



Vaccine confidence in the time of COVID-19

Emily A. Harrison^{1,2} · Julia W. Wu¹

Received: 4 April 2020 / Accepted: 11 April 2020 / Published online: 22 April 2020
© Springer Nature B.V. 2020

Abstract

In the early months of the COVID-19 epidemic, some have wondered if the force of this global experience will solve the problem of vaccine refusal that has vexed and preoccupied the global public health community for the last several decades. Drawing on historical and epidemiological analyses, we critique contemporary approaches to reducing vaccine hesitancy and articulate our notion of vaccine confidence as an expanded way of conceptualizing the problem and how to respond to it. Intervening on the rush of vaccine optimism we see pervading present discourse around the COVID-19 epidemic, we call for a re-imagining of the culture of public health and the meaning of vaccine safety regulations. Public confidence in vaccination programs depends on the work they do for the community—social, political, and moral as well as biological. The concept of public health and its programs must be broader than the delivery of the vaccine technology itself. The narrative work and policy actions entailed in actualizing such changes will, we expect, be essential in achieving a true vaccine confidence, however the public reacts to the specific vaccine that may be developed for COVID-19.

Keywords Vaccine hesitancy · Vaccine confidence · COVID-19 · Vaccine safety regulation · Culture · Historical

As a historian of public health and an infectious disease epidemiologist, we watch from Boston, Massachusetts as coronavirus SARS-CoV-2 grips headlines around the world. We recognize that, in some ways, the COVID-19 epidemic has many precedents. In other ways, it has no precedents. It features a novel pathogen. It has achieved pandemic status at a moment when social media use is widespread, fostering the fast and global exchange of information, misinformation, and facile but not necessarily wise comparisons across countries and across prior epidemics. And this virus spreads—swift and furtive—at a time when the global health community has come to rely on technical responses to public health problems [1].

Vaccines are prominent among these technical solutions, and with good reasons. In human struggles against major infectious diseases such as smallpox, polio, rabies, typhoid, plague and many more, vaccines have played critical roles in reducing disease-specific mortality rates. The Bill and

Melinda Gates Foundation credits immunization with a 55% global decline in under-five mortality between 1990 and 2017 [2]. The US Centers for Disease Control and Prevention laud vaccination as the leading success story for public health in the twentieth century [3]. This optimism has translated into policy and planning. Over the past decade, prominent White House reports on pandemic preparedness have prioritized vaccines in their strategic plans and recommendations without training full attention to the possibility of pandemics for which there is no precedent vaccine [4, 5].

Given these stories about success, it should not be surprising that vaccine optimism has also been prominent in the public imagination during the early weeks of the COVID-19 epidemic, amidst a mixture of bravado, uncertainty, and fear. In the United States, high-level promises from the White House that a vaccine was coming within unrealistic timelines masked early federal inaction on both life-saving non-pharmaceutical public health measures and proven preparations for diminishing transmission [6]. Prominent voices in Global Health, aspiring to speak for social justice, called for any future vaccine to be equitably distributed [7]. The heat of this epidemic has even brought vaccine optimism to bear on the problem of vaccine hesitancy. Indicating the strength of public hopes in vaccines, some individuals posting on social media and in the letters columns of local news outlets have

✉ Emily A. Harrison
harrison@post.harvard.edu

¹ Department of Epidemiology, Harvard University (TH Chan School of Public Health), Boston, USA

² Department of the History of Science, Harvard University (GSAS), Cambridge, USA

wondered if the global force of COVID-19 would change the minds of those who refuse routine vaccination.

A caveat to vaccination success stories, vaccine hesitancy has preoccupied health experts and media for the last several decades. Like the present fixation with vaccines themselves, this attention to vaccine refusal has good reasons. Over the past two decades, global disease tracking has registered a significant rise in previously managed infectious diseases, measles being the celebrity example [8–12]. While there are competing hypotheses about the nature of this rise, the CDC—based on epidemiological data—has attributed it to reduced vaccination [13]. And there is no doubt that the public does not fully participate in even freely available vaccination programs. In 2019, for example, the CDC estimated that half of the US population did not get a seasonal influenza vaccine [14]. The WHO listed “vaccine hesitancy” as one of the top threats to global health in this same year [15].

