Financing for WHO*, at 1, WHO Doc. A64/4 (May 5, 2011).

2019,[201] only two directly address infectious disease burdens, and none addresses disease eradication.[202]

The WHO has initiated four major disease eradication campaigns, all in the second half of the twentieth century, and all passed by majority resolutions in the WHO's primary decision-making body, the World Health Assembly (WHA). In 1949, the WHA passed a resolution to support control of endemic treponematoses (including yaws).[203] After the WHO convened two international conferences on yaws, the control program evolved into a full-blown eradication effort, led by the WHO and UNICEF.[204] The Global Malaria Eradication Programme was launched by WHA resolution in 1955,[205] and formally ended by a similar resolution in 1969.[206] Campaigns against guinea worm disease (1986) and polio (1988) were also initiated by WHA resolutions.[207]

By taking on disease eradication within the traditional WHO framework, funding of these initiatives became subject to inherent limitations of the organization's funding structure. Under financial

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[201] *See WHO Unveils Sweeping Reforms in Drive Towards "Triple Billion" Targets*, WORLD HEALTH ORG. (Mar. 6, 2019), https://www.who.int/news-room/detail/06-03-2019-who-unveils-sweeping-reforms-in-drive-towards-triple-billion-targets; World Health Org. [WHO], *Programme Budget 2020-2021*, at 22, WHO Doc. WHO/PRP/19.1 (May 30, 2019). The nine outcomes are: (1.1) improved access to quality essential health services, (1.2) reduced number of people suffering financial hardship, (1.3) improved access to essential medicines, vaccines, diagnostics and devices for primary health care, (2.1) countries prepared for health emergencies, (2.2) epidemics and pandemics prevented, (2.3) health emergencies rapidly detected and responded to, (3.1) determinants of health addressed, (3.2) risk factors reduced through multisectoral action, and (3.3) healthy settings and Health in All Policies promoted. *Id.* at 9-10.

[202] *Id.* This is not to say that the WHO is eschewing infectious diseases in its operations. It continues to allocate $863 million (17.8%) of its total budget of $4.84 billion towards polio eradication alone. *See id.* at 7.

[203] World Health Org. [WHO], Assembly Res. WHA2.36, *Bejel and Other Treponematoses*, Off. Rec. Wld Hlth Org. 17, 11; 15, 29 (June 1949), https://www.who.int/neglected_diseases/mediacentre/WHA_2.36_Eng.pdf.

[204] *See* Asiedu et al., *supra* note 62, at 499.

[205] World Health Org. [WHO], Assembly Res. WHA8.30, *Malaria Eradication*, Handb. Res., 2nd ed., 1.3.10; 7.1.5 (May 26, 1955), https://apps.who.int/iris/bitstream/handle/10665/88150/WHA8.30_eng.pdf.

[206] World Health Org. [WHO], Assembly Res. WHA22.39, *Re-examination of the Global Strategy of Malaria Eradication*, Handb. Res., 10th ed., 1.2.2 (July 24, 1969), https://apps.who.int/iris/bitstream/handle/10665/91264/WHA22.39_eng.pdf.

[207] World Health Org. [WHO], Assembly Res. WHA39.21, *Elimination of Dracunculiasis*, Hbk Res., Vol. II (1985), 1.14.2; 1.16.3.3 (May 16, 1986), https://www.who.int/neglected_diseases/mediacentre/WHA_39.21_Eng.pdf.

regulations adopted by the WHA,[208] the agency's funding consists of two components: assessed contributions, paid by member nations according to a scale determined by the WHA and based on a country's wealth and population, and voluntary contributions from both private and public organizations, which are typically earmarked for specific programs.[209]

This structure limits the WHO's ability to set and fund the public health needs that the agency determines are most pressing.[210] Voluntary contributions made up $2.2 billion (81.7%) of the WHO's total budget revenue of $2.7 billion in 2018,[211] all but $181 million (8% of $2.2 billion) of which was earmarked for designated programs,[212] a sum that is inadequate to support even a single disease eradication campaign. Although $754 million of earmarked funds was devoted to polio eradication,[213] the polio eradication campaign is estimated to require $4.2 billion to achieve its goals from 2019-2023.[214] In 2018, the WHO was able to fund only 84% of the 2018-2019 biennium budget allotted internally for polio eradication,[215] although private donors managed to make up most of the difference by the biennium's end.[216] The Global Polio Eradication Initiative, which derives about 60% of its funding from the WHO, reported a shortfall of roughly $3.3 billion (77.8%) in the required funding of its 2023 polio eradication goal.[217]

