HOW SMALLPOX BECAME A "SUITABLE CANDIDATE FOR GLOBAL ERADICATION"

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ABSTRACT: This article explains how a shifting ecological consciousness after World War II led to the definition of smallpox as a "suitable candidate for global eradication." Post-war transportation technologies and international institutions created a global environment in which disease eradication, rather than control, became the goal of international health authorities. They first targeted malaria, inspired by the power of dichloro diphenyl trichloroethane (DDT) to rationalize environments. As that power faltered and the hazards of DDT became better known, the public and some health experts questioned the wisdom of efforts to master environments. Smallpox, though, lived only in human bodies and was vulnerable to an effective, modern, and industrialized vaccine. And so efforts to master the nonhuman natural world shifted from malarial environments to smallpox-infected human bodies.

In the spring of 1947, smallpox struck an unprepared New York City. Eugene Le Bar arrived in Manhattan on March 1, six days after boarding a bus in Mexico City, where he worked as an importer. Le Bar was on his way to Maine, but during the course of the bus ride, he developed a headache and unusual rash, and he decided to pause in New York for some rest, sightseeing, and shopping. Four days after arriving, the stricken traveler checked into Bellevue Hospital with a cough and strange rash; the frightened staff quickly transferred him to Willard Parker Hospital, where doctors diagnosed a case of bronchitis with hemorrhages. Le Bar died on March 10 of hemorrhagic smallpox, one of the most gruesome forms of the disease. But lab results did not return a final verdict until April 4, by which time smallpox had infected two other patients. On April 5, readers of the *New York Times* learned of Le Bar's fate in an article urging the city's residents to "receive an inoculation at once." Within a month, the New York Health Department vaccinated 6,350,000 people and tracked the disease to nine more patients, including one who made it all the way to Germany before learning of the infection. Two people died directly from smallpox; three more died of complications from the vaccine.[1]

The New York outbreak suggested the need for radical action in a new global environment, in which technological and institutional changes rendered conventional methods of disease control antiquated and even dangerous. Countries in North America and Europe had previously counted on smallpox remaining isolated in less developed countries, but such a defensive strategy no longer provided sufficient safety when airplane travel would facilitate rapid exchange in goods, people, and

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[1] Israel Weinstein, "An Outbreak of Smallpox in New York City," *American Journal of Public Health and the Nations Health* 37, no. 11 (November 1947): 1376–1384; "Smallpox in city, inoculation urged" *The New York Times*, 5 April 1947, p. 2; "Many vaccinated against smallpox," *The New York Times*, 6 April 1947, p. 27.

pathogens. As the editors of the *New York Times* wrote in the aftermath of the outbreak, "In the twenty-one-day incubation period of smallpox a man can fly twice around the world by commercial plane. The epidemic diseases of Asia are only as distant from New York City as the nearest airway flight schedule."[2] If the people of North America and Europe truly wanted freedom from smallpox, they would have to take proactive measures to find, root out, and destroy the disease in its endemic homes in foreign lands. Fortunately, the post-World War II global environment presented not just new disease threats, but also new opportunities through the World Health Organization (WHO), established the year before the New York smallpox outbreak. Like its parent, the United Nations, the WHO both recognized global interdependency and expressed confidence in the possibilities of international cooperation. The world, then, had a choice: stick with local and national smallpox control, which could barely keep up with deadly outbreaks like the one in New York, or forge a bolder path towards global smallpox eradication, by which humans could assert total mastery over an age-old scourge.

Ultimately, the world chose eradication. In 1977, the WHO's Smallpox Eradication Program (SEP) isolated the last naturally occurring case of smallpox, and the disease has not appeared outside the laboratory since. Participants in and observers of the global eradication program called smallpox a "suitable candidate for global eradication," meaning that the disease possessed certain qualities that made it vulnerable to human mastery.[3] Specifically, smallpox spread through close contact and always displayed symptoms, so health professionals could track and accurately predict the course of a smallpox outbreak. The disease had another critical vulnerability: *vaccinia*, the powerful and effective smallpox vaccine, which inspired dreams of eradication as early as 1806, when Thomas Jefferson wrote that "future nations will know by history only that the loathsome smallpox has existed." Perhaps most importantly, smallpox had no connection to natural environments. The *variola* virus – the cause of smallpox – infected humans only; there was no animal vector or other nonhuman reservoir. Because of this quality, smallpox control and eradication campaigns could ignore complicated environmental factors and instead concentrate on humans, who, again, could be protected with relative ease by an effective vaccine. In this explanation of eradication, by the mid twentieth century, smallpox's nature made it a candidate for extinction.

But smallpox did not become the first target for global eradication. Instead, delegates to the World Health Assembly (WHA, the

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[2] "Small World," *New York Times*, April 12, 1947.

[3] For smallpox's suitability for eradication, see F. Fenner et al., *Smallpox and Its Eradication* (Geneva: World Health Organization, 1988), chapter nine; D. A. Henderson, *Smallpox: The Death of a Disease* (New York: Prometheus Books, 2009), 302–303; Bruce Aylward et al., "When Is a Disease Eradicable? 100 Years of Lessons Learned," *American Journal of Public Health* 90, no. 10 (October 2000): 1515–1520.

representative decision-making body of the World Health Organization) selected malaria for the first global eradication campaign in 1955, while effectively rejecting smallpox eradication in 1953 and again in 1958. This choice suggests that a disease's "suitability" for eradication should not be seen only as a matter of etiology, but of non-biological factors as well, including ideology and politics, which, as other historians have argued, help "construct" particular diseases as threats requiring particular responses.[4] The decision to pass over smallpox in favor of malaria was particularly revealing given the relatively complex disease ecology of malaria, with its inextricable relationships to mosquitoes and environments. Of the two diseases, smallpox was the simpler – or, from one perspective, more suitable – disease to eradicate. But global health experts initially devoted their efforts to a disease eradication program premised on control of the nonhuman natural world, specifically, malarial mosquitoes and their environments. Meanwhile, smallpox – a disease with no connection to the natural environment – continued to maim and kill practically unabated until 1965, when global smallpox eradication began in earnest. Although a few historians have observed the seemingly strange decision to pass over smallpox, most accounts attribute the delay to a host of unrelated causes: the need for better smallpox vaccination technology, changing trends in medical science, or a lack of institutional and professional interest in smallpox.[5] From this perspective, the initiative to eradicate smallpox required the right convergence of contingent factors, but the disease itself was, by its nature, always eradicable.

In contrast, this article argues that smallpox was not always conceptually suitable for eradication, but over time became so as a result of changing relationships, both real and perceived, between human health and environments.[6] This process unfolded both within and outside the

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[4] Scholars of disease and colonialism have been particularly interested in the social construction of disease; see Sheldon J. Watts, *Epidemics and History: Disease, Power, and Imperialism* (New Haven: Yale University Press, 1997); David Arnold, *Colonizing the Body: State Medicine and Epidemic Disease in Nineteenth-Century India* (Berkeley: University of California Press, 1993); Andrew Cunningham and Birdie Andrews, *Western Medicine as Contested Knowledge* (New York: St. Martin's Press, 1997).

[5] Anne-Emanuelle Birn and Nancy Lays Stepan have made this observation; see Anne-Emanuelle Birn, "Erradicacao da variola: medida do sucesso?" *Ciência & Saúde Coletiva*, 2011, 16:591+ and Nancy Lays Stepan, *Eradication: Ridding the World of Diseases Forever?* (Ithaca: Cornell University Press, 2011), especially pages 106, 193-194, 197, and 204-206. For contingent factors, see Henderson, *Death of a Disease,* 63 and Fenner, et al., *Smallpox and its Eradication*, 388-389.