It is possible that this COVID-19 crisis may ignite a collective memory of long human struggles against infectious disease. But will re-experiencing the force of an epidemic alone be sufficient to solve the problem of vaccine hesitancy? Hoping to generate more light than heat, we view this as a critical moment to reimagine the problem: to think not only about vaccine hesitancy, or vaccine optimism, but about vaccine confidence.

Many professionals have proposed “interdisciplinary” approaches to address vaccine hesitancy. Broaching cultural analysis and clinical practice, Dan Kahan from Yale University and colleagues have advised medical professionals to “reshape the cultural environment” of medicine in order to better communicate about risks and benefits with the general public. Advanced risk communication strategies, built on evidence that people listen to information that matches their pre-existing cultural expectations or preferred aesthetics, aspire to identify and counteract “ungrounded” vaccine fears in the population. Medical and public health communities often frame lack of scientific information among the public as the culprit: medical societies call for coalitions with technology companies to ensure user access to scientifically valid information on vaccines; the WHO Vaccine Safety Net initiative aims to better align public questions and provide the most updated scientific evidence; outreach efforts to vulnerable communities prioritize “informing” skeptical parents. Turning to legal solutions, states are passing more regulations on vaccinations and school attendance [16–23]. Still, a string of difficult challenges persist despite some local successes with these strategies. These challenges range from misinformation promulgated on social media, to vaccine refusal among well-educated communities, to lack of trust of public health agencies.

Such persistent challenges suggest to us that the current modes of thinking about the problem still fall within too narrow and too clinically-oriented of an idea about health,

disease, and how complex the human responses to them truly are. In our view these approaches are self-limiting. They consider vaccine confidence as something that can be accomplished “in itself,” without broader development of the physical and intellectual infrastructures of public health. But vaccine confidence—a wider trust in the directives of those advising or requiring pre-emptive actions—is not the same as an agreement to be vaccinated against a particular and immanently frightening disease. Here we reflect on four interrelated points that shape our perspective.

The first point is that vaccinations are the remains of a much broader vision of public health that has eroded in the presence of political tensions. In the nineteenth century, public health emerged as a complex mixture of movements: some for social and political equality, some eugenic governance initiatives to maintain the most “fit” populations, some economically-interested efforts to protect trade and extractive industries from the ravages of disease. As vaccination technologies became viable public health measures in the early twentieth century, they offered an alternative to what were seen as the more politically controversial social, moral, and environmental approaches to disease; they were sold to the public as a technical, objective solution to the problem of prevention and population health [24]. Medical professionals and academics were among those resisting broader conceptions of public health, perhaps setting in motion the narrow approaches to fixing the problem of vaccine hesitancy that we observe in the present. As public health authority rose in the early twentieth century, professional medical societies worried about losing influence and income if prevention strategies grew too powerful. Across both clinical medicine and public health, some influential figures voiced concerns about protecting *all* people from exposure to disease. In 1938, John Rodman Paul of the Yale School of Medicine called for a “courageous clinical judgment” that could withstand the “black looks [that] would certainly be cast in our direction if we found for instance that all disease is not necessarily bad, but that a wise Providence inflicts some one with tuberculosis as a just regard for his bad living; or that children’s diseases are rained upon us as a means of inflicting, not only specific immunity, but who knows, how much non-specific immunity too which may be of inestimable value to us in adult life” [25]. From the Department of Epidemiology at Johns Hopkins, Wade Hampton Frost concurred with the idea that sacrificing children to high tuberculosis mortality could confer protection on the population later in life—at least until 1936, when he received data from Edgar Sydenstricker in Massachusetts that allowed him to study mortality patterns by cohorts [26]. The fantasy that vaccines could obviate the need for broader social and environmental policies kept prevention in clinical hands—along with all that prevention implied for decisions about who deserved protection, who could be utilized for the

benefit of others, and what kinds of people should constitute a “good future society.” In a different world, vaccination and other pharmacologic forms of disease prevention and mitigation could have risen in concert with the development of broader concepts of public health. Instead, pharmaceutical approaches including vaccines advanced as though such broader concepts were technologically replaceable.