Underfunding of eradication was a problem even during the successful smallpox campaign.[218] When the WHO endorsed smallpox eradication as a goal in 1959, it estimated that eradication would cost

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[208] World Health Org. [WHO], Fin. Reg. 5, *Provision of Budget Funds*, *in* WHO, Basic Documents, at 139-40 (49th ed. 2020); World Health Org. [WHO], Fin. Reg. 6, *Assessed Contributions*, *in* WHO, Basic Documents, at 140-41 (49th ed. 2020).

[209] *See* Sridhar & Gostin, *supra* note 199, at 1586.

[210] *See id.*

[211] WORLD HEALTH ORG., WHO RESULTS REPORT: PROGRAMME BUDGET 2018-2019 MID-TERM REVIEW 82 (2018) [hereinafter WHO BUDGET].

[212] *Id.* at 83.

[213] *Id.* at 80. Earmarked funds include funds recorded in the 2018-2019 biennium and funds brought forward from previous bienniums, less funds carried forward to subsequent bienniums. *Id.*

[214] *See* GLOB. POLIO ERADICATION INITIATIVE, INVESTMENT CASE 6 (2019).

[215] *See* WHO BUDGET, *supra* note 211, at 80.

[216] *Contributions and Pledges to the Global Polio Eradication Initiative, 1985-2019*, *supra* note 108.

[217] *See* GLOB. POLIO ERADICATION INITIATIVE, *supra* note 214, at 6.

[218] *See* Scott Barrett, *The Smallpox Eradication Game*, 130 PUB. CHOICE 179, 185 (2006).

$97.7 million. However, less than $200,000 was allocated in the WHO's 1960 budget,[219] and voluntary contributions initially failed to make up the difference. From 1959 to 1973, countries voluntarily donated a trivial total of $106,845 to fund the program.[220] Voluntary donations did not increase until 1974, after smallpox had successfully been eliminated in Brazil and Indonesia.[221] Over the next five years, the WHO received a total of $97.97 million in contributions,[222] and the last case of smallpox was reported in 1978.[223]

Although the polio and guinea worm campaigns are tantalizingly close to success, the WHO so far has not been able to effectively generate the political and financial will necessary to overcome the last mile problem, and charitable organizations such as the Bill and Melinda Gates Foundation and the Carter Center have played so central a role as to be viewed by some as the true drivers of these eradication campaigns.[224] The apparent politicization of U.S. membership in the WHO—symbolized by former President Trump's threatened withdrawal from the organization,[225] and President

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[219] *Id.* at 183. (discussing that the 1960 budget allocation for smallpox was less than 0.2 percent of the $97.7 million needed to eliminate the disease).

[220] *Id.* at 184, 186 (noting that eight countries donated a total of $27,345 from 1959 to 1966 and cash donations totaled $79,500 from 1967 to 1973).

[221] *See* Alasdair M. Geddes, *The History of Smallpox*, 624 CLINICS DERMATOLOGY 152, 155 (2006).

[222] Barrett, *supra* note 218, at 186.

[223] Geddes, *supra* note 221, at 156.

[224] *See, e.g.*, Laura Freschi & Alanna Shaikh, *Gates: A Benevolent Dictator for Public Health?*, ALLIANCE MAG. (Sept. 1, 2011), http://www.hudson.org/content/researchattachments/attachment/1198/benevolent_dictator_for_public_health.pdf; Karolin Seitz & Jens Martens, *Philanthrolateralism: Private Funding and Corporate Influence in the United Nations*, 8 GLOB. POL'Y 46, 47 (2017) ("Between 2014 and 2017, the Gates Foundation grant[ed] more than US$1 billion to the WHO."); *Eradication of Guinea Worm Disease: Case Statement*, CARTER CTR. & WORLD HEALTH ORG., https://www.who.int/docs/default-source/ntds/dracunculiasis/center-who-gw-case-statement2020.pdf?sfvrsn=5c00d407_4&download=true (last visited Aug. 13, 2020) ("The Carter Center, WHO, and partners assist national eradication programs to halt disease transmission in humans and animals . . . .").