[6] Environmental historians have shown how the health/environment relationship has shaped understandings of and responses to diseases that have clear connections to their nonhuman environments. See Conevery Bolton Valenčius, *The Health of the Country: How American Settlers Understood Themselves and Their Land* (New York: Basic Books, 2004); Gregg Mitman, *Breathing Space: An Ecological History of Allergy in America* (New Haven: Yale University Press, 2007); Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: University of California Press, 2006); Gregg Mitman, Michelle Murphy, and Christopher Sellers, *Landscapes of Exposure: Knowledge and Illness in Modern Environments* (Chicago: University of

realms of medical and scientific expertise, and was shaped by evolving American efforts to engage with—and lead—the rest of the world in the post-World War II period. Post-war health professionals, like their colleagues in physics and engineering, sought to improve human lives by using modern science and technology to master environments. Disease eradication efforts began with malaria, a decision inspired in large part by the synthetic chemical dichloro diphenyl trichloroethane (DDT), which promised control over the environments in which mosquitoes and other pests thrived – better health through chemical mastery of the nonhuman natural world.[7] Smallpox eradication, on the other hand, would require intimate interactions with complicated and diverse people and cultures, and that prospect led global health authorities to twice reject smallpox eradication proposals. Instead, the WHO embarked on a global malaria eradication program that, not incidentally, suited American foreign policy interests in the early Cold War.[8]

But as DDT-driven malaria eradication continued, global health authorities became increasingly concerned with the limits of chemical prophylaxis, just as the public and some health professionals expressed anxiety about the potential hazards of DDT to both humans and their ecosystems. In this broader context of shifting ecological consciousness, smallpox – isolated from environments and vulnerable to a modern, industrialized vaccine – seemed like a much simpler, safer, and surer target for elimination. This shift did not immediately produce a global smallpox eradication program; Cold War antagonisms and a particular approach to U.S. foreign policy delayed a coordinated, earnest effort to eliminate the disease until 1965. But by then, smallpox had already displaced malaria as a conceptually suitable candidate disease for global eradication.

Chicago Press, 2004); Michelle Murphy, *Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, and Women Workers* (Durham: Duke University Press, 2006).

7 For DDT and confidence in the power of science and technology as important factors in malaria eradication efforts, see Randall Packard, *The Making of a Tropical Disease: A Short History of Malaria* (Baltimore: The Johns Hopkins University Press, 2007), chapter six; Amy L. S. Staples, *The Birth of Development: How the World Bank, Food and Agriculture Organization, and World Health Organization Changed the World, 1945-1965* (Kent, Ohio: Kent State University Press, 2006), chapter ten; James Webb, *Humanity's Burden: A Global History of Malaria* (Cambridge: Cambridge University Press, 2009), chapter six; David Kinkela, *DDT and the American Century: Global Health, Environmental Politics, and the Pesticide That Changed the World* (Chapel Hill: University of North Carolina Press, 2011).

8 Socrates Litsios, "Malaria Control, the Cold War, and the Postwar Reorganization of International Assistance," *Medical Anthropology* 17, no. 3 (May 1997): 255–278; Marcos Cueto, *Cold War, Deadly Fevers: Malaria Eradication in Mexico, 1955-1975* (Washington, D.C.: Woodrow Wilson Center Press, 2007); Randall Packard, "Visions of Postwar Health and Development and Their Impact on Public Health Interventions in the Developing World," in *International Development and the Social Sciences: Essays on the History and Politics of Knowledge* (Berkeley: University of California Press, 1997), 93–118; Staples, *The Birth of Development*, 166–167 and 170–171.

From Quarantine to Eradication

In the interwar period, smallpox continued to take lives, steal sight, and scar faces throughout much of the world. From 1919 to 1938, health authorities worldwide reported nearly five and a half million cases of smallpox and over one and a half million deaths from the disease.[9] Smallpox experts later concluded that these estimates reflected no more than 1-2% of cases, meaning that the disease struck perhaps more than 350 million people during the interwar period.[10] Most of that pain and suffering occurred in Africa, Asia, and Latin America, which accounted for all but two of the world's endemic smallpox countries in 1939. In Europe and North America, smallpox had become a foreign disease, rather than an endemic danger. Soon after Edward Jenner's discovery in 1796 that cowpox protected against smallpox (thus "vaccine," from *vaca* for cow), vaccination spread throughout the Atlantic world and beyond.[11] By 1936, endemic smallpox had disappeared from Europe (except for Spain and Portugal, where relatively poor health infrastructures delayed eradication until 1948 and 1953, respectively); in the United States and Canada, smallpox carried on only in the much less dangerous form of *variola minor*, with a case-fatality rate of 0.3% in 1938.[12] In that year, smallpox accounted for just 412 deaths in Europe and North America, compared to 47,922 deaths reported in the rest of the world. Empowered by centralized states and expanding health infrastructures, medical authorities effectively eliminated smallpox from the disease environments of Europe and North America.

In addition to national vaccination and relatively well-funded public health systems, rigid defensive procedures increasingly isolated smallpox in tropical and subtropical environments. Local and national governments had long taken it upon themselves to identify, isolate, and

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[9] For smallpox morbidity (cases), see Fenner et al., *Smallpox and Its Eradication*, chapter eight; and League of Nations Health Organization, *Annual Epidemiological Report*, 1922, 21–27; for smallpox mortality (deaths), see Cyril William Dixon, *Smallpox* (Churchill, 1962), appendix two.

[10] Fenner et al., *Smallpox and Its Eradication*, 173–175; William Schneider argues that colonial health records in Africa were not as inaccurate as claimed by Fenner, et al.; see William H Schneider, "Smallpox in Africa during Colonial Rule," *Medical History* 53, no. 2 (April 2009): 193–227.

[11] For overviews of the history of vaccination, see Donald Hopkins, *Princes and Peasants: Smallpox in History* (Chicago: The University of Chicago Press, 1983) and the 2009 special issue of the *Bulletin of the History of Medicine*, with introduction by Sanjoy Bhattacharya and Niels Brimnes, "Simultaneously Global and Local: Reassessing Smallpox Vaccination and Its Spread, 1789–1900," *Bulletin of the History of Medicine* 83, no. 1 (2009): 1–16.

[12] Fenner et al., *Smallpox and Its Eradication*, p. 328–332.

expel potential cases of smallpox.[13] Such national defensive efforts began to expand across borders in the mid-nineteenth century. In Europe, health professionals held the first International Sanitary Conference in 1851; the United States participated in the 1881 conference and was a founding member of the first international public health office, the Office International d'Hygiène Publique (OIHP) in 1907.[14] The US also helped form the first regional health bureau, the International Sanitary Bureau (later the Pan-American Sanitary Bureau, or PASB) in 1902.[15] These international organizations helped disseminate knowledge about communicable diseases like smallpox, transmitted warnings of epidemics, and recommended standards for vaccination and quarantine procedures.

The need for such coordination increased as European countries and the United States engaged in colonial adventures, further integrating disease environments and facilitating the exchange of both viruses and vaccines. Colonial health authorities made smallpox vaccination one of their first disease control priorities, for reasons ranging from genuine interest in the health of native populations to expanding the power of the imperial state.[16] But those colonial efforts failed to eliminate smallpox, for a variety of reasons: it was logistically difficult (tracking down and vaccinating widely dispersed and often mobile populations), technically challenging (heat-sensitive liquid smallpox vaccine perished in tropical environments), politically troublesome (native populations sometimes co-opted or outright resisted colonial vaccination programs), and perhaps even contrary to the long-term reformist (rather than short-term

[13] Peter Baldwin, *Contagion and the State in Europe, 1830-1930* (New York: Cambridge University Press, 1999), 246–249, 319–325, 338–342.; Elizabeth Fenn, *Pox Americana: The Great Smallpox Epidemic of 1775-82* (New York: Hill and Wang, 2002), 30–31; Michael Willrich, *Pox: An American History* (New York: Penguin Press, 2011), 38, 80–81, 218–221.

[14] For international health history, see Staples, *The Birth of Development*, chapter eight; Kelley Lee, *The World Health Organization* (London: Routledge, 2009), 1–9; World Health Organization, *The First Ten Years of the World Health Organization* (Geneva: World Health Organization, 1958), chapters one and two.

[15] On US involvement in international health, see Karen A. Mingst, "The United States and the World Health Organization," in *The United States and Multilateral Institutions: Patterns of Changing Instrumentality and Influence*, ed. Margaret P. Karns and Karen A. Mingst (New York: Routledge, 1992).

