



## Perspective

## Eradicating infectious disease: Can we and should we: A critical examination

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## ABSTRACT

To highlight the possible consequences of eradicating disease, relevant literature on the intended and unintended consequences of disease eradication was reviewed. Though resource-intensive, eradication is often more cost-effective than long-term control. Global health leaders pursue eradication when the benefits promise lasting public health gains and transformative impact, as in the case of smallpox, guinea worm, and rinderpest. Competitive release, where other pathogens with similar transmission modes or tissue tropism expand into the vacated niche, is discussed. One underlying principle of the One Health approach to understanding emerging infectious diseases is that human, animal, and environmental health are driven by a complex interplay of ecological, behavioral, and socioeconomic factors. The law of unintended consequences means that whenever humans alter one factor, a completely unexpected event may occur. This complexity should be kept in mind in the formulation of any disease eradication or control program.

## Eradicating infectious disease: can we and should we?"

Eradication refers to the complete global elimination of a disease, with no remaining cases and no need for further vaccination or treatment. Smallpox remains the only human disease officially eradicated (declared in 1980), while rinderpest—a viral disease in cattle—was eradicated in 2011 [1]. Guinea worm disease (dracunculiasis) is nearing eradication, with fewer than 13 cases reported globally in 2023 [2]. Polio is close to eradication but persists in Afghanistan and Pakistan [3]. Eradication is feasible when the pathogen has no alternate reservoir hosts and relies solely on primary host-to-host transmission. Key enablers include effective vaccines or therapies, affordable diagnostics, distinct clinical signs, and rapid outbreak response. Political commitment, global cooperation, and robust surveillance systems are essential. Though resource-intensive, eradication is often more cost-effective than long-term control. Global health leaders pursue eradication when the benefits promise lasting public health gains and transformative impact.

Addressing health care inequities that are based on access to products and education regarding their value, such as sanitation, hygiene, mask-wearing, nutrition, use of insect repellents, and safe sexual practices, is most likely as important as attempting to alleviate the

global burden of infectious disease through the use of antibiotics and vaccines [4,5]. In today's world, where the control of infectious diseases has been increasingly disrupted, this question (raised by Russell [5]) is particularly relevant.

Animals co-evolved with microbes, but a mainly commensal relationship can be disrupted [5]. There are many reasons why new infectious diseases emerge and why old diseases affect new hosts or change their geographical variation. Each microbe, as do all organisms, occupies a particular ecological niche [6]. A niche is the position of a species within an ecosystem, including the range of conditions it needs to survive and its ecological role or function in that ecosystem [7].

Factors that can affect the conditions under which microbes thrive and their role in the ecosystem include microbial factors, environmental factors, and host factors [4]. Microbial factors include altered virulence and host preference, often due to genetic changes. Examples include increased virulence in *Streptococcus A* bacteria, resulting in severe tissue necrosis, and the current H1N1 highly pathogenic influenza outbreak [8,9]. Environmental factors such as climate can affect the range of areas in which microbes and their vectors flourish by altering the humidity and temperature of the habitat [10]. Floods and other natural disasters may facilitate the spread of diseases such as cholera [11]. Host factors that may contribute to disease include

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changes in host immunity due to concurrent disease, age, and poverty [8]. People with infections that affect the immune system, such as those with AIDS, or domestic dogs with distemper, are more susceptible to opportunistic infections [12,13].

Lastly, human actions can alter the balance between microbes and their hosts.

International travel, illegal trade in birds, and/or the inadvertent transport of mosquitoes likely triggered the 1999 epidemic of West Nile virus in humans, birds, and horses in the Americas [8]. The Eastern European (2007) and Asian (2018) outbreaks of African Swine Fever were likely due to improper treatment of ship food waste [14]. The African Ebola virus outbreak in 2014 was at least partly due to new roads being built to facilitate deforestation in Africa, which brought burgeoning human populations into closer contact with forest animals than ever before [15]. Diseases can also be spread due to war-related disruption of health facilities, such as leishmaniasis in Syrian refugees [16]. Growing resistance of microbes to antimicrobials and bioterrorism are further examples of how human actions can precipitate disease [8].