[225] Berkeley Lovelace, Jr., *Trump Says the U.S. Will Cut Ties with World Health Organization*, CNBC (May 29, 2020, 2:56 PM), https://www.cnbc.com/2020/05/29/trump-says-the-us-will-cut-ties-with-world-health-organization.html; *see Trump Threatens to Leave W.H.O. and Permanently End Funding*, N.Y. TIMES (May 18, 2020), https://www.nytimes.com/2020/05/18/us/coronavirus-updates.html.

Biden's re-commitment to it[226]—suggests that WHO funding challenges will only persist in the future.

B. Implementing Eradication Treaties

The World Health Assembly should utilize its unique legislative powers to promote and adopt international health conventions with a focus on eradicating infectious disease. Rather than promulgating regulations that countries can elect to "opt out" of,[227] the WHO Constitution provides the WHA with power to propose and adopt international health conventions.[228] The political efforts needed to coordinate an eradication convention would place governmental obligations in the public eye in a way that the internal workings of a specialized agency cannot.[229] In addition, adoption requires a two-thirds majority vote in the WHA, with each member country casting one vote.[230] Together, these actions would help to ensure broad international and public support for eradication

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[226] Jamey Keaten, *Biden's U.S. Revives Support for WHO, Reversing Trump Retreat*, AP News (Jan. 21, 2021), https://apnews.com/article/us-who-support-006ed181e016afa55d4cea30af236227; *see* Amanda Macias, *U.S. Will Pay WHO More Than $200 million in Membership Fees Withheld by Trump*, CNBC (Feb. 17, 2021, 3:20 PM), https://www.cnbc.com/2021/02/17/us-will-pay-who-more-than-200-million-in-membership-fees-withheld-by-trump.html.

[227] Lawrence O. Gostin, *A Proposal for a Framework Convention on Global Health*, 10 J. INT'L ECON. L. 989, 994 (2007).

[228] WORLD HEALTH ORG., BASIC DOCUMENTS, at art. 2, 19 (49th ed. 2020).

[229] For example, the WHO's Framework Convention on Tobacco Control garnered significant press attention during and after its proposal and enactment process. *See* Elizabeth Olson, *W.H.O. Treaty Would Ban Cigarette Ads Worldwide*, N.Y. TIMES (July 22, 2002), https://www.nytimes.com/2002/07/22/world/who-treaty-would-ban-cigarette-ads-worldwide.html; Alison Langley, *World Health Meeting Approves Treaty to Discourage Smoking*, N.Y. TIMES (May 22, 2003), https://www.nytimes.com/2003/05/22/world/world-health-meeting-approves-treaty-to-discourage-smoking.html; Agence France-Presse, *World Briefing, World: Anti-Smoking Treaty Proposed*, N.Y. TIMES (Sept. 14, 2001), https://www.nytimes.com/2001/09/14/world/world-briefing-world-anti-smoking-treaty-proposed.html.

[230] *See* World Health Org. [WHO], R. 70, *Rules of Procedure of the World Health Assembly*, *in* WHO, Basic Documents, at 191 (49th ed. 2020). Thus far, the WHO has only passed one global health treaty under Article 19 of its constitution, the WHO Framework Convention on Tobacco Control. *Parties to the Framework Convention on Tobacco Control,* WORLD HEALTH ORG., https://www.who.int/fctc/cop/en (last visited July 13, 2020).

efforts.[231] The symbolic, norm-setting power of the WHO would also lend credibility and expertise to the effort.[232]

Treaties provide funding advantages as well. Past efforts have suffered from underfunding, leaving programmatic success dependent on the generosity of future donors. By contrast, eradication treaties could establish a budgetary commitment of signatories for the duration of the campaign or until eradication is achieved, if earlier. Total treaty funding should be determined by working backwards from the anticipated expenditures necessary to completely eradicate the targeted disease by a specified target date. This total amount would be divided into individual country funding obligations, the amounts of which would ultimately be the product of negotiation, but which should be equitably calculated based on factors such as the costs a country is likely to save as a result of eradication, in-kind contributions such as technical support, and ability to pay.