[16] For colonial smallpox vaccination, see Sanjoy Bhattacharya, Mark Harrison, and Michael Worboys, *Fractured States: Smallpox, Public Health and Vaccination Policy in British India, 1800-1947* (Hyderbad: Orient Longman, 2005) and William H. Schneider, "Smallpox in Africa During Colonial Rule"; for the diverse motivations and effects of colonial medicine more generally, see Emmanuel Kwaku Akyeampong, "Disease in West African History," in *Themes in West Africa's History*, ed. Emmanuel Kwaku Akyeampong, (Athens: Ohio University Press, 2006), 186–207; John Farley, *Bilharzia: A History of Imperial Tropical Medicine*, Cambridge History of Medicine (Cambridge: Cambridge University Press, 1991); Warwick Anderson, *Colonial Pathologies : American Tropical Medicine, Race, and Hygiene in the Philippines* (Durham: Duke University Press, 2006); David Arnold, *Colonizing the Body*; Andrew Cunningham and Birdie Andrews, *Western Medicine as Contested Knowledge*; Sheldon J. Watts, *Epidemics and History*.

interventionist) impulses of the imperial state.[17] And so, by the beginning of World War II, European and North American health professionals had created a world in which smallpox was an endemic menace of certain tropical and subtropical areas.[18]

World War II then initiated a shift in the global disease environment and undermined the viability of smallpox control. *Variola* posed a much smaller wartime threat than diseases like malaria and typhus, since smallpox no longer existed in the European theater and because soldiers received an effective vaccine.[19] But increased contact with smallpox-endemic areas of Africa and Asia increased the threat of smallpox importation into North America and Europe.[20] For instance, smallpox imported from northern Africa in 1944 led to a three-year outbreak in Italy that produced in excess of 6,000 cases.[21] The end of the war would bring more, not less, exchange of people, goods, and plagues. Wartime developments in transportation technology – from automobiles to steamships to air travel – promised to increase and quicken peacetime trade and travel. A case of smallpox could incubate as long as two weeks before revealing its telltale spots – plenty of time to travel thousands of miles from a smallpox-endemic country in the tropics or subtropics to a smallpox-free country in North America or Europe. Between January and July of 1946, for example, fifteen passengers infected with smallpox from India and the Middle East disembarked in England; thirteen by boat and two by plane.[22] In that year alone, a total of 2,178 cases of smallpox slipped past quarantine lines in Europe and North America.[23] As the barriers between different disease environments fell before new technologies, a more integrated global disease environment emerged, one in which the health problems of one country threatened to become the health problems of all.

Recognizing the dangers presented by a global environment transformed anew by artifice, delegates to the United Nations Conference on International Organization – the meeting that would create the United

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[17] Schneider, "Smallpox in Africa during Colonial Rule," 206; Sanjoy Bhattacharya, Mark Harrison, and Michael Worboys, *Fractured States: Smallpox, Public Health and Vaccination Policy in British India, 1800-1947* (Hyderbad: Orient Longman, 2005); Arnold, *Colonizing the Body*; Warwick Anderson, "Immunization and Hygiene in the Colonial Philippines," *Journal of the History of Medicine and Allied Sciences* 62, no. 1 (January 1, 2007): 1–20, doi:10.1093/jhmas/jrl014.

[18] For historical rates of smallpox infections, see Fenner et al., *Smallpox and Its Eradication*, chapter 8.

[19] For disease in World War II, see J.E. Gordon, "The Strategic and Tactical Influence of Disease in World War II," *The American Journal of the Medical Sciences*, 1948, 215:311-326.

[20] J. Fabre, "Smallpox Prevalence Throughout the World During and After the Second World War," *Epidemiological and Vital Statistics Report*, 1948, p. 268–289; Fenner et al., *Smallpox and Its Eradication*, p. 348, 351.

[21] Fabre, "Smallpox Prevalence," 288.

[22] Fabre, "Smallpox Prevalence," 287.

[23] Fabre, "Smallpox Prevalence," 287.

Nations – called for an International Health Conference, which met in New York in 1946.[24] Health professionals from around the world gathered at the Henry Hudson Hotel to discuss a new vision: a truly global organization that would supersede all previous international health arrangements.[25] The conference welcomed not only delegates from the member states of the United Nations, but also representatives from thirteen non-member states, ten international organizations interested in public health, and the Allied Control Authorities for Germany, Japan, and Korea. Such a gathering of so many health officials from every corner of the world signified deep concern about new threats in the global disease environment. It also expanded the reach of international health institutions – heretofore largely the domain of North American and European health officials – and reinforced a growing awareness of an inseparably interconnected world; no nation, organization, or individual should be excluded from the reach of the new global organization, just as none could escape the global disease environment. In his message of welcome, President Harry Truman reminded the delegates that, "modern transportation has made it impossible for a nation to protect itself against the introduction of disease by quarantine."[26] While each country had its own public health responsibilities, that work "must be co-ordinated through international action." A new world needed a new, global approach to old plagues.

Responding to Truman's call, delegates laid out an ambitious agenda for the new World Health Organization. In this world of rapid trans-Atlantic travel and enthusiasm for international cooperation, health care professionals and government bureaucrats adopted a loftier goal than ever before: the eradication, not just control, of disease. The health professionals at the conference in 1946 could not entirely avoid the tensions of the early Cold War and decolonization era, bickering over everything from the voting status of colonial territories to the definition of health (eventually defined "positively and broadly," as "a state of complete physical, mental and social well-being").[27] At the time, with the complexities of human culture, society, and politics outside their control, these health professionals decided that they would focus their energies on attacking disease. As the American delegation argued, "the fight against disease should outweigh any political considerations."[28] And that fight should become a total war.

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[24] Health cooperation was not originally part of the San Francisco agenda, but was added by delegates from Brazil and China; see Lee, *The World Health Organization*, 13.

[25] For the global vision and ambition of the health conference and the subsequent development of the WHO, see Staples, *The Birth of Development*, 132–136 and chapter nine.

[26] WHO Interim Commission, *Official Records of the World Health Organization, No. 2: Proceedings and Final Acts of the International Health Conference* (Geneva: World Health Organization, 1946), p. 31.

[27] WHO Interim Commission, *Official Records, No. 2*, p. 16, 18-19.

[28] WHO Interim Commission, *Official Records, No. 2*, p. 18.

Article (g) [2(g)] of the WHO's constitution stated that the organization would "stimulate and advance work to eradicate epidemic, endemic and other diseases." This represented a significant change in the international health regime. The concept of eradication wasn't particularly new; humans had long dreamed of complete elimination of their disease enemies. There had even been efforts to do so, including, most famously, the Rockefeller Foundation's eradication programs against hookworm in the American South (started in 1909; later extended to 52 other countries), yellow fever in the Americas (started in 1918), and two disease-carrying species of mosquitoes, *Anopheles aegypti* and *Anopheles gambiae*, in Brazil (1934 and 1939, respectively), led by the "arch-eradicationist" Dr. Fred L. Soper.[29] All of these programs succeeded in reducing suffering and death from disease; none eliminated their targets throughout the entire world. In fact, although eradication advocates like Soper hoped that these national and regional eradication programs would spread to other places in the world, none of these efforts advanced a coherent, integrated, global approach to disease. These were, at most, international, not global, eradication programs.[30] In contrast, the delegates who designed the World Health Organization created a truly global institution, unshackled (in concept, at least) by the parochialisms and politics of national boundaries. The founders of the WHO saw it as a new kind of global body for a new global era, advocating a new global vision. Instead of maintaining the status quo of national vaccination and international quarantine, the world would embark on a cooperative program of total and complete mastery over all diseases.[31]

Smallpox's Suitability for Eradication

Before such a program could begin, scientists needed to know and better define smallpox's eradicable qualities. In April 1948, the WHO convened an expert study group, which concluded that scientific medicine had established important facts about smallpox: its method of transmission, its

[29] The title "arch-eradicationist" is from Stepan, *Eradication*; for more on Soper, see "The Fred L. Soper Papers: Biographical Information," *Profiles in Science, National Library of Medicine*, accessed February 4, 2014, http://profiles.nlm.nih.gov/ps/retrieve/Narrative/VV/p-nid/76; and Fred Lowe Soper, *Ventures in World Health: The Memoirs of Fred Lowe Soper*, ed. John Duffy (Washington, D.C.: Pan American Health Organization, 1977); for brief survey of other eradication programs, see Fenner et al., *Smallpox and Its Eradication*, 373–379.
[30] Theodore M. Brown, Marcos Cueto, and Elizabeth Fee, "The World Health Organization and the Transition From 'International' to 'Global' Public Health," *American Journal of Public Health* 96, no. 1 (January 2006): 62–72, doi:10.2105/AJPH.2004.050831; David P. Fidler, "From International Sanitary Conventions to Global Health Security: The New International Health Regulations," *Chinese Journal of International Law* 4, no. 2 (November 1, 2005): 325–392, doi:10.1093/chinesejil/jmi029.
[31] WHO Interim Commission, *Official Records, No. 2,* 18, 49.

