


# We should not dismiss the possibility of eradicating COVID-19: comparisons with smallpox and polio

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## INTRODUCTION

Elimination and eradication of disease are among the ultimate goals of public health<sup>1</sup> (for definitions see [box 1](#)). Vaccination has globally eradicated smallpox, rinderpest (a cattle disease that caused famines<sup>2</sup>) and two of the three serotypes of poliovirus.<sup>3</sup> Three other vaccine-preventable diseases are eradicable globally with current technology,<sup>4</sup> with measles the leading contender and with MMR vaccination potentially eradicating mumps and rubella at the same time. Some other diseases are close to being eradicated but without use of vaccines such as with the Guinea Worm Eradication Programme.<sup>5</sup> Similarly, China has recently eliminated malaria with a range of non-vaccination tools, to become the 40th country to be certified malaria-free.<sup>6</sup>

Is COVID-19 also potentially eradicable? Or is it inevitably endemic having established itself across the world? Commentators have focused on the challenges of reaching population (herd) immunity,<sup>7</sup> yet population immunity is not essential and was not achieved for smallpox, which was eradicated through ring vaccination.

As proof of concept for COVID-19 eradication, several countries and jurisdictions have achieved elimination without vaccination, using new and established public health and social measures (PHSMs) (eg, border control, physical distancing, mask wearing, testing and contact tracing supported by genome sequencing).<sup>8</sup> Successful jurisdictions have included those with vast land borders such as China, high population densities such as Hong Kong,<sup>9</sup> but also island nations such as Iceland and New Zealand, although with occasional outbreaks from border control failures that have been brought under control.<sup>10</sup>

## Summary box

- ▶ With the success of public health and social measures (PHSMs) at eliminating COVID-19 in several jurisdictions, combined with the arrival of safe and highly effective vaccines, the question is raised: is global eradication of COVID-19 feasible?
- ▶ Our scoring for eradicability suggests that COVID-19 eradication might be slightly more feasible than for polio (although only two of three serotypes eradicated to date), but much less so than smallpox.
- ▶ The main challenges are probably around achieving high vaccination coverage and the potential need to update vaccine designs. Yet an advantage for COVID-19 eradication, over that for smallpox and polio, is that PHSMs can complement vaccination. There is also very high global interest in COVID-19 control due to the massive scale of the health, social and economic burden.
- ▶ There is a need for a more formal expert review of the feasibility and desirability of attempting COVID-19 eradication by the WHO or coalitions of national health agencies.

## Box 1 Definitions of key disease control terms from the Dahlem Workshop<sup>19</sup>

- ▶ **Control:** The reduction of disease incidence, prevalence, morbidity or mortality to a locally acceptable level as a result of deliberate efforts; continued intervention measures are required to maintain the reduction. Example: diarrhoeal diseases.
- ▶ **Elimination of disease:** Reduction to zero of the incidence of a specified disease in a defined geographical area as a result of deliberate efforts; continued intervention measures are required. Example: neonatal tetanus.
- ▶ **Elimination of infections:** Reduction to zero of the incidence of infection caused by a specific agent in a defined geographical area as a result of deliberate efforts; continued measures to prevent re-establishment of transmission are required. Example: measles, poliomyelitis.
- ▶ **Eradication:** Permanent reduction to zero of the worldwide incidence of infection caused by a specific agent as a result of deliberate efforts; intervention measures are no longer needed. Example: smallpox.
- ▶ **Extinction:** The specific infectious agent no longer exists in nature or in the laboratory. Example: none.



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**Table 1** Factors favouring the eradicability of vaccine-preventable diseases with comparisons between smallpox, polio and COVID-19 (graded for the relative strength of favourability in supporting eradication\*)

