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Elimination could be the optimal response strategy for covid-19 and other emerging pandemic diseases

Michael Baker and colleagues argue that aiming for elimination of community transmission of the SARS-CoV-2 virus could offer important advantages over a suppression or mitigation strategy with ongoing transmission

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The covid-19 pandemic might be remembered for the astonishingly rapid development of effective vaccines. But it should also be remembered as the first respiratory disease pandemic in which non-pharmaceutical interventions were widely used to eliminate transmission, including in large countries such as China. As the covid-19 pandemic continues to intensify across much of the globe, many countries are increasing their use of non-pharmaceutical interventions such as “lockdowns” to mitigate its harmful effects. Here we describe the potential benefits of using an elimination strategy to minimise the negative health and economic effects of the covid-19 pandemic. Pursuing

this strategy will become more feasible when effective vaccines are widely available.

Strategic choices for pandemic responses

The typical approach of high income nations (such as those in North America and Europe) has been a “suppression strategy,” sometimes after initial use of a “mitigation strategy” (fig 1). The goal of suppression is to flatten the epidemic curve further than with mitigation, but still without expecting to end community transmission.¹ These approaches are largely consistent with plans designed to mitigate or suppress pandemic influenza.

* **Pandemic interventions:** Border controls to “keep it out”; testing, contact tracing, case isolation and contact quarantine to “stamp it out”; improved hygiene behaviours and use of masks; physical distancing; movement restrictions; combinations including “lockdown”; vaccines; antimicrobials
NB. There are multiple other interventions to reduce harm, including protecting vulnerable populations, reorienting health services, social and economic support

Fig 1 | Strategic choices for responding to covid-19 and other pandemics. These choices can be divided according to goal: no community transmission (exclusion and elimination), controlled transmission (suppression and mitigation), or uncontrolled transmission. Some jurisdictions pursuing elimination describe this goal as containment. Although the framework divides approaches into five strategies, they exist on a continuum in and between categories. Countries may also change their strategic direction based on experience with controlling the pandemic.

By contrast, China’s success in containing the pandemic has shown that SARS-CoV-2 can be eliminated even after widespread community transmission.² Several other Asian jurisdictions also achieved some success in containing the pandemic at an early stage, notably Taiwan,³ Hong Kong,⁴ and South Korea.⁵

Confronted with the rapidly spreading covid-19 pandemic in January 2020, New Zealand initially rolled out its existing national influenza pandemic plan as the basis for its response. Australia did

likewise. Fortunately, both countries had a brief period to refine their approaches before the first reported covid-19 case arrived on 25 January in Australia and 26 February in New Zealand. This timing gave them an opportunity to learn from the effects of the pandemic on countries in the northern hemisphere and consider the different response strategies (fig 1).

The New Zealand government chose an explicit elimination approach.^{6,7} Australia also has elimination of community transmission as the stated

goal, but has generally described its strategy as “aggressive suppression.”⁸ A related strategy that also aims to achieve zero community transmission is the exclusion approach that has been successfully used by some Pacific Island countries and territories (fig 1).

The goal of elimination is a major departure from pandemic influenza mitigation. With a mitigation goal, the response is typically to increase stringency as the pandemic progresses and for more disruptive interventions, such as school closures, to be held in reserve to flatten the peak. By contrast, the goal of elimination rapidly escalates the stringency of control measures to extinguish chains of transmission.

Choosing a strategy is not necessarily a fixed path, and countries might change their approach. Sweden, for example, initially seemed to pursue a version of mitigation with the intent of achieving herd immunity and then seemed to switch to a suppression strategy.⁹

Defining disease elimination

Disease elimination has been used to control a wide range of human and animal infectious diseases, although an effective vaccine is generally required for the final phase.¹⁰ Eradication refers to the global reduction to zero (for example, smallpox and the animal disease rinderpest).