incubation period, and the efficacy of the vaccine.[32] The group expressed particular enthusiasm about laboratory work that promised to isolate the virus from its environments. Scientists had recently used the electron microscope to accurately diagnose smallpox from tissue taken from a victim of the New York outbreak, the first such use of the device for any virus. This level of precision would help prevent misdiagnosis of clinically similar diseases, such as chickenpox or syphilis, which would threaten any comprehensive smallpox control efforts.[33] Other research sought to further isolate the virus from complicating factors. In smallpox-endemic environments, local people had long known that smallpox took more victims during cool, dry weather than during hot, wet monsoons. Bengals, for instance, called smallpox "gutt bashunto," the spring rash.[34] In 1948, Sir Leonard Rogers, doctor and professor at Calcutta Medical College, built on this local knowledge to create a predictive model of smallpox's behavior: "increased prevalence [of smallpox] in any year may usually be foreseen by watching the meteorological records in time to control the expected increase to some extent by increased use of vaccination."[35] Combining forecasts for smallpox transmission in the field with control of the virus in the laboratory, scientists drew closer to the level of mastery necessary for disease eradication.

Smallpox experts also developed a modern, industrial weapon that would overwhelm the disease. Since the mid nineteenth century, vaccinators had procured their material by cultivating and harvesting the vaccine on live animals of different types (such as cows, sheep, and water buffalo) and processed in different ways.[36] For instance, some producers killed and exsanguinated the animal before scraping off the vaccine pulp, while others only used anesthetic. As D. A. Henderson, the head of the WHO smallpox eradication campaign, later wrote to a colleague, vaccine production was "as much of an art form as it was a science."[37] This particular "art form" left modern medicine dependent on the variables of local animals, cultures, and environments, producing an irregular vaccine – an unacceptable situation in the drive to more perfectly know and master smallpox. The barnyard had to become sanitary, modern, and industrial. The Michigan Department of Health set the standard at its facility in Lansing, where every aspect of the vaccine production process

[32] WHO Interim Commission, *Official Records of the World Health Organization, No. 11: Reports of Expert Committees and Other Advisory Bodies to the Interim Commission* (Geneva: World Health Organization, 1948), p. 18–20.
[33] For example of problems of misdiagnosis, see C. Simpson Smith, "Smallpox in Staffordshire, 1947," *British Medical Journal,* 1948, 1:139–142.
[34] Fenner et al., *Smallpox and Its Eradication*, 179.
[35] Leonard Rogers, "Further Work on Forecasting Smallpox Epidemics in India and British Tropical Countries Based on Previous Climatic Data," *The Journal of Hygiene*, 1948, 46:19-33, on p. 33.
[36] Fenner et al., *Smallpox and Its Eradication*, p. 277–294.
[37] D. A. Henderson to Frank Fenner, 5 January 1983, "Correspondence with D.A. Henderson and F. Fenner, 'Smallpox and its Eradication,' 1981-1983," Box 667, ID 1242, Archives of the Smallpox Eradication Program, World Health Organization, Geneva.

proceeded under strict guidelines, from the precise mixture of feed for the cows ("1 1/2 quarts of rolled oats and 1/2 of a pitchfork full of good-quality alfalfa hay") to the process of "sacrific[ing] the calf" on the seventh day of virus growth.[38] Although smallpox experts looked forward to developments that would bring vaccine production entirely within the confines of the lab, for now, the thorough and rigid procedures exemplified in Lansing would help standardize the quality and potency of the vaccine.

Advances in freeze-dried preservation further modernized the smallpox vaccine and rationalized the disease's relationship to people and their environments. Even the purest and most potent smallpox vaccine lost its power in tropical and subtropical environments; without refrigeration, liquid vaccine quickly became useless. Building on French colonial innovations, American scientists refined a process for freeze-drying vaccine in 1938, publishing what would become the standard guide for the process of "lyophilisation," the appropriately modern moniker they gave to this laboratory procedure.[39] Technological developments during World War II enabled further industrialization of "lyophilised" vaccine. In 1948, an English graduate student, Leslie Collier, used a large centrifugal dryer developed by British scientists during the war to produce heat-stable vaccine that retained its potency up to four years, a dramatic improvement over the month-long stability then standard.[40] This new freeze-drying process was quickly scaled up to industrial production using the latest marvels of modern technology. For instance, the centrifugal freeze-driers produced by the Edwards High Vacuum company of Sussex, England consisted of two machines: one that spun the vaccine under vacuum to eliminate 95% of the liquid, and a secondary drier that used both vacuum and chemicals to eliminate the remaining 5%.[41] Equipped with such advanced devices, a laboratory could produce thousands, even millions, of doses of potent, pure, and stable vaccine – a powerful weapon for a global offensive against smallpox.

Choosing a Candidate for Eradication

With these developments in scientific knowledge of the disease and the modern vaccine, smallpox became increasingly attractive as a suitable candidate for the ambitions of global health authorities. In October of 1950, the Pan American Sanitary Conference, the governing body of the

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[38] "Production Method of Smallpox Vaccine at the Michigan State Laboratories, Lansing, USA," October 25, 1955, WHO/Smallpox/4, World Health Organization Library, Geneva (hereafter cited as WHO Library).
[39] R. & J. Fasquelle, "Desiccation of Vaccinia Virus and Smallpox Vaccination," November 8, 1950, WHO/BS/105, WHO Library.
[40] Fenner et al., *Smallpox and Its Eradication*, p. 286–288.
[41] "Methodology of Freeze-Dried Smallpox Vaccine Production," July 22, 1968, SE/68.3, WHO Library.

Pan American Sanitary Bureau, passed a resolution calling for a hemisphere-wide smallpox eradication campaign.[42] The initiative inspired hopes for global, not just regional, eradication, and in 1953, WHO Director-General Brock Chisholm proposed the first-ever global campaign against smallpox.[43] Chisholm believed that the time had come for the WHO to commence "world-wide campaigns" that would "demonstrate [the WHO's] essential place in the interest of *all* countries," transforming the organization into a real force for good in global health.[44] The Director-General nominated smallpox for this demonstration, arguing that the disease represented a "suitable candidate for action." Chisholm noted its universal nature ("people of all races and ages may contract the disease"), the virus's vulnerability to the vaccine ("it can be prevented by simple and effective methods"), and the threat that smallpox importation posed to the developed world. Chisholm called on the WHO to seize the opportunity presented by smallpox and show what the organization could do within the global disease environment.

Few of Chisholm's colleagues shared his certainty that smallpox was a "suitable candidate." During discussions of Chisholm's plan by the World Health Assembly's Committee on Programme and Budget, only three delegations voiced support: Uruguay, France, and Panama. But India, Indonesia, the Netherlands, the United Kingdom, Venezuela, Finland, Spain, Belgium, the USA, El Salvador, and South Africa all rejected Chisholm's plan. Of course, no one opposed the idea of smallpox eradication. As Colonel Whayne, the US delegate, explained, his resistance should not "in any way be interpreted as minimizing the importance of the disease and the necessity of combating it by every possible means." But a comprehensive, world-wide campaign was not one of those means—smallpox was simply too difficult and complicated. Dr. Mackenzie, representing the United Kingdom, cited "practical difficulties such as the lack of public education, general apathy and the physical and economic difficulties connected with vaccination." More to the point: "Such a campaign might prove uneconomical." Dr. Pandit, the Indian delegate, objected to the proposal on the grounds of national autonomy, insisting that "the problem of smallpox would have to be tackled first of all on a regional basis, since it involved public-health services, laboratories for production of vaccines, and machinery to ensure vaccination."[45] In short, as Dr. Mackenzie explained, "The problem was a vast and complicated

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42 Pan American Sanitary Organization, "XIII Pan American Sanitary Conference Resolutions," October 1950, http://www.paho.org/english/gov/csp/ftcsp_13.htm#R19.
43 World Health Organization Interim Commission, *Official Records of the World Health Organization, No. 48: Proposals for World-Wide Campaigns: Smallpox* (Geneva, 1953).
44 Executive Board, "Further Action on General World Health Problems" (World Health Organization, January 12, 1953), EB11/63, WHO Library.
45 Sanjoy Bhattacharya has deftly explored the complexities of post-independence efforts to rid the subcontinent of smallpox; see Sanjoy Bhattacharya, *Expunging Variola: The Control and Eradication of Smallpox in India, 1947-1977* (New Delhi: Orient Longman, 2006).

one." Rather than calling for a global smallpox eradication campaign, the committee passed a resolution calling for more study of the problem.[46] It hardly mattered. Brock Chisholm soon left the WHO, and the World Health Assembly elected a new Director-General, Marcelino Candau, who would lead the organization into its first global eradication campaign – but not against smallpox.