Broad public support is critical for the success of an eradication campaign, and treaties allow countries to build public support for eradication programs organically. After adoption, a WHO convention must be ratified by each signatory, making engagement within each country during preceding negotiations a logistical necessity. The negotiating process thus transforms nations from subjects to stakeholders, giving affected parties influence in the planning process and allowing the incorporation of national priorities. Disease eradication and control programs can be constructed in such a way so as to integrate certain tools (e.g., surveillance infrastructure) across disease categories and strengthen national health care systems, further engendering public support.[233] Broad public support of

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[231] *See* World Health Org. [WHO], R. 69, *Rules of Procedure of the World Health Assembly*, *in* WHO, Basic Documents, at 191 (49th ed. 2020).

[232] Some aspects of disease-specific eradication treaties would overlap with existing WHO requirements, such as parts of the International Health Regulations that require member states to establish and maintain core infectious disease surveillance and response capabilities. *See* David P. Fidler & Lawrence O. Gostin, *The New International Health Regulations: An Historic Development for International Law and Public Health*, 34 J. L. MED. & ETHICS 85, 86 (2006).

[233] *See generally* Daniel Tarantola & Stanley O. Foster, *From Smallpox Eradication to Contemporary Global Health Initiatives: Enhancing Human Capacity Towards a Global Public Health Goal*, 29 VACCINE D135, D136-37 (2011) (analyzing how eradication programs can be used to broadly strengthen contemporary global health initiatives); PAN AM. HEALTH ORG., PAHO DISEASE ELIMINATION INITIATIVE: A POLICY FOR AN INTEGRATED SUSTAINABLE APPROACH TO COMMUNICABLE DISEASES IN THE AMERICAS (2019) (laying out a framework for the elimination of communicable disease in the Americas in a holistic and sustainable fashion).

eradication, particularly in the countries most afflicted by a targeted disease, is critical if campaigns are to be successful.

An absence of public support helps to explain why some past efforts have failed and others have progressed slowly. For example, the dramatic success of the polio eradication campaign reduced the disease by 99% within about a decade after the campaign's launch in 1988, but polio cases in Nigeria quadrupled between 2001 and 2003 to account for nearly half the world's total, a resurgence that some believe could have been avoided by more effective engagement with local political, community, and religious leaders.[234] India's polio eradication program also met with distrust and resistance at the local level, particularly in underserved communities, but after program directors instituted intentional engagement with local leaders, community mobilization coordinators, and other stakeholders, resistance to vaccination decreased and polio was ultimately declared eliminated in 2014.[235]

Eradication treaties should leverage rather than replace the expertise and infrastructure of existing private organizations. Following the success of the smallpox campaign and the well-documented failure of the much larger Malaria Eradication Programme, international support for eradication waned, leading to a fragmented global disease eradication infrastructure. In the absence of a strong WHO capable of funding and leading eradication efforts, other organizations emerged to organize, plan, and fund campaigns alongside the WHO. The Carter Center is home to the International Task Force for Disease Eradication (ITFDE), a group founded in 1988 that "reviews progress in the field of disease and the status of diseases selected for control or eradication, and recommends action

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[234] *See generally* Cecilia Chen, *Rebellion Against the Polio Vaccine in Nigeria: Implications for Humanitarian Policy*, 81 AFRICAN HEALTH SCI. 205, 207 (2004) (explaining the need for future polio immunization campaigns to take a more community-based approach); *See generally* Jon K. Andrus & Henry B. Perry, *Community Engagement, Ownership, and Civil Society Organizations in Polio Eradication*, 101 AM. J. TROPICAL MED. & HYGIENE (SUPPL. 4) 1 (2019).

[235] *See generally* Roma Solomon, *Involvement of Civil Society in India's Polio Eradication Program: Lessons Learned*, 101 AM. J. TROPICAL MED. & HYGIENE (SUPPL. 4) 15 (2019). The author of the referenced article witnessed such resistance first-hand, when a child's grandmother "hid [the child] in a chicken coop and threatened to kill him and the team with a large knife if the team stepped inside." *Id*. at 15.

steps."[236] The Bill and Melinda Gates Foundation, founded in 2000 and now with an endowment of $49.8 billion[237] (compared to the WHO's 2018-2019 two-year program budget of approximately $4.4 billion),[238] provides financial support to fund numerous eradication and disease control initiatives.[239] The US currently supports polio eradication efforts through the CDC and the US Agency for International Development, which together provided technical support and $237 million in funding in 2020.[240] These programs are planned and administered by various specialty organizations, such as the Global Polio Eradication Initiative.[241] The decentralized nature of eradication efforts highlights the difficulties involved in building international consensus—a role that the WHO has been unable to fill alone.