Eradication of disease could also result in an ‘empty’ niche that becomes filled with another microbe [17]. Viruses are obligatory pathogens and may have very specific niches, especially those with narrow host ranges. The use of an attenuated virus to control a wild-type virus, as in the case of the oral polio vaccine, has been associated with reversion to virulence and/or delay in eradication. Bacteria, in contrast, may fill various niches in the host, the environment, and in animals and are therefore both more difficult to control and less likely to leave a niche vacant [5]. Bacteria such as *Streptococcus pneumoniae* and *Staphylococcus aureus* may compete with each other to fill a niche [18]. Improper use of antibiotics allows commensal bacteria to proliferate, for example, in *Clostridium difficile* infections in humans and horses treated with antibiotics [5,19]. Similarly, treatment with fluconazole affects the gut microbiome as well as the host immune response in mice [20]. To date, only smallpox (declared eradicated in 1980) and rinderpest (2011) have been eradicated, while new and re-emerging diseases occur regularly [21] (Table 1). Is it possible that mpox utilizes a niche that smallpox used to occupy, and that the paramyxovirus *Peste des Petits Ruminants* fills a niche previously filled by the paramyxovirus rinderpest?

Polio is nearing eradication, but the wild virus persists in Afghanistan and Pakistan [3]. The decision of the World Health Organization (WHO) to pursue eradication stems from its biological feasibility—no animal reservoir, effective vaccines, and strong global surveillance. Eradication promotes health equity by protecting vulnerable

children from paralysis. The infrastructure built—trained health workers, cold chains, and acute flaccid paralysis surveillance—offers a high return on investment and strengthens broader health systems. These assets support pandemic preparedness, routine immunization, and sustainable integration into national programs, making eradication both strategic and transformative.

Polio resurgence remains a serious risk if eradication is incomplete. Vaccine-derived poliovirus from the oral polio vaccine can mutate and circulate in under-immunized communities. Immunity gaps resulting from disrupted health systems, conflict, or displacement allow outbreaks. Surveillance failures, especially in remote areas, hinder early detection. Global travel can reintroduce the virus into polio-free regions. Post-eradication vaccine withdrawal, through a careful transition to inactivated polio vaccine, is vital to prevent immunity gaps. The WHO’s strategy includes maintaining vaccine stockpiles, strengthening acute flaccid paralysis and environmental surveillance, and ensuring rapid outbreak response to safeguard progress and prevent resurgence [3].

Global organizations pursue disease eradication based on their core mandates and strategic priorities [22]. The WHO aligns eradication efforts with the Sustainable Development Goals, aiming to reduce disease burden and strengthen health systems—exemplified by the Neglected Tropical Diseases 2030 roadmap. The United Nations Children’s Fund focuses on protecting children’s health and rights by improving access to vaccines, clean water, and essential services, as seen in the Global Polio Eradication Initiative [3].

The Food and Agriculture Organization and the World Organization for Animal Health (WOAH, formerly Office International des Epizooties) emphasize zoonotic disease control through One Health approaches, safeguarding livelihoods and food security—illustrated by the rinderpest eradication and rabies control programs. The WOAH promotes animal disease eradication to safeguard international trade and help countries maintain official disease-free status—an essential requirement for exporting animal products. Under World Trade Organization rules, communicable animal diseases are among the most legitimate and enforceable grounds for import restrictions, as they pose direct threats to public health, agriculture, and biosecurity. Common examples include bans on live birds, poultry meat, and eggs from avian influenza (H5N1, H7N9) zones; restrictions on pigs, pork, and feed from African swine fever regions; and prohibitions on beef and bone meal from BSE-affected areas. These measures protect the livestock and food industries of disease-free countries.

What happens to ecological niches after eradication? When a pathogen is eradicated, its ecological niche—defined by host susceptibility, transmission routes, and environmental conditions—becomes vacant. This can lead to competitive release, where other pathogens with similar transmission modes or tissue tropism expand into the vacated space. For example, mpox cases increased in parts of Africa after smallpox eradication, possibly due to reduced cross-immunity and diminished surveillance focus [23]. Polio, which lacks an animal reservoir and targets human gut mucosa with neuroinvasive potential, occupies a relatively specific niche. No virus is expected to strictly replace it. However, enteroviruses such as EV-D68, Coxsackie, and echoviruses—already endemic and capable of causing similar symptoms—may gain ecological prominence if immunity gaps or surveillance shifts occur. Crucially, vacated niches can favor the emergence of novel or previously undetected pathogens, especially in immunologically naïve populations or disrupted ecosystems, underscoring the need for sustained vigilance post-eradication [24,25].

In some cases, disease control and prevention are more sustainable than eradication. Maintaining ecological stability helps avoid niche shifts or the emergence of new threats. For diseases such as foot-and-mouth disease in endemic regions, long-term control has proven more cost-effective than eradication campaigns. Moreover, ongoing control ensures continuous investment in surveillance, detection, and response infrastructure, strengthening health systems over time.