Instead, global health experts targeted malaria, embracing the promises of new human efforts to master the environment. The process began in the early years of the WHO. In April of 1947, a WHO Expert Committee on Malaria heralded scientific and medical advances that introduced what the Committee called a "new era" in malaria control.[47] Specifically, wartime science had revealed the amazing power of dichloro diphenyl trichloroethane (DDT), a long-lasting synthetic pesticide that killed insects by destroying their nervous systems, as demonstrated by US military programs in Algiers, Naples, and the South Pacific. The miraculous power of the new chemical suggested that malaria eradication – which the Committee noted had been "impossible, in fact unthinkable, in pre-war days" – had become possible.[48] The chemical gave a boost to eradication advocates like Fred Soper, who saw in DDT a powerful weapon for his on-going war against malaria.[49] DDT-inspired and -driven malaria eradication programs were quickly underway. The US's Communicable Disease Center (CDC) and the Pan American Sanitary Bureau initiated anti-malaria programs in 1947.[50] The CDC declared total victory over malaria in the United States in 1953, and PASB redoubled its efforts in 1954, setting a goal of eradication by 1955.[51] That same year, at the World Health Assembly in Mexico City, Marcelino Candau shepherded a plan for global malaria eradication through the gauntlets of committee work and budget evaluations.[52] On May 26, 1955, the World Health Assembly passed resolution WHA8.30, which initiated the worldwide eradication campaign

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[46] World Health Organization, Resolution WHA6.18, *Handbook of Resolutions and Decisions of the World Health Assembly and the Executive Board, Volume I, 1948-1972* (Geneva: World Health Organization, 1973).

[47] WHO Interim Commission, *Official Records of the World Health Organization, No. 8*, p. 8–16; "Expert Committee on Malaria, Report on the First Session," June 30, 1947, WHO.IC/Mal./4, WHO Library.

[48] "Expert Committee on Malaria," p. 3.

[49] For Soper, DDT, and malaria eradication, see Stepan, *Eradication*, 110–112 and Socrates Litsios, "Rene J. Dubos and Fred L. Soper: Their Contrasting Views on Vector and Disease Eradication," *Perspectives in Biology and Medicine*, 1997.

[50] Elizabeth W. Etheridge, *Sentinel for Health: A History of the Centers for Disease Control* (Berkeley: University of California Press, 1992), 11–22; Pan American Sanitary Organization, "Eradication of Malaria in the Americas," October 8, 1954, Pan American Health Organization (PAHO) Library, http://hist.library.paho.org/English/GOV/CSP/14_36.pdf.

[51] Margaret Humphreys, "Kicking a Dying Dog: DDT and the Demise of Malaria in the American South, 1942-1950" *Isis*, 1996, 87:1–17. Pan American Health Organization, Resolution CSP14.R42, "XIV Pan American Sanitary Conference Resolutions," October 1954, PAHO Library, http://www.paho.org/english/gov/csp/ftcsp_14.htm.

[52] Cueto, *Cold War, Deadly Fevers*, 35.

against malaria.[53] In short, international health experts, who rejected smallpox eradication two years earlier citing the "difficulties" of such a "complicated problem," enthusiastically embraced a program against malaria – a disease that, by nature of its transmission through mosquitoes and their habitat, was inextricably connected to complicated environments.

And they would reject smallpox eradication again just three years later. At the 1958 World Health Assembly, held in Minneapolis, Soviet delegate and minister of health Dr. Viktor Zhdanov called for a global campaign against smallpox.[54] Zhdanov began by quoting Thomas Jefferson's 1806 prediction that "future nations will know by history only that the loathsome smallpox has existed" – a thinly veiled jab at the failure of the United States to fulfill the prophecy of one of its Founders. After noting that the Soviet Union had eradicated endemic smallpox within its enormous borders twenty years previously, Zhdanov made a scientific argument for the candidacy of smallpox, noting advances in the "modern status of medical science and health protection," especially the "high grade smallpox vaccine" produced by the Soviet industrial machine. With an effective vaccine, scientific knowledge of the virus, and historically-proven vaccination programs like the Soviet Union's, "there can be no doubt," argued Zhdanov, that "smallpox, which has been a scourge of mankind for centuries, will be practically eradicated within five years."

Again, WHA members greeted a proposal for global smallpox eradication with skepticism. The Belgian delegation wondered if the Soviet timeline "might be too optimistic"; Australia and South Africa also expressed doubts.[55] Rather than initiating such a program, the delegates gave tepid support to the desirability of smallpox eradication and asked for further study and a new report.[56] The next year, the WHA discussed the study, which estimated that eradication would cost nearly $98 million; the delegates unanimously passed another resolution that recognized the "urgency of achieving world-wide eradication," while completely ignoring the WHO budget, which allocated only $55,568 for smallpox control.[57] Meanwhile, the malaria eradication program consumed ever more resources: total WHO expenditures on the initiative increased from $2.4 million in 1955 to more than $13 million in 1958.[58]

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[53] World Health Organization, Resolution WHA8.30, *Handbook of Resolutions and Decisions of the World Health Assembly and the Executive Board, Volume I, 1948-1972*.

[54] "Eradication of Smallpox (Draft Resolution Proposed by the Government of the USSR)," March 6, 1958, page 4, A11/P&B/1, WHO Library.

[55] "Committee on Programme and Budget, Provisional Minutes of the Fifteenth Meeting, Eleventh World Health Assembly" June 11, 1958, page 23, A12/P&B/Min/15, WHO Library.

[56] Fenner et al., *Smallpox and Its Eradication*, p. 369–371.

[57] World Health Organization, Resolution WHA12.54, *Handbook of Resolutions and Decisions of the World Health Assembly and the Executive Board, Volume I, 1948-1972*; Fenner, et al., *Smallpox and its* Eradication, Table 9.1, 369-370.

[58] Fenner, et al., *Smallpox and its Eradication*, Table 9.2, p. 383.

Of course, the World Health Organization had very good reasons to attack malaria; namely, the disease affected millions of people throughout the world every year. In the *First Report on the World Health Situation, 1954-1956*, the WHO estimated 150 million cases of malaria per year, with 1.5 million deaths.[59] Relative to smallpox, which health authorities blamed for 39,899 deaths in 1955, malaria was a much more dangerous killer, at least from a statistical point of view.[60] Additionally, health experts worried that DDT might not always retain its power against mosquitos, adding urgency to a malaria eradication scheme that depended on the chemical.[61] But this perspective diminished the World Health Organization, at least to some international health experts who argued that the WHO ought to eradicate both diseases. As the Ecuadorian delegate to the WHO's Committee on Programme and Budget said in support of the Soviet proposal in 1958, "the eradication of smallpox was just as important as the eradication of malaria."[62] Why shouldn't the WHO fulfill its constitutional promise to eradicate smallpox with the same vigor as it applied to malaria? Why didn't more WHA delegates agree with their Peruvian colleague, who said that smallpox eradication "deserved the same full support from WHO as was accorded to the malaria eradication programme"? Why didn't smallpox eradication receive the same support as malaria eradication? Why, to be more precise, did the WHA twice reject a world-wide campaign against smallpox, a disease that only infects humans and for which the world has long possessed a simple vaccine, while malaria, with its much more complicated disease ecology, became the first target for a global eradication campaign?