The second point is that vaccine hesitancy is not a novel phenomenon. There is good reason to question whether there has ever been a deep public confidence in vaccines. It was not until the 1960s that mass preemptive vaccination programs were instituted for “milder” diseases like seasonal influenza and measles. As historian Elena Conis has argued, the success of these programs in their early decades was the product not of a timeless public acceptance of vaccination as a preventive strategy, but of a complex set of circumstances defining a particular historical moment [27]. Prior to this era of mass vaccination, immunizations were typically sought out amidst immanent or ongoing epidemics as reactions to immediately apparent death and debility. Although many people were willing to vaccinate in the frightening face of outbreaks, not all publics concurred. It was widespread community resistance to vaccination on grounds of safety and other concerns that drove the 1905 Supreme Court ruling on *Jacobson v. Massachusetts*, a case that set the precedent for much of the subsequent public health law in the United States [28]. Dissent has long been observed among communities who do not feel represented by authorities dispensing the vaccine or a sense of belonging to the broader public in whose interest they are asked to participate. In the nineteenth and twentieth centuries, for instance, vaccination campaigns were a tool of colonial and military enterprises seeking to sanitize bodies that were viewed as a threat to the security of privileged classes, an occupying army, or economic interests. Local movements protested that these campaigns were no salve for the neglect or destruction of broader programs for public well-being [29–33]. As illustrated in the point above, medical and public health authorities have at times been complicit in this neglect of broader public programs, raising reason to think carefully about their proposed role as vaccine brokers with disenfranchised publics.

The third point is that vaccine hesitancy is not a singular problem. On the one hand, it is a symptom of a larger willingness to ignore predicted threats because they are inconvenient or not (yet) an emergency [34]. This condition is characteristic not only of individuals making choices, but also of organizations receiving advisories about preventive strategies. For example: Although some seek refuge in the claim that the current COVID-19 pandemic could not have been foreseen, the historical record shows that national and international agencies, in both academic and state institutions, did predict and advise preparedness action for an epidemic much like the one underway [5, 35, 36].

The tendency to simulate epidemics in which a vaccine was either available or just over the horizon only amplifies the ways in which vaccine optimism has clouded thinking about public health prevention. Borrowing from historian Allan Brandt’s 2015 reflection on the Ebola epidemic, this present pandemic may be less aptly cast as a “perfect storm” than as an “accident waiting to happen” [37]. In other cases, such as the community resistance behind the *Jacobson v. Massachusetts* ruling, vaccine hesitancy has reflected medical safety concerns [28]. But vaccine hesitancy does not necessarily revolve around biomedical debates, as suggested by those who emphasize Wakefield’s 1998 *Lancet* article as a “cause” of MMR-hesitancy in the present. Among individuals who have opted out of vaccination programs, there have been a variety of serious considerations that were not about competing biological risks. For some, the potential for catastrophic social, economic, religious, or moral outcomes outweighs the risk from disease. Putting an ancient tradition or cultural foundation at risk, or cooperating with a state that carries out structural and other forms of violence against the community, may motivate a conscientious objection that outweighs bodily risk. For some, the ideology or aesthetic identity of the person doing the messaging makes the difference. When it comes to vaccine hesitancy, what matters most varies across time and communities.

The fourth point is that we as a public health community have been programmed with a mindset in which the essential ethical dilemma of public health is a tension between autonomy and state power. The construct of autonomy as right to individual choice and an antipode to state power has cast the terms of precedent-setting legal decisions, dominated our principles of mainstream bioethics, pervaded explanations of public hesitancy about vaccines, and been sold to the public as a foundational story about American ideals and culture [38, 39]. As pointed out by sociologist Renee Fox, this construct of a right to individual choice avoids, by design, the social and moral conditions in which people are asked to make choices. Choice is treated as a task that can be considered *ceteris paribus*, perhaps because the group of individuals who set the terms of public health law in the early 1900s and bioethics in the 1960s lacked substantial diversity in the social, moral, and material conditions of their lives. For these foundation-builders, “all else” was relatively equal. Although more diverse representation in academic and public forums has, over the past several decades, demanded more consideration of the ways in which constructs like “choice” are heavily conditioned by context, these approaches to bioethics largely remain “special interest” fields marginal to mainstream bioethics. Like Fox, philosopher Annemarie Mol has proposed a “logic of care” as an alternative to the “logic of choice” currently operating in biomedical systems, and we imagine an analogous reconsideration of the ethical frameworks of public health [40].