**Table 1**

Examples of emerging or re-emerging human infectious diseases.

Sources: [21]; CDC, <https://www.cdc.gov/vaccines-children/diseases/index.html>.

Date	Emerging diseases <sup>a</sup>
1970	Yellow fever (Yellow fever virus)
1980s	AIDS (Human immune deficiency viruses)
1989	Hepatitis C (Hepatitis C virus)
1993	Hantavirus disease (Hantaviruses)
1996	Meningococcal encephalitis ( <i>Neisseria meningitidis</i> )
2002	SARS (SARS-CoV-1 virus) <sup>a</sup>
2006	Non-polioencephalomyelitis virus
2007	Zika (Zikavirus) (Micronesia)
2009	H1N1 influenza (Influenza A virus)
2011	Peste des petits ruminants (Peste des petits ruminants virus)
2012	MERS (MERS-CoV) <sup>a</sup>
2013	Yellow fever (Yellow fever virus)
2014	Ebola (Ebolavirus)
2015	Zika (Zikavirus) (Brazil)
2019	Covid 19 (SARS-CoV-2 virus) <sup>a</sup>
2022	Mpox virus <sup>a</sup>

<sup>a</sup> New diseases.

Emerging diseases are driven by interconnected environmental, social, animal, microbial, and governance factors. Climate change, deforestation, and biodiversity loss disrupt ecosystems, increasing spillover risks. Urbanization, population growth, global travel, and agricultural expansion intensify contact between humans, livestock, and wildlife, while bushmeat hunting and wildlife trade expose people to novel pathogens [26]. Intensive animal farming, pet ownership, and wildlife reservoirs (e.g., bats, rodents) expand the human-animal interface and facilitate cross-species transmission. Microbial evolution—especially in RNA viruses—enables rapid adaptation, while antimicrobial resistance, driven by misuse in humans and animals, complicates disease control.

One underlying principle of the One Health approach to understanding emerging infectious diseases is that human, animal, and environmental health are driven by a complex interplay of ecological, behavioral, and socioeconomic factors. Weak surveillance systems and fragmented One Health coordination delay outbreak detection and response. Effective integration across human, animal, and environmental health sectors is essential to mitigate these risks and prevent future pandemics [24]. The law of unintended consequences means that whenever humans alter one factor, a completely unexpected event may occur [27]. This complexity should be kept in mind in the formulation of any disease eradication or control program.

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#### Declaration of Competing Interest

The authors have no competing interest to declare.