Compared to malaria, smallpox was not "suitable" for eradication for two reasons that had very little to do with the diseases themselves. First, political and institutional contingencies in the early 1950s had empowered advocates of malaria eradication. The United States possessed remarkable influence in the WHO between 1949 and 1957, when the Soviet Union (and the rest of the Eastern Bloc) abandoned the organization, citing its bloated bureaucracy and failure to invest sufficiently in social health programs.[63] Acting as the sole superpower in the WHO, the United States threw its support behind global malaria eradication, beginning with

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[59] World Health Organization, *Official Records of the World Health Organization: First Report on the World Health Situation, 1954-1956* (Geneva: World Health Organization, 1959), 20, http://apps.who.int/iris/handle/10665/85718.
[60] Dixon, *Smallpox*, appendix III.
[61] World Health Organization, *Expert Committee on Malaria, Athens, 20-28 June 1956: Sixth Report* (Geneva: World Health Organization, 1956); Packard, *The Making of a Tropical Disease*, 154–155; Webb, *Humanity's Burden*, 166–167.
[62] "Committee on Programme and Budget, Provisional Minutes of the Fifteenth Meeting," June 11, 1958, A12/P&B/Min/15, WHO Library.
[63] Christopher Osakwe, *The Participation of the Soviet Union in Universal International Organizations: A Political and Legal Analysis of Soviet Strategies and Aspirations inside ILO, UNESCO and WHO* (Leiden, The Netherlands: Sijthoff, 1972); Javed Siddiqi, *World Health and World Politics: The World Health Organization and the UN System* (Columbia, SC: University of South Carolina Press, 1995).

its advocacy of Candau's 1955 proposal, which the US advanced over the objections of some important allies, including the UK and France. As other historians have explained, the United States supported the malaria program partially because its potential foreign policy gains could be won without direct, potentially redistributionist (that is, socialist or communist) anti-poverty efforts.[64] Congress made DDT-driven malaria eradication part of the nation's Cold War soft-power campaigns when it amended the Mutual Security Act in 1957 to "declare it the policy of the United States...to assist other peoples in their efforts to eradicate malaria." [65] And in his State of the Union address the next year, President Eisenhower lauded the global malaria eradication campaign and challenged the Soviet Union "to join with us in this great work of humanity."[66] Instead, the USSR called for its new program against smallpox, offering a competitor for the budget and attention allocated to the WHO's malaria eradication program, thereby potentially threatening American foreign policy interests.[67]

More fundamentally, smallpox eradication posed an essentially different challenge than malaria eradication: rather than simplified environments, a smallpox campaign would confront diverse peoples and cultures – the "difficulties" to which Chisholm's opponents alluded in 1953. Such differences represented a level of complexity, or even backwardness, that might undermine any effort to eliminate smallpox. In an influential study published in 1948, Dr. C.W. Dixon (who would literally write the textbook on smallpox in 1962) blamed a recent outbreak in Tripolitania (now part of Libya) on Arab cultural practices: concealment of cases during Ramadan, the reluctance of women to visit vaccination centers, and the "Arab experience of insect pests," which allegedly made

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[64] See Marcos Cueto, *Cold War, Deadly Fevers;* Harry Cleaver, "Malaria and the Political Economy of Public Health," *International Journal of Health Services*, 1977, 7:557-579; Staples, *The Birth of Development,* 170-171; and the "Malaria and Development" special issue of *Medical Anthropology* from May 1997, edited by Randall Packard.

[65] "Disease Eradication," January 1966, 4–5, Folder "Diseases - Disease Eradication," Committees-Diseases, Correspondence 1949-1969, Box 40, Office of International Health, Records of the Public Health Service, Record Group 90, National Archives, College Park, MD (hereafter cited as RG 90, NA).

[66] Dwight D. Eisenhower, "Annual Message to the Congress on the State of the Union," January 9, 1958, *The American Presidency Project*, http://www.presidency.ucsb.edu/ws/index.php?pid=11162.

[67] For Eisenhower and Congress's anxiety about the Soviet foreign aid and how that anxiety shaped American foreign aid policy in the 1950s, see Burton Ira Kaufman, *Trade and Aid: Eisenhower's Foreign Economic Policy, 1953-1961* (Baltimore: Johns Hopkins University Press, 1982); for an example, see "Memorandum of Meeting re: Establishment of an Interdepartmental Committee on International Health Policy and World Health Organization Fund for Conquest of Disease," March 13, 1959, RG 59, General Records of the Department of State, Records Pertaining to the World Health Organization and the Committee on International Health Policy, 1945-1962, Box 4, Folder: "Health--Interdepartmental Committee on International Health Policy--Memoranda (Miscellaneous)," NARA.

them more tolerant of the presence of potentially-infectious flies.[68] Health authorities also warned that, left to their own devices, the people of the tropics and subtropics would destroy the modern defense against smallpox. A WHO survey of smallpox in 1948 quoted a 1940 report by Dr. Van Hoof, Medical Superintendent of Belgian Congo, who attributed the continued prevalence of smallpox in part to "natives [who] try to neutralize the vaccine by exposing scarifications to the sun, by treating them with acid fruit juices or by mechanical means, and often succeed if they are not closely watched."[69] Although the study did not address the reasons for these practices, it seemed clear that the people of the "black continent" (as the WHO study referred to Africa) simply did not understand smallpox or its vaccine.[70] The lesson, like Dixon's conclusions, seemed clear: the people of smallpox endemic environments would frustrate any eradication efforts. These were the "complexities" and "difficulties" to which opponents of smallpox eradication in 1953 and 1958 referred.

Smallpox, then, was not yet a "suitable candidate for global eradication," in part because that category was defined by the capacity to rationalize environments, rather than people. DDT-driven malaria eradication simultaneously expressed and reinforced a worldview that put faith in the ability of science to eliminate the "complicated" and "difficult" elements of the nonhuman natural world. In an era when technology promised absolute control over the atom, synthetic chemicals promised absolute control over environments and the diseases in them. A human-produced chemical, concocted in a laboratory, promised to reduce malaria's disease ecology – a complex relationship between humans, insects, environments, and the parasite – into a simple matter of chemical application.[71] Smallpox eradication, on the other hand, would demand that physicians and healthcare technocrats assert control of human nature and culture. Whereas malaria eradication pitted global health professionals against mosquitoes and the environments in which they lived, smallpox eradication would require intimate interactions with millions of individuals in the developing world – a backwards world, to many health professionals, where neither patients nor local healers could be trusted to

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68 C. W. Dixon, "Smallpox in Tripolitania, 1946: An Epidemiological and Clinical Study of 500 Cases, Including Trials of Penicillin Treatment," *The Journal of Hygiene*, 1948, 46:351–377.

69 "World Prevalence of Smallpox During and After the Second World War," p. 280.

70 Such direct references to race ("the dark continent") were increasingly rare among smallpox experts; instead, concerns about the non-white other were usually much more oblique, focusing primarily on cultural differences. For racialized discourses about disease, see Anderson, *Colonial Pathologies*, especially chapter eight, "Malaria Between Race and Ecology."

71 Many histories of malaria control note the simplifying effects and intent of DDT. See Margaret Humphreys, "Kicking a Dying Dog"; Stepan, *Eradication*; Litsios, "Malaria Control, the Cold War, and the Postwar Reorganization of International Assistance"; Anderson, *Colonial Pathologies*; Packard, *The Making of a Tropical Disease*; Webb, *Humanity's Burden*; Kinkela, *DDT and the American Century*.

understand modern medicine, including an industrialized smallpox vaccine. And so smallpox initially failed to meet the standard for a suitable candidate for global eradication, as established by DDT-driven malaria eradication.

Smallpox Becomes Suitable

Yet even the latest medical and scientific breakthroughs could not completely rationalize malaria's relationship to humans, their environments, and mosquitoes. From the outset, malaria eradication had been premised on the power of DDT to kill insects without regard for their environments. But as early as 1947, scientists learned of cases in which house flies developed resistance to DDT, and at the 1953 World Health Assembly – the same gathering at which he proposed smallpox eradication – Director-General Brock Chisholm confirmed that mosquitoes could, in fact, develop resistance to DDT within just a few years of spraying.[72] Such concerns lent urgency to malaria eradication, which, supporters argued, must move forward quickly, before DDT lost too much of its power.[73] But the news kept getting worse. Researchers found more species of mosquitoes in more parts of the world developing resistance to DDT, and they discovered that lower primates could host malaria, introducing yet another natural factor in the process of transmission.[74] It also became clear that DDT did not work equally well in all environments; for instance, the walls of adobe and mud huts quickly absorbed DDT, rendering it useless against mosquitoes.[75] In response to these challenges, eradicationists made a variety of adjustments, applying additional or alternative chemicals like dieldrin, distributing salt mixed with anti-malarial drugs, and varying insecticide concentrations and spraying schedules. With each new chemical, new drug, and new approach, anti-malarial efforts became increasingly complicated and difficult, and malaria became a less ideal candidate for global eradication.[76]

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[72] Gregory Livadas and WHO Expert Committee on Malaria, "Do Anophelines Acquire Resistance to DDT?" 1951, WHO/Mal/74, WHO Library; Pan American Sanitary Organization, "Eradication of Malaria in the Americas," 28.