In a logic of care, the failure of states to provide not only the biomedical but also the economic and social resources that would allow citizen lives to be equitably protected from health catastrophe, while in democratic relationship with communities, would be cast not as a form of government that respected “autonomy” or “the rights of individuals to choose,” but as abject neglect. A powerful state would be one that could govern across the difference between autonomy and neglect.

These analyses lead us to conclude that the deeper need lurking in the problem of vaccine hesitancy is a re-imagination of the culture of public health and the essential relationships on which it depends. In the 1960 textbook *Epidemiologic Methods*, authors Brian MacMahon, Thomas Pugh, and Johannes Ipsen cautioned epidemiologists about the difference between actions that asked the public to change a behavior and actions that asked healthy people to add something foreign to their airs, waters, or places [41]. Their point was that the latter was much harder to legislate and implement, regardless of what the science on safety said. This did not mean that the intervention was not worthwhile or good, but that its acceptance would take broad political action and confidence. Their example in 1960 was water fluoridation, but a similar caution could be advised for how we approach vaccine hesitancy now. Rather than seeing the FDA’s regulatory standards for vaccine safety, much higher than for most drugs, as a technical matter, we might more productively understand them as a social negotiation wrought from complicated relationships among individuals, communities, and government authority [42]. Indeed, as epidemiologists, lawmakers, and social scientists (including historians) have long insisted, public confidence in vaccination programs depends on the work they do for the community—social, political, and moral as well as biological [43–45]. Recent implementation studies—for example of Ebola vaccine responses, malaria vaccine trials, polio eradication efforts and HPV vaccine scale up—underscore the importance of comprehensive community work [46–49]. Put another way, we might understand confidence in vaccines as a gauge for how much common value we have collectively constructed as a society that includes communities, individuals, and the state.

Will COVID-19 fix the problem of vaccine hesitancy? It may fix the problem with respect to a COVID-19 specific vaccination. But a failed vaccine—one in which major post-licensure toxicities occur—might also lead to public backlash with devastating consequences for routine childhood vaccination [50]. And however quickly the public rushes for a vaccine in this particular outbreak, and however successful this one-off vaccine may be, a broader confidence in vaccines after the charted epidemic passes will likely depend on widespread public trust that cooperation with preventive health directives will not equal catastrophe. For vaccination, or any pre-emptive measure, to take

root across a diverse public, we expect that constructs of care and social solidarity must be as strong as the desire to protect and determine our own futures and our faith in the possibility of being saved. We must practice these constructs in word as well as deed. This likely means a re-imagination of cultures of public health, in which the ideal of social solidarity is granted enough power to infuse and shift our guiding ethical constructs.

Is it possible that COVID-19 will teach this lesson? Much of that depends on how we make sense of, and make stories about, the failures and successes in our global and local responses to it. Will we tell stories about self-interest and personal responsibility? Or about those who seek common ground for multi-lateral cooperation and support for those whose livelihoods—and not just immediate lives—are threatened? Will our accounts fixate on the salvation that comes from a successful vaccine, if that vaccine does ever come, or will they focus our gaze on the unnecessary loss of life that came before and continued in quietly persisting social, economic, and biomedical tragedies after the epidemic officially concluded? Will we let these stories guide our policy actions? This narrative work needs to happen now, in this constitutional moment of crisis, and not just in the future’s retrospectives.

Once this particular epidemic has fallen into historical memory, the development of a vaccine for COVID-19 should not be the indicator of a successful response, nor should it indicate the achievement of an improved public health system. Vaccine confidence may be the better indicator.

Acknowledgements We thank David S. Jones and Jaap Goudsmit of Harvard University, and Phyllis Freeman of University of Massachusetts, Boston for insightful comments and discussion.

Funding Not supported by outside funding (EAH, JWW).

Availability of data References cited are available and accessible to the public.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

1. World Health Organization. Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19). February 2020. pp. 16–24.
2. Bill & Melinda Gates Foundation. The Goalkeepers Report 2018. 2020. <https://www.gatesfoundation.org/goalkeepers/report>. Accessed 3 Apr 2020.