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[236] Additionally, the ITFDE houses two current eradication programs, against dracunculiasis and lymphatic filariasis, respectively. *See What is ITFDE?*, CARTER CTR., https://www.cartercenter.org/health/itfde/index.html (last visited July 13, 2020).

[237] *Foundation Fact Sheet*, GATES FOUND., https://www.gatesfoundation.org/Who-We-Are/General-Information/Foundation-Factsheet (last visited Feb. 24, 2021).

[238] WHO BUDGET, *supra* note 211, at 80.

[239] *What We Do*, GATES FOUND., https://www.gatesfoundation.org/What-We-Do (last visited Aug. 20, 2020).

[240] *See The U.S. Government and Global Polio Efforts*, KAISER FAMILY FOUND., (Apr. 28, 2020), https://www.kff.org/global-health-policy/fact-sheet/the-u-s-government-and-global-polio-efforts/.

[241] The Global Polio Eradication Initiative is a public-private partnership with six partners. *See GPEI History Project*, GLOBAL POLIO ERADICATION INITIATIVE, http://polioeradication.org/who-we-are/partners/the-gpei-history-project/ (last visited July 13, 2020); *GPEI Welcomes the Strong Commitment of Partners at Global Vaccine Summit*, GLOBAL POLIO ERADICATION INITIATIVE (Sept. 6, 2020), https://polioeradication.org/news-post/gpei-welcomes-the-strong-commitment-of-partners-at-global-vaccine-summit/. Of these six organizations, half are headquartered in the United States (Rotary International, the Gates Foundation, and the US Centers for Disease Control and Prevention), two are United Nations-affiliated bodies (WHO and UNICEF), and one is an international public-private partnership (Gavi) that has received over $4 billion in funding commitments from the Gates Foundation. Rotary International, an international organization, was founded in the United States and is based in Evanston, Illinois. See *Our History*, ROTARY, https://www.rotary.org/en/about-rotary/history (last visited July 13, 2020); *The Bill and Melinda Gates Foundation*, GAVI, THE VACCINE ALLIANCE, https://www.gavi.org/investing-gavi/funding/donor-profiles/bill-melinda-gates-foundation (last visited July 7, 2020). The United States is by far the largest donor to the WHO, with the Gates Foundation and Gavi constituting the third and fourth largest sources of funding. WORLD HEALTH ORG., WHO RESULTS REPORT: PROGRAMME BUDGET 2018-2019: DRIVING IMPACT IN EVERY COUNTRY 13 fig.6 (2020); *see also Contributors*, WORLD HEALTH ORG., http://open.who.int/2020-21/contributors/contributor (last visited July 7, 2020).

VI. Conclusion

The infectious disease burden is distributed inequitably worldwide. While disease control measures can be effective under optimal circumstances, major disruptions are inevitable in the long term, whether from natural disasters, political conflict, antimicrobial resistance, or economic hardship. Infectious diseases, by their nature, lie in wait until circumstances become ripe for reemergence—a perennial threat that can be finally laid to rest only through eradication. Even in the short term, control measures are resource-intensive, straining the budgets and infrastructure of the low-income countries that bear the highest disease burdens.

Disease eradication is a cost-effective public good that can be achieved only through international cooperation. Yet no organization has the funding or political capital necessary to quickly bring disease eradication programs to completion. The tireless efforts of those within existing eradication programs, as well as those championing the cause of eradication through private nonprofit efforts, deserve stronger political and financial backing from a global community of nations. This can be achieved through the creation of a series of multinational, disease-specific treaties enacted under the auspices of the WHO.

New treaties would enable low-income nations to have a larger voice in the development and implementation of eradication initiatives, helping to avoid the appearance of externally imposed objectives that can engender distrust. Treaties would facilitate increased awareness of a sensible public health objective and, when undertaken in good faith and with broad global support, be an equitable means of permanently lowering infectious disease burdens worldwide.