[73] For urgency in DDT-driven malaria eradication, see Pan American Sanitary Organization, "Eradication of Malaria in the Americas," October 8, 1954, PAHO Library, http://hist.library.paho.org/English/GOV/CSP/14_36.pdf.

[74] "Expert Committee on Malaria, Lisbon, Seventh Report," September 15-23, 1958, page 21, WHO/MAL/197-214, WHO Library; WHO Expert Committee on Malaria, *Eighth Report*, Technical Report Series, No. 205 (Geneva: World Health Organization, 1961), p. 46–48. For disease ecology of malaria, see Packard, *The Making of a Tropical Disease*.

[75] E. Bordas, "Inactivation of DDT by Mud Surfaces" (Geneva, World Health Organization, 1952); for more on DDT resistance, see Kinkela, *DDT and the American Century*, 58, 93–95.

[76] For problems with DDT and the failure of the malaria eradication program, see Staples, *The Birth of Development*, 173–179; Webb, *Humanity's Burden*, 174–177; Packard, *The Making of a Tropical Disease*, 162–176.

More troublingly, the safety of DDT came under question. In 1951, the WHA commissioned a report on the potential hazards of the chemical.[77] Submitted to the World Health Assembly in 1953, the report noted that "there is no shred of experimental evidence" of dangers to humans from DDT.[78] "On the other hand," the report admitted, "there is no one yet in a position to say with any confidence that the ingestion of small quantities of a material like DDT over the virtual life-span of a human being would be entirely harmless." Despite such doubt, the WHA-commissioned report remained confident in DDT, and the WHO's malaria eradication program went forward, emphasizing not the unknown hazards of DDT, but the ability of experts to manage the power of the chemical and control environments and improve human health. But the more scientists learned about DDT, the more uncertain, complicated, and potentially dangerous malaria eradication became.

As problems with malaria eradication raised questions about the program's feasibility and safety, the concept of eradication itself increasingly came under fire. Eradicationism was hardly a universal creed among health experts. Some doctors and medical scientists embraced an evolutionary theory of disease's relationship to humans, in which people, microbes, and their environments were inextricably linked in a process of continual change and adaptation.[79] Microbiologist René Dubos (who coined the phrase, "think globally, act locally") was perhaps the most well-known medical scientist to advance this understanding of disease ecology.[80] Dubos argued in his 1959 book *Mirage of Health* that humans would never master nature enough to eradicate diseases, and that health professionals could best serve humanity by observing evolutionary processes and carefully calibrating their responses to disease.[81] Although less fervently opposed to the concept of eradication, Frank Fenner, an Australian microbiologist who had witnessed first-hand the capacity of

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[77] WHO, *Official Records of the World Health Organization, No. 13: First World Health Assembly, Geneva, 24 June to 24 July 1948* (Geneva: World Health Organization, 1948), 304.

[78] J. M Barnes, *Toxic Hazards of Certain Pesticides to Man: Together with a Select Bibliography on the Toxicology of Pesticides in Man and Mammals* (Geneva: World Health Organization, 1953), 33.

[79] For physicians and scientists developing "disease ecology" as an approach to infectious diseases, see Warwick Anderson, "Natural Histories of Infectious Disease: Ecological Vision in Twentieth-Century Biomedical Science," *Osiris* 19, 2nd Series (2004): 39–61; for a comparison to conventional disease concepts, see Litsios, "Rene J. Dubos and Fred L. Soper"; see also Stepan, *Eradication*, especially chapters four and five; for disease ecology as historical analysis, see examples by J. R. McNeill, *Mosquito Empire: Ecology and War in the Greater Caribbean, 1620-1914* (New York: Cambridge, 2010) and Guenter Risse, "Epidemics and History: Ecological Perspectives and Social Responses," in *AIDS: The Burdens of History*, ed. Elizabeth Fee and Daniel M. Fox (University of California Press, 1988), 33–66.

[80] For an excellent biography, Carol Moberg, *René Dubos: Friend of the Good Earth* (Washington, D.C.: ASM Press, 2005).

[81] René Jules Dubos, *The Mirage of Health: Utopias, Progress, and Biological Change* (New Brunswick: Rutgers University Press, 1959).

rabbits to develop resistance to a cousin of smallpox, doubted whether humans could ever exercise total control over disease environments. Fenner saw a world in which human populations grew ever larger and closer together, creating a "single ecological unit" in which old diseases thrived and "'new' viral disease for man himself" developed.[82] Although Dubos, Fenner, and other disease ecologists carefully avoided misanthropic neo-Malthusianism, their arguments about human-environment-disease interrelationships carried ominous implications: disease eradication would produce too many humans, upsetting the balance of nature on which the species depended.[83] From this perspective, in which humans were intimately and inextricably connected to the nonhuman natural world, disease eradication was highly improbable or perhaps very, very dangerous.

Such doubts about eradication among health professionals merged with deeper and more popular concerns about humanity's efforts to control complex ecological systems. Worries about the toxic effects of chemicals like DDT increased during the 1960s, despite assurances from insecticide manufacturers and the WHO. The publication of Rachel Carson's *Silent Spring* in 1962 and the ensuing storm of publicity and controversy surrounding the book marked a watershed moment in concern about human intervention in ecological processes, bringing obscure scientific discussions to a broader public and vice-versa.[84] Carson began *Silent Spring* with reference to tragic changes to the environment, but she ultimately focused on the human body's inextricable connection to the nonhuman natural world. The book's themes spoke directly to the debate about eradication: Carson doubted that humans would ever master nature enough to eradicate any part of it (hence her reminders of the failures of insect control programs), but in the process of trying to do so, they would create a miserable, unlivable world.

Appearing at a conference of the American Public Health Association just one month after the publication of *Silent Spring*, Dr. Anthony Payne, chairman of the Department of Epidemiology and Public Health at Yale University, called on his colleagues to think carefully about eradication, evoking Carson's "imaginative phantasy" of a world suffocated

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[82] Anderson, "Natural Histories of Infectious Disease."

[83] René Jules Dubos, *The Mirage of Health: Utopias, Progress, and Biological Change* (New Brunswick: Rutgers University Press, 1959), chapter 7; for concerns about health programs and population, see William Vogt, *Road to Survival* (W. Sloane Associates, 1948) as analyzed by Thomas Robertson, *The Malthusian Moment: Global Population Growth and the Birth of American Environmentalism* (New Brunswick: Rutgers University Press, 2012), 52–53 and; Packard, *The Making of a Tropical Disease*, 146–147 and Paul Farr Russell, *Man's Mastery of Malaria* (Oxford University Press, 1955) as analyzed by Anderson, *Colonial Pathologies*, 225; and Stepan, *Eradication*, 181.

[84] Linda Lear, *Rachel Carson: Witness for Nature* (New York: H. Holt, 1997); Priscilla Coit Murphy, *What A Book Can Do: The Publication and Reception of Silent Spring* (Amherst: University of Massachusetts Press, 2005).

by insecticides.[85] "The phantasy is quite frightening, but at the same time it is a real possibility," warned Payne, "It is not science fiction." As the heavy application of insecticides disturbed "ecological balance," so too might eradication produce a dangerous shift in the relationship between humans and disease. Echoing Carson's warnings about the ecologically insidious effects of pesticides, Payne cautioned that the full costs of eradication had not been accounted for, quoting from Albert Schweitzer: "'man can hardly even recognize the devils of his own creation.' What devils," Payne asked, "might lie in wait for us along the road to eradication?" Payne did not ask his colleagues to surrender to disease. He admitted that eradication "might be preferred" for some diseases, specifically naming smallpox, cholera, and malaria. But the decision to eradicate must be "subject always to ecological considerations," and he justified malaria eradication in just those terms: "the continued use of insecticides for [malaria] control rather than eradication would prove more dangerous ecologically." But "the best candidates of all for eradication," argued Payne, were "man-made diseases mostly due to chemical and physical agents" which "have upset the ecological balance by causing disease." The gravest threat to humanity came not from natural enemies, but from foolish efforts to control the nonhuman natural world.