There is no internationally agreed definition of covid-19 elimination. But there are three main elements that we would expect to see in such a definition (box 1).^{11 12} Countries pursuing elimination aim for zero transmission in the community but accept that outbreaks from border control failures might occur, resulting in a temporary loss of elimination status until community transmission is again stopped.

Box 1: Provisional definition of covid-19 elimination

A definition for elimination of covid-19 could include the following three components (modified from¹¹):

- *Absence of newly diagnosed SARS-CoV-2 virus infections from community transmission*—within a defined jurisdiction or region, for a specified period (such as 28 days since the last known case in the community was placed into isolation)
- *Presence of a high performing surveillance system*—with appropriate targeting and geographic and demographic coverage, operating continuously, with sufficient volumes of testing to provide reasonable certainty of detecting outbreaks in a set period (for example, testing a specified minimum number of people per 1000 population per day or a specified minimum number of tests per day)
- *Acceptance of suitable exemptions*—such as cases of SARS-CoV-2 infection among incoming travellers detected at the border and held in supervised isolation or quarantine facilities until safe to release into the community and potentially cases of community transmission that are epidemiologically and genomically linked to staff or a traveller in an isolation or quarantine facility.

Achieving and sustaining disease elimination

New Zealand and Australian experiences of the covid-19 pandemic offer lessons for achieving and sustaining elimination (see supplementary file online for additional details).

Firstly, elimination is more likely to be achieved quickly with informed scientific input, strong political commitment, and decisive action. To achieve elimination, New Zealand probably had no feasible alternative to a national lockdown (which began on 26 March 2020). The country's public health infrastructure was at a low point after decades of neglect.¹³ Time was needed to expand

essential activities such as testing and contact tracing. A lockdown was probably also required to ensure that the population would swiftly understand and adhere to the physical distancing behaviours needed to limit spread of the virus.^{6 7 14} Better preparedness, as seen in countries that experienced the SARS pandemic in 2003, reduced the need for stringent lockdowns, as exemplified by Taiwan.^{15 16}

Secondly, investment in three broad categories of public health infrastructure is needed to achieve elimination or quickly regain it in the event of an outbreak: border management with closely supervised quarantine of all arrivals from places that have not eliminated the virus; case based control measures, notably testing, case isolation, contact tracing, and quarantine; and population based interventions such as physical distancing and mask use. In addition, disease surveillance, coordination, and communication activities are critical to delivering an effective response.^{7 14 17}

Thirdly, outbreaks arising from border control failures might occur after elimination has been achieved and these require swift and decisive action. New Zealand experienced such an outbreak after three months without a case in the community (see supplementary file online). This outbreak was brought under control and elimination status regained after extensive testing, contact tracing, physical distancing, and mandated use of masks. Improved case based controls enabled these interventions to be geographically targeted with a shorter and less intense lockdown. The state of Victoria in Australia experienced a major resurgence peaking at over 700 cases a day yet managed to eliminate community transmission in three months using lockdowns and a detailed plan (“roadmap”) underpinned by modelling.⁸

Finally, given the inevitable loss of employment and other social disruption when stringent lockdowns are used, a range of health, social, and economic support measures are likely to be required.^{7 14} The New Zealand government's response has included multiple economic actions and income support measures to protect the most disadvantaged people. Australia was likewise rapid to implement economic support nationally to employers who kept workers on the payroll while unable to work. It also dramatically increased unemployment benefits for those becoming unemployed, and states and territories such as Victoria also initiated support packages.

Benefits, costs, and areas of uncertainty with disease elimination

Achieving elimination offers major advantages, but also some disadvantages, compared with a suppression strategy that allows continued virus circulation. The balance of benefits and costs is uncertain, however, and may not be clear until after the pandemic has been fully controlled (see supplementary file).