3. Centers for Disease Control and Prevention (CDC). Ten great public health achievements—United States, 1900–1999. *MMWR*. 1999;48:241–3.
4. Homeland Security Council. National strategy for pandemic influenza: implementation plan. Washington, DC: Government Printing Office; 2006.
5. US Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. Crimson Contagion 2019 Functional Exercise Draft After-Action Report. October 2019.
6. Andersen RM, et al. How will country-based mitigation measures influence the course of the COVID-19 epidemic? *Lancet*. 2020;395:931–4.
7. Gates B. Responding to Covid-19—a once-in-a-century pandemic? *NEJM*. 2020. <https://doi.org/10.1056/NEJMp2003762>.
8. Dabbagh A, Laws RL, Steulet C, Dumolard L, Mulders MN, Kretzinger K, Alexander JP, Rota PA, Goodson JL. Progress toward regional measles elimination—worldwide, 2000–2017. *MMWR*. 2018;67:1323–9.
9. World Health Organization. New measles surveillance data for 2019. 2020. www.who.int/immunization/newsroom/measles-data-2019/en/. Accessed 3 Apr 2020.
10. Portnoy A, Jit M, Ferrari M, Hanson M, Brenzel L, Verguet S. Estimates of case-fatality ratios of measles in low-income and middle-income countries: a systematic review and modeling analysis. *Lancet Glob Health*. 2019;7:e472–81.
11. Centers for Disease Control and Prevention (CDC). Measles (Rubeola): cases and outbreaks. 2020. <https://www.cdc.gov/measles/cases-outbreaks.html>. Accessed 3 Apr 2020.
12. Robert A, Funk S, Kucharski AJ. The measles crisis in Europe—the need for a joined-up approach. *Lancet*. 2019. [https://doi.org/10.1016/S0140-6736\(19\)31039-6](https://doi.org/10.1016/S0140-6736(19)31039-6).
13. Yang L, Grenfell BT, Mina MJ. Measles vaccine escape: Should we be concerned? *Eur J Epidemiol*. 2019;34:893–6.
14. CDC. Flu vaccination coverage, United States, 2018–19 Influenza Season. 2019. <https://www.cdc.gov/flu/fluvaxview/coverage-1819estimates.htm>. Accessed 3 Apr 2020.
15. WHO. Ten threats to global health in 2019. 2020. <https://www.who.int/news-room/feature-stories/ten-threats-to-global-health-in-2019>. Accessed 3 Apr 2020.
16. Kahan D, Braman D, Cohen G, Gastil J, Slovic P. Who fears the HPV vaccine, who doesn't, and why? An experimental study of the mechanisms of cultural cognition. *Law Human Behav*. 2010;34:501–16.
17. Larson HJ, Schulz WS. Reverse global vaccine dissent. *Science*. 2019;364:6436.
18. Piot P, Larson HJ, O'Brien KL, N'kengasong J, Ng E, Sow S, Kampmann B. Immunization: vital progress, unfinished agenda. *Nature*. 2019. <https://doi.org/10.1038/s41586-019-1656-7>.
19. WHO. Vaccine Safety Net. 2019. https://www.who.int/vaccine_safety/initiative/communication/network/vaccine_safety_websites/en. Accessed 3 Apr 2020.
20. Benecke O, DeYoung SE. Anti-vaccine decision-making and measles resurgence in the United States. *Global Pediatr Health*. 2019;6:1–5.
21. Steelfisher GK, Blendon RJ, Caporello H, Ben-Porath E. Harvard Vaccination Poll. Harvard TH Chan School of Public Health and SSRS. 2019. <https://ssrs.com/harvard-vaccination-poll/>. Accessed 3 April 2020.
22. Robbins A. The CIA's vaccination ruse. *J Public Health Policy*. 2012;33:387–9.
23. Koh H, Gellin B. Measles as metaphor: what resurgence means for the future of immunization. *JAMA*. 2020;323(10):914–5.
24. Hammonds E. Childhood's deadly scourge: the campaign to control diphtheria in New York City. Baltimore: Johns Hopkins University Press; 1999.
25. Paul JR. Original text of Address to the ASCI. John Rodman Paul Papers, MS 1333 Series III, Box 18, Folder 4. Manuscripts and Archives, Yale University Library.
26. Frost WH. The age selection of mortality from tuberculosis in successive decades. 1936. *Am J Epidemiol*. 1995;141:4.
27. Conis E. Vaccine-Nation: America's changing relationship with immunization. Chicago: University of Chicago Press; 2015.