From this ecologically-sensitive perspective of the mid 1960s, DDT-driven malaria eradication seemed to have become one of these foolish, and perhaps even dangerous, efforts, despite Payne's efforts to justify malaria eradication in ecological terms. The WHO's malaria eradication campaign relied on a deceptively simple strategy: kill mosquitoes, eliminate malaria. The approach assumed that DDT worked equally well against all mosquitoes in all environments. But this idea of a simplified interaction between humans, a pathogen, and a vector ran into a much more complicated reality. Mosquito resistance and variability, sub-primate malaria hosts, and other nonhuman factors revealed a disease ecology that stymied the WHO's DDT-driven eradication program. The folly of such an effort compared only to the hazard of the exercise. Chemical insecticides might pose a danger to human health, and, if not, they would certainly disrupt the ecological balance on which humans depended. In short: the very thing that promised to make malaria eradication possible – DDT – had created experiences and understandings of the relationship between humans, diseases, and their environments that undermined malaria's suitability for eradication.

At the same time, and for the same reasons that malaria fell out of favor, smallpox became an attractive candidate for eradication. Though the Soviet proposal in 1958 did not initiate a global smallpox eradication campaign, it did inaugurate a new phase in the process of knowing and mastering the disease. In November 1958, the WHO convened a "Study

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85 Anthony M.M. Payne, "The Role of Health Today in Social and Economic Development," *American Journal of Public Health and the Nation's Health*, 1963, 53:369–375.

Group on Recommended Requirements for Smallpox Vaccine" to draw up international standards for vaccine production and administration, based primarily on national regulations recently developed by the UK, Japan, the USSR, and the US.[86] The Study Group called for still more research, and in the six years following the Soviet proposal, the *Bulletin of the World Health Organization* published twice as many articles about smallpox than it had run during the twelve years previous. The publication explored diagnosis, transmission, and, of course, improvement in vaccine potency, purity, stability, and delivery. The WHO also sponsored training sessions for freeze-dried vaccine production and conferences to disseminate knowledge about the disease and encourage individual nations to step up their fight against smallpox. In these ways, smallpox experts both revealed and reinforced how smallpox could be isolated from its environments – an increasingly important consideration, given the concern over manipulation of ecological systems.

Smallpox literally knocked malaria from the top of the list of eradicable diseases. In 1963, the American Public Health Association's Committee on Eradication drew up a list of six diseases potentially suitable for eradication, based on "public health importance, ease of identification, knowledge of epidemiological characteristics, knowledge of methods of control and ease of eradicability."[87] The last factor – "ease of eradicability" – depended on the role of the environment; if eradication required intervention in complex ecological systems, then it might not be possible or even safe. By this reckoning, the APHA's Committee on Eradication ranked smallpox as its first choice, while malaria finished last. Citing the expense and duration of malaria eradication campaigns, and the discoveries of "reservoirs in sub-human primates," the Committee "put malaria eradication in the 'perhaps' category." Smallpox, on the other hand, presented a perfect opportunity. "Besides the scientific feasibility of eradication," explained the Committee, "psychological factors (universal knowledge and fear of the disease) and logistical factors (availability of vaccine, methods and resources) make this the top priority target for eradication." Malaria, interconnected to so many dynamic nonhuman forces that its eradication seemed both foolish and dangerous, did not offer the "scientific feasibility" and "logistical factors" that made smallpox so perfect for eradication.

In January of 1964, a WHO Expert Committee on Smallpox conclusively defined smallpox as an eradicable disease.[88] Field research

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[86] WHO, *Requirements for Biological Substances: 5. Requirements for Smallpox Vaccine, Report of a Study Group, 3-8 November 1958*, Technical Report Series No. 180 (Geneva: World Health Organization, 1959).

[87] "APHA Discussions on Eradication Possibilities," 1962, Folder "APHA (Committee on Disease Eradication)," Correspondence 1949-1969, Administrative - Associations 1964-1966, Box 22, RG 90, NARA.

[88] WHO Expert Committee on Smallpox, *First Report,* Technical Report Series, No. 283 (Geneva: World Health Organization, January 14, 1964), WHO Library; "Expert

had shown that transmission of smallpox depended on only three "extrinsic" factors: a victim's mobility, her or his family size (which determined the amount of contact with an infected patient), and the threat posed by some occupations – hospital workers, for instance, had more potential exposure to smallpox. The natural environment, in other words, was definitely not a factor in the quest to eliminate smallpox. At the same time, diagnosis techniques in the lab had advanced to provide quick and accurate identification of infected specimens, thus bringing the target for eradication more clearly into view. The committee also clarified the best procedures for vaccine production and storage and compared vaccine strains from different laboratories to identify the most powerful weapon for the task of eradication. Based on all of the above, the committee concluded, "As the only source of the virus is man and as vaccination provides good protection...eradication of smallpox in endemic areas is well within the compass of modern preventive medicine." From the perspective of scientific medicine, smallpox had become a suitable candidate for global eradication.

Smallpox, then, suited evolving understandings, both in the public and among health professionals, of human bodies and disease ecology. With just one application of simple, potent, and heat-stable vaccine, a human body gained complete protection from smallpox. No swamps to drain, no chemicals to spray, no insects to eliminate or primate hosts to track down: smallpox eradication pitted humans vs. a virus, a contest that represented a much simpler endeavor than malaria eradication. Dr. T. Aidan Cockburn, one of the most active members of the APHA's Committee on Eradication, provided a clear explanation of the essential difference between the two diseases in his book *The Evolution and Eradication of Infectious Diseases*, published the year after Carson's *Silent Spring*. Cockburn explained that the nature of malaria – moving through mosquitoes to humans, and also infecting nonhuman animal reservoirs – made it entirely possible that "after the eradication measures had been halted, man would be reinfected." Smallpox, on the other hand, infected only humans, so "the chances, therefore, of permanent eradication of the infections seem good."[89] Frank Fenner, who had questioned the feasibility of eradication in general within the "single ecological unit" of the global environment, harbored fewer doubts about smallpox eradication specifically. Fenner eventually chaired the global commission that certified the eradication of smallpox in 1979 and co-authored the WHO's official history of smallpox eradication. Explaining the ultimate success of the program and his participation in it, Fenner argued that, "the case of smallpox is unique," pointing to the list of reasons that made smallpox so special: the vaccine, the obvious symptoms of infection, and its lack of a

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Committee on Smallpox (Conference Proceedings)," January 14, 1964, Smallpox/WP/1-28, WHO Library.

[89] Aidan Cockburn, *The Evolution and Eradication of Infectious Diseases* (Baltimore: The Johns Hopkins Press, 1963), p. 140–142.

non-human animal reservoir and vector.[90] In light of increasing anxiety about the dangers of interfering with complex ecological systems, smallpox had become unusually—perhaps even uniquely—vulnerable to eradication.

Conclusion

In 1964, though, smallpox had yet to supplant malaria as the main target for global eradication. Scientific medicine and international health experts had confirmed smallpox's vulnerability to a global eradication program, but international politics stood in the way of any such effort. Instead, the WHO's malaria program monopolized the organization's attention and resources, with thousands of staff members and millions of dollars dedicated to the program. In 1965, the WHO spent more than $12.6 million on malaria eradication, while spending just $233,000 on smallpox.[91] Observing this disparity in the WHO's approach to the two diseases, the USSR delegation to the WHA complained that "malaria eradication seemed to have been the favoured daughter of WHO, whereas smallpox eradication seemed to have been treated rather as a foster child."[92] And so it would continue, as long as American foreign policy in health concentrated on malaria. Implementing a global smallpox eradication program would require changes in how American doctors, bureaucrats, and politicians understood the purposes of international health programs, a process that would eventually bear fruit under the administration of Lyndon B. Johnson. But even before then, smallpox had started on its path to eradication. The scientific developments of the post-war era and a shifting ecological consciousness had transformed smallpox into a suitable candidate disease, joining inextricably this unique disease to its unique fate.

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[90] Frank Fenner, "Smallpox: Emergence, Global Spread, and Eradication," *History & Philosophy of the Life Sciences*, 1993, 15:397–420.

[91] Fenner et al., *Smallpox and its Eradication*, table 9.3, p. 384.

[92] "Committee on Programme and Budget, Provisional Minutes of the Twelfth Meeting, Eleventh World Health Assembly" May 17, 1965, page 27, A18/P&B/Min/12, WHO Library.