Obvious benefits of rapid elimination are greatly reduced case numbers, a lower risk of health sector overload, and fewer overall deaths from covid-19. There is also an opportunity to avoid serious health inequalities, such as the catastrophic effect of previous pandemics on Māori, the Indigenous people of New Zealand.¹⁸ Similar concerns apply to the health of Indigenous Australians.¹⁹ Given the growing evidence for long term effects from SARS-CoV-2 infection, there are also benefits from reducing the numbers of even mild infections.²⁰

One of the perceived barriers to applying a vigorous response, such as elimination, to the covid-19 pandemic is the belief that this might sacrifice the economy and ultimately result in more hardship and negative health effects. Our preliminary analysis suggests that the opposite is true. Countries following an elimination strategy (notably China, Taiwan, Australia, and New Zealand) have had markedly

lower covid-19 mortality than those in Europe and North America pursuing mitigation and suppression. Similarly, the effect on gross domestic product (GDP), based on International Monetary Fund projections for all of 2020, was more favourable for countries with elimination goals than for those with suppression goals (see supplementary file).

However strategic choices are assessed, the benefits and costs need to be considered using realistic alternative scenarios or counterfactuals. International tourism, for example, is substantially reduced regardless of individual countries having border control restrictions. Iceland reopened to tourism but the demand remained low, imported cases of covid-19 increased, and the net effect was a larger decline in GDP than was seen in New Zealand.²¹

Given the huge costs of the pandemic response, gaining as many co-benefits as possible is important (see supplementary file). One such benefit is improved public health infrastructure that can support a more rapid and effective response to future pandemics, as seen in Taiwan.¹⁵ The covid-19 pandemic response has also emphasised the importance of integrating scientific advice into decision making that could improve capacity to respond to a range of major existential threats including climate change.

Future use of the elimination strategy

Several institutional, technical, and scientific actions could enable more widespread adoption of elimination approaches and better chances of success for jurisdictions already committed to an elimination goal (box 2). The World Health Organization would be the ideal agency to facilitate some of these institutional measures, supported by other agencies. Technological advances in such areas as rapid point-of-care antigen testing could make elimination more feasible.²³

Box 2: Actions to support use of an elimination strategy for covid-19 and future pandemic diseases

Institutional actions, including guidelines

- Develop a standard definition for covid-19 elimination (box 1)
- Revise WHO reporting processes and standards to accurately represent the covid-19 elimination status of countries, notably to distinguish imported cases (who acquired their infections outside that country and are in isolation/quarantine facilities) from those in the community and to report if they have achieved elimination (box 1) and the date this was reached
- Develop a process for review of country progress towards elimination to facilitate quarantine-free movement between countries meeting agreed standards (analogous to the verification approach applied to elimination of diseases such as polio, measles, and rubella)
- Identify conditions and infrastructure needs to support an elimination approach at national and subnational levels (for example, by state and territory in Australia)
- Develop evidence informed guidelines for approaches that countries can use to engage populations in disease elimination programmes, including partnerships with at-risk groups in pandemic strategy decision making; ensuring transparency and accountability; effective public communication
- Establish a network of agencies to share scientific knowledge about the elimination approach
- Revise pandemic plans to reflect the role of elimination as a potential method for responding to future severe pandemic disease threats, including pandemic influenza. These plans could include a typology of strategic response options (fig 1) and guidelines to help select an optimal approach (including exclusion strategies²²).

Technical and scientific actions

- Improve SARS-CoV-2 testing, notably rapid, low cost, point-of-care antigen testing
- Develop tools to support rapid contact tracing, notably digital and analytical tools that enhance manual contact tracing
- Evaluate and document case studies and methods used to achieve elimination of SARS-CoV-2 community transmission (eg, mandated mass masking)
- Analyse and evaluate optimal use of the elimination approach (relative to control options such as mitigation and suppression), notably its role in complementing future vaccination scenarios
- Conduct an integrated epidemiological and economic analysis of future pandemic management choices (fig 1) to guide decision making that considers wider medium and longer term health, equity, and economic effects.