Factors favouring eradicability	Smallpox (eradicated)	Polio (2/3 wild serotypes eradicated)	COVID-19
<b>Technical factors favouring eradicability of vaccine-preventable diseases (from Hinman 1999<sup>4</sup>)</b>			
A highly effective and safe vaccine (preferably cheap and quite stable)	+++ Combined with ring vaccination of contacts this proved to be a 'great success' in smallpox eradication <sup>20</sup>	+ Suboptimal effectiveness where high enteric infection burdens exist; major problems with vaccine-derived poliovirus spread <sup>21</sup>	+ Uncertainty around length of protection, some adverse effects concerns with some vaccines; and cannot be used for contact management. Nevertheless, mRNA vaccines are likely to be further improved and there is potential with intranasal spray vaccines <sup>22</sup>
Lifelong immunity after natural infection or immunisation	+++ Immunity probably persists for decades <sup>23</sup>	++ See row above, although immunity probably life-long after natural infection	+ Not known but data suggest robust immune response to COVID-19 vaccines in general, and especially mRNA vaccines
A short period of communicability (no long-term carrier state)	+++	+++	+++
A highly characteristic clinical syndrome (preferably with no or few unapparent infections)	+++ Typically very distinctive skin lesions	Zero score Only around 24% of those infected develop clinical signs which are typically mild and non-specific <sup>21</sup>	+ While around 30% of infections are asymptomatic, <sup>24</sup> illness is typically more severe and some symptoms are more specific than for polio, for example, anosmia
An easy and reliable means of diagnosis	+++ See row above	+ Typically needs a laboratory test for diagnosis; acute flaccid paralysis occurs in 1 per 200 to 1 per 1000 cases	+ Needs a laboratory test for diagnosis
The absence of a non-human (or environmental) reservoir	+++ No such reservoirs	+++ No such reservoirs	++ There is some risk that other reservoirs might become established—see main text
A genetically stable causative agent, and seasonality of occurrence	+++ Stable and some evidence for seasonality <sup>25</sup>	++ Stable and seasonal in temperate zones but not the tropics <sup>26</sup>	+ New variants may be a problem with some vaccines <sup>27</sup> ; seasonality still unclear
<b>Additional technical factors favouring eradicability (author additions)</b>			
Relatively low transmissibility (basic reproduction number, R0) resulting in low population immunity threshold (PIT) and greater ease of achieving and sustaining sufficient vaccination coverage	++ R0=4.5, PIT=78% (source <sup>28</sup> )	+ R0=6.0, PIT=84% (source <sup>28</sup> )	+ Initially R0=2.5, PIT=60% (source <sup>28</sup> ), but as of mid-2021 with new variants circulating these figures are probably now much higher in most settings
Vaccination can be supported by PHSMs, for example, border controls, physical distancing, hygiene, improved ventilation, mask use, contact tracing (with quarantine and isolation) and community engagement	+++ Contact tracing with ring vaccination of these contacts proved to be a 'great success' with eradication <sup>20</sup>	+ Sanitation improvements can potentially play a role but are far more expensive than vaccination. Community involvement assists with national immunisation days <sup>29</sup>	+++ Important with PHSMs achieving elimination before vaccines were available in various Asia-Pacific countries <sup>10</sup>
Environmental surveillance can contribute	Not scored. Not included in the scoring as it is not relevant due to the highly characteristic clinical syndrome—see above.	+ Wastewater testing is used and can focus enhanced vaccination efforts <sup>30</sup>	++ Wastewater testing <sup>31</sup> is proving valuable in elimination settings (allowing enhanced additional surveillance)
<b>Additional socio-political and economic factors favouring eradicability (author additions and building on Dowdle 1998<sup>1</sup> and Hinman 1999<sup>4</sup>)</b>			
Governments can manage disease control messaging (eg, promote vaccination and/or PHSMs)	+++ Largely true for the eradication period 1959 to 1979	++ Largely true for much of the period 1988 to 2021, although eradication is ongoing for one serotype in two countries	+ Media, and especially social media, are now less favourable to the goals of government health messaging. Actual governments are involved in 'antiscience aggression' <sup>13</sup>
Public and political concern about the health burden from the disease (including on health inequalities)	++ At the time the programme started in 1959: probably moderate concern in the 59 countries with endemic disease; total of ≥20 million cases/year <sup>32</sup>	+ At the time the programme started in 1988: probably some concern in the 125 countries with endemic disease; total of 350 000 cases/year <sup>32</sup>	+++ Very high in nearly all countries; an estimated 7.1 million deaths globally from January 2020 to 3 May 2021 <sup>33</sup>

Continued

Table 1 Continued

Factors favouring eradicability	Smallpox (eradicated)	Polio (2/3 wild serotypes eradicated)	COVID-19
Public and political concern about the social and economic impacts of the disease (from illness and control measures required)	+	+	+++
	As per the row directly above; but also around the ongoing cost of vaccination in both endemic and non-endemic countries	As per the row directly above	Very high in 2021 in all countries. In the USA alone trillions of dollars have had to be spent because of the pandemic <sup>34</sup>
Public acceptability of control measures needed to achieve eradication (vaccination and PHSMs)	+++	++	++
	High acceptability given the very targeted interventions such as ring vaccination	Generally high acceptability of the vaccine, although occasional problems in some settings	Problems with vaccine hesitancy in some countries as of mid-2021 and resistance to some PHSMs, for example, mask wearing
Relatively low up-front cost of achieving eradication	+++	++	+
	Relatively low cost at US\$298 million in 1970s dollars <sup>35</sup>	Polio eradication efforts cost \$16.5 billion (US, nominal) for 1988–2018 <sup>36</sup>	Largely unknown, but the costs are probably vast (eg, \$66 billion to just vaccinate populations in low-income countries). <sup>37</sup> Major upgrading health systems in low-income countries might also be needed
Relatively favourable benefit to cost ratio of attempting and then achieving eradication	+++	++	+
	Very large benefit to cost ratios, 'probably the greatest global public investment in human history' <sup>35</sup>	Estimated incremental net benefits of eradication are very large at US\$28 billion in 2019 <sup>36</sup> (but there is still uncertainty around ultimate success—that is, the remaining serotype)	Unknown, but the benefit to cost ratio might still be very favourable given the possible high cost on health systems of endemic disease and if repeat vaccinations are required (as seen with influenza vaccination) <sup>38</sup>
Level of global cooperation to achieve the collective goal of eradication	++	+	+
	Initially the campaign 'suffered from a lack of funds, personnel, and commitment from countries, and a shortage of vaccine donations'. <sup>39</sup> But cooperation subsequently improved	There have been funding shortfalls <sup>29</sup> and in 2021 there was a high-income country (the UK) which cut funding support by 95% <sup>40</sup>	There have been vaccine shortfalls with the COVAX programme: 'about 200 million doses behind where we want to be'. <sup>41</sup> There are also concerns about 'new vaccine nationalism' and government-mediated 'antiscience aggression' <sup>13</sup>
<b>Totals and means</b> (with the highest score being +++ for each of the applicable categories)	Total=43/48; mean=2.7	Total=26/51; mean=1.5	Total=28/51; mean=1.6