28. Walloch K. The Antivaccine Heresy: Jacobson v. Massachusetts and the troubled history of vaccination in the United States. Rochester: Rochester University Press; 2015.
29. Bhattacharya S, Harrison M, Worboys M. Fractured States: small pox, public health and vaccination policy in British India 1800–1947. Hyderabad: Orient Longman; 2005.
30. Dreze J, Sen A. India: development and participation. Oxford: Oxford University Press; 2002.
31. McMillen C, Brimnes N. Medical modernization and medical nationalism: resistance to mass tuberculosis vaccination in postcolonial India 1948–1955. *Comp Stud Soc Hist*. 2010;52:180–209.
32. Meade R. Civilizing Rio de Janeiro: the public health campaign and riot of 1904. *J Soc Hist*. 1986;20:301–22.
33. Needell JD. The Revolta Contra Vacina of 1904: the revolt against modernization in Belle-Epoque Rio de Janeiro. *Hisp Am Hist Rev*. 1987;67:233–69.
34. Rosenberg C. What is an epidemic? AIDS in historical perspective. *Daedalus*. 1989;118(2):1–17.
35. WHO. Implementation of the International Health Regulations (2005): Report of the Review Committee on the Functioning of the International Health Regulations (2005) in relation to Pandemic (H1N1) 2009. In: Presented to the 64th World Health Assembly, Provisional Agenda Item 13.2; 5 May 2011.
36. Nuzzo JB, Mullen L, Snyder M, Cicero A, Inglesby TV. Preparedness for a high-impact respiratory pathogen pandemic. A report of the Johns Hopkins center for health security. 2019. https://www.centerforhealthsecurity.org/our-work/pubs_archive/pubs-pdfs/2019/190918-GMPBReport-respiratorypathogen.pdf. Accessed 3 April 2020.
37. Interviewee Brandt AM. Lessons from Ebola: preventing the next pandemic. Interview by Jha A. HarvardX. September 2015. <https://www.edx.org/course/lessons-from-ebola-preventing-the-next-pandemic-2>. Accessed 3 April 2020.
38. Colgrove J, Bayer R. Manifold restraints: liberty, public health, and the legacy of Jacobson v Massachusetts. *AJPH*. 2005;95(4):571.
39. Fox R. The evolution of American bioethics. In: Weisz G, editor. Social science perspectives on medical ethics. Philadelphia: University of Pennsylvania Press; 1990.
40. Mol A. The logic of care: health and the problem of patient choice. London: Routledge; 2008.
41. MacMahon B, Pugh T, Ipsen J. Epidemiologic methods. Boston: Little, Brown, and Co.; 1960.
42. Marks H. The progress of experiment: science and therapeutic reform in the United States, 1900–1990. Cambridge: Cambridge University Press; 1997.
43. Freeman P. The biology of vaccines and community decisions to vaccinate. *Public Health Rep*. 1997;112(1):21.
44. Rosenberg C. The therapeutic revolution: medicine, meaning and social change in nineteenth century America. *Perspect Biol Med*. 1977;20(4):485–506.
45. Warner JH. The therapeutic perspective: medical practice, knowledge, and identity in America, 1820–1885. Cambridge: Harvard University Press; 1986.
46. Vibian A, Kamuya D, Mwachiro D, Kalama B, Marsh V, Njuguna P, Molyneux S. Complex realities: community engagement for a paediatric randomized controlled malaria vaccine trial in Kilifi, Kenya. *Trials*. 2014;15(1):65.

47. Enria L, Lees S, Smout E, Mooney T, Tengbeh AF, Leigh B, Greenwood B, Watson-Jones D, Larson H. Power, fairness and trust: understanding and engaging with vaccine trial participants and communities in the setting up the EBOVAC-Salone vaccine trial in Sierra Leone. *BMC Public Health*. 2016;16:1140.
48. Larson HJ, Bhutta ZA. Security, insecurity, and health workers: the case of polio. *JAMA Intern Med*. 2013;173(15):1393–4.
49. Wilson R, Paterson R, Chiu J, Schulz W, Larson H. HPV vaccination in Japan: The continuing debate and global Impacts. A Report of the CSIS Global Health Policy Center. 2015.
50. Fitzpatrick M. The cutter incident: how America's first polio vaccine led to a growing vaccine crisis. *J R Soc Med*. 2006;99(3):156.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.