Experience with covid-19 elimination indicates that this goal is achievable in a wide range of settings. Elimination seems to be the dominant strategy in multiple Asian jurisdictions, including China, Hong Kong (China), Taiwan, Singapore, Vietnam, Cambodia, Laos, Thailand, and Mongolia. Future collaborative research could consider all these jurisdictions to provide a more comprehensive assessment of the effects of the elimination approach. Experience in Asia and in some states in Australia is that long complex borders can be managed to largely prevent importation of covid-19 from adjacent jurisdictions. Conditions favouring successful elimination include informed input from scientists, political commitment to take decisive action, sufficient public health infrastructure to deliver the necessary interventions, public engagement and trust in the measures being taken, and a social safety net to support vulnerable populations.

The introduction of effective covid-19 vaccines is also likely to facilitate elimination. Countries and jurisdictions combating the pandemic will need to consider two main choices. They could take a control approach (suppression) using a range of vaccination strategies to protect the most vulnerable people (as with seasonal influenza) and accepting that SARS-CoV-2 virus infection might become endemic in their population. Or they could follow an elimination strategy using vaccination systematically to reduce transmission to zero in the population and to help contain outbreaks if they occur (as most countries now approach measles). Global eradication could eventually be considered if national and regional elimination proves feasible and if it is justifiable based on economic analysis, as was the case with smallpox.

Some of the most important lessons from the covid-19 response are about the management of future pandemics. Elimination is probably the preferred strategy for responding to new emerging infectious diseases with pandemic potential and anything more than moderate severity, particularly while key parameters are being estimated. Some biological and ecological factors also need to be considered before deciding that a novel disease can be eliminated, notably the role of animal reservoirs.¹⁰ Non-pharmaceutical interventions are usually the only early interventions available. The experience of Asia-Pacific countries such as China, Taiwan, Australia, and New Zealand shows the benefits of applying these measures rapidly and intensively with the goal of elimination. The New Zealand response also eliminated seasonal influenza in the winter of 2020, showing that it is also a potential option (cost effectiveness aside) for preventing future influenza pandemics.²⁴

Conclusions about use of the elimination strategy

Experience indicates that elimination of covid-19 has been successful in several jurisdictions, albeit with occasional outbreaks from border

control failures that need to be managed rapidly and effectively. Elimination is associated with major public health and equity benefits, and it probably reduced overall economic contraction relative to the suppression strategy. It also has the potential to support covid-19 containment while long term interventions, notably vaccination, are being developed, assessed, and implemented.

We need tools and guidelines to support decision making around effective use of elimination approaches for responding to covid-19 and future pandemics (box 2). Research and development are needed to provide a greater evidence base on the circumstances where the elimination strategy is likely to be the optimal approach.

Key messages

- A goal of eliminating community transmission of the pandemic virus causing covid-19 (SARS-CoV-2) is achievable and sustainable for some jurisdictions using non-pharmaceutical interventions and will be facilitated by the introduction of effective vaccines
- Elimination of community transmission offers public health, equity, and potentially economic advantages compared with a control strategy using mitigation or suppression
- Conditions favouring successful elimination include informed input from scientists, political commitment, sufficient public health infrastructure, public engagement and trust, and a safety net to support vulnerable populations
- Elimination might be the preferred strategy for responding to new emerging infectious diseases with pandemic potential and moderate to high severity, particularly while key parameters are being estimated

Contributors and sources: The authors have all been involved in researching aspects of the covid-19 pandemic and response, providing expert advice to health agencies, and commentary via science and mass media. MB initiated and drafted this paper. He is a member of the New Zealand Ministry of Health's covid-19 technical advisory group (TAG). MB and NW took leading roles in formulating New Zealand's elimination strategy. TB has been a prominent epidemiological commentator in Australia on covid-19 and has been involved in providing modelling to the Victorian Department of Health and Human Services to underpin its roadmap out of the midyear resurgence and to achieve elimination. This paper draws on publicly available data and information.

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