\*Our preliminary assessment for the likely relative strength of favourability for each factor in terms of supporting the eradicability of each pathogen using the following scale: +++ high; ++ medium; + low, and 'zero score'.  
PHSMs, public health and social measures.

## COMPARISONS WITH SMALLPOX AND POLIO FOR ERADICABILITY

To make comparisons between smallpox, polio, and COVID-19, we consider established technical factors that favour the eradicability of vaccine-preventable diseases, published in 1999<sup>4</sup> (table 1). To this list we added additional technical, socio-political, and economic factors that are likely to favour achieving eradication. On our scoring for eradicability using a three-point relative scale across 17 variables, the mean (total) scores were smallpox at 2.7 (43/48), then COVID-19 at 1.6 (28/51), and finally polio at 1.5 (26/51) (table 1). While our analysis is a preliminary effort with various subjective components, it does seem to put COVID-19 eradicability into the realms of being possible, especially in terms of technical feasibility.

The technical challenges of COVID-19 eradicability (relative to smallpox and polio) include poor vaccine acceptance, and the emergence of more variants that may be more transmissible or have greater immuno-evasion, potentially allowing vaccine escape so they can outrun global vaccination programmes.<sup>11</sup> Nevertheless, there are of course limits to viral evolution, so we can expect the virus to eventually reach peak fitness<sup>12</sup> and new vaccines can be formulated.

Other challenges would be the high upfront costs (for vaccination and upgrading health systems), and achieving the necessary international cooperation in the face of 'vaccine nationalism' and government-mediated 'antiscience aggression'.<sup>13</sup>

Another concern is the risk of the persistence of the pandemic virus in non-human animal reservoirs. However, wild animal infections with SARS-CoV-2 appear to be fairly rare to date,<sup>14</sup> and when companion animals become infected they do not appear to re-infect humans.<sup>15</sup> Infections among farmed animals could potentially be controlled by quarantining and culling. Furthermore, COVID-19 vaccines for domestic animals are being developed (as they were for the eradication of rinderpest<sup>2</sup>) and oral vaccine in bait has effected successful regional elimination of rabies in wild foxes.<sup>16</sup> Furthermore, the problem of Guinea worm infection in domestic dogs has not stopped the global eradication efforts for that disease,<sup>5</sup> since various non-vaccination control measures can be successfully used in dogs.

On the other hand, the massive scale of the health, social and economic burden from COVID-19 in most of the world means that there is unprecedented global interest in disease control and massive investment in vaccination against the pandemic. There is also the advantage for COVID-19

eradication over these other diseases in that PHSMs can be highly effective and can complement vaccination. The upgrading of health systems to facilitate COVID-19 eradication could also have large co-benefits for controlling other diseases (and indeed eradicating measles as well). Collectively these factors might mean that an 'expected value' analysis could ultimately estimate that the benefits outweigh the costs, even if eradication takes many years and has a significant risk of failure.

### POTENTIAL NEXT STEPS

The preliminary assessment we have performed indicates the value of further work on the potential for the eradication of COVID-19. This work would ideally be done by the WHO, but failing that it could be done by coalitions of national-level agencies working collaboratively. Any expert review needs to consider two main questions: (1) Could sustained COVID-19 eradication be technically feasible with currently available technologies? (2) Should eradication be attempted based on its desirability in terms of benefits versus costs (which provides the context of opportunity cost) and the risk of failure? It should also take a more sophisticated approach than we have by giving the different categories weights and also by making comparisons with measles, where elimination has been achieved at times for large regions (eg, the Americas<sup>17</sup>) and which is potentially eradicable.<sup>5</sup> Modelling work that integrates both the health and economic aspects of COVID-19 control (as per recent work in Australia<sup>18</sup>) should also inform the decision-making processes.

### CONCLUSIONS

In this very preliminary analysis, COVID-19 eradication seems slightly more feasible than for polio, but much less so than for smallpox. There is a need for a more formal expert review of the feasibility and desirability of attempting COVID-19 eradication by the WHO or other agencies.

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**Contributors** NW, ODM and MB are New Zealand based public health physicians/epidemiologists. AK is an epidemiologist. MJ is a philosopher and catastrophic risks researcher. Content of this analysis was drawn from the experience of smallpox and polio eradication and on the epidemiology and control of COVID-19 to date. NW conceived the paper and wrote the initial draft. MJB and MB contributed to methodological issues. All authors contributed to revisions of the text. All authors approved the final version of the manuscript.

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