#### References

- [1] World Health Organization. Public health milestones through the years; n.d. <https://www.who.int/campaigns/75-years-of-improving-public-health/milestones#year-1945>. Accessed 23 October 2025.
- [2] Roser M., Ochmann S., Behrens H., Ritchie H., Dadonaite B. Eradication of diseases. Which diseases could we eradicate in our lifetimes and how? Our world in data; 2014. <https://ourworldindata.org/eradication-of-diseases>. Accessed 23 October 2025.
- [3] Batson A, Glassman A, Federgruen A, Diment J, Ganguly NK, Makoni S, et al. The world needs to prepare now to prevent polio resurgence post eradication. *BMJ Glob Health* 2022;7:e011485. <https://doi.org/10.1136/bmjgh-2022-011485>.
- [4] Reingold AL. Infectious disease epidemiology in the 21st century: will it be eradicated or will it reemerge? *Epidemiol Rev* 2000;22:57–63. <https://doi.org/10.1093/oxfordjournals.epirev.a018024>.
- [5] Russell CD. Eradicating infectious disease: can we and should we? *Front Immunol* 2011;2:53. <https://doi.org/10.3389/fimmu.2011.00053>.
- [6] Malard LA, Guisan A. Into the microbial niche. *Trends Ecol Evol* 2023;38:936–45. <https://doi.org/10.1016/j.tree.2023.04.015>.
- [7] Polechova J, Storch D. Ecological niche. In: Capinera J, editor. *Encyclopedia of ecology*. 2nd ed. Dordrecht: Semantic Scholar; 2019. p. 1088–97.
- [8] Murray KO, Mertens E, Desprès P. West Nile virus and its emergence in the United States of America. *Vet Res* 2010;41:67. <https://doi.org/10.1051/vetres/20100039>.
- [9] Smith GJD, Vijaykrishna D, Bahl J, Lycett SJ, Worobey M, Pybus OG, et al. Origins and evolutionary genomics of the 2009 swine-origin H1N1 influenza A epidemic. *Nature* 2009;459:1122–5. <https://doi.org/10.1038/nature08182>.
- [10] Caminade C, McIntyre KM, Jones AE. Impact of recent and future climate change on vector-borne diseases. *Ann N Y Acad Sci* 2019;1436:157–73. <https://doi.org/10.1111/nyas.13950>.
- [11] Walika M, Moitinho De Almeida M, Castro Delgado R, Arcos González P. Outbreaks following natural disasters: a review of the literature. *Disaster Med Public Health Prep* 2023;17:e444. <https://doi.org/10.1017/dmp.2023.96>.
- [12] Rubaihayo J, Tumwesigye NM, Konde-Lule J, Wamani H, Nakku-Joloba E, Makumbi F. Frequency and distribution patterns of opportunistic infections associated with HIV/AIDS in Uganda. *BMC Res Notes* 2016;9:501. <https://doi.org/10.1186/s13104-016-2317-7>.
- [13] Headley SA, Oliveira TES, Pereira AHT, Moreira JR, Michelazzo MMZ, Pires BG, et al. Canine morbillivirus (canine distemper virus) with concomitant canine adenovirus, canine parvovirus-2, and Neospora caninum in puppies: a retrospective immunohistochemical study. *Sci Rep* 2018;8:13477. <https://doi.org/10.1038/s41598-018-31540-0>.
- [14] Mighell E, Ward MP. African Swine Fever spread across Asia, 2018–2019. *Transbound Emerg Dis* 2021;68:2722–32. <https://doi.org/10.1111/tbed.14039>.
- [15] Alexander KA, Sanderson CE, Marathe M, Lewis BL, Rivers CM, Shaman J, et al. What factors might have led to the emergence of Ebola in West Africa? *PLoS Negl Trop Dis* 2015;9:e0003652. <https://doi.org/10.1371/journal.pntd.0003652>.
- [16] Lindner AK, Richter J, Gertler M, Nikolaus M, Martinez GE, Müller K, et al. Cutaneous leishmaniasis in refugees from Syria: complex cases in Berlin 2015–2020. *J Travel Med* 2020;27:taaa161. <https://doi.org/10.1093/JTM/TAAA161>.
- [17] Church DL. Major factors affecting the emergence and re-emergence of infectious diseases. *Clin Lab Med* 2004;24:559–86. <https://doi.org/10.1016/j.cll.2004.05.008>.
- [18] Regev-Yochay G, Dagan R, Raz M, Carmeli Y, Shainberg B, Derazne E, et al. Association between carriage of *Streptococcus pneumoniae* and *Staphylococcus aureus* in children. *J Am Med Assoc* 2004;292:716–20. <https://doi.org/10.1001/jama.292.6.716>.
- [19] Diab SS, Songer G, Uzal FA. *Clostridium difficile* infection in horses: a review. *Vet Microbiol* 2013;167:42–9. <https://doi.org/10.1016/j.vetmic.2013.03.032>.
- [20] Heng X, Jiang Y, Chu W. Influence of fluconazole administration on gut microbiome, intestinal barrier, and immune response in mice. *Antimicrob Agents Chemother* 2021;65:e02552-20. <https://doi.org/10.1128/AAC.02552-20>.
- [21] Racaniello VR. Emerging infectious diseases. *J Clin Investig* 2004;113:796–8. <https://doi.org/10.1172/JCI200421370.796>.
- [22] World Health Organization. *A road map for neglected tropical diseases 2021–2030*. Geneva: World Health Organization; 2021.
- [23] Srivastava S, Kumar S, Jain S, Mohanty A, Thapa N, Poudel P, et al. The global monkeypox (mpox) outbreak: a comprehensive review. *Vaccines* 2023;11:1093. <https://doi.org/10.3390/vaccines11061093>.
- [24] Roche B, Broutin H, Choisy M, Godreuil S, De Magny GC, Chevalere Y, et al. The niche reduction approach: an opportunity for optimal control of infectious diseases in low-income countries? *BMC Public Health* 2014;14:753. <https://doi.org/10.1186/1471-2458-14-753>.
- [25] Lloyd-Smith JO. Vacated niches, competitive release and the community ecology of pathogen eradication. *Philos Trans R Soc B Biol Sci* 2013;368:20120150. <https://doi.org/10.1098/rstb.2012.0150>.
- [26] Nichol AA. Emerging infectious diseases at the intersections of human, animal, and environmental health. *AMA J Ethics* 2024;26:E99–102. <https://doi.org/10.1001/amajethics.2024.99>.
- [27] Dracup K, Bryan-Brown CW. The law of unintended consequences. *Am J Crit Care* 2004;13:97–9. <https://doi.org/10.7326/M15-2840>.