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All authors were involved in the development of the concepts presented in this Comment and contributed to writing and editing of the content.

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T.R.R.'s wife is a consultant to AstraZeneca. All other authors declare no competing interests.

An equitable roadmap for ending the COVID-19 pandemic

Many governments are rolling back restrictions, but the pandemic will end only with a renewed focus on equitable distribution of vaccines and therapeutics, responsive public health plans, and policies to protect the vulnerable.

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More than 2 years into the COVID-19 pandemic, it remains unclear when and how it will end. The global outcome is dependent on multiple factors: the level of cooperation between governments; equitable access to vaccines, testing and therapeutics; local government action and the response of citizens; and competing outbreaks, conflicts or natural disasters. Ending the pandemic will also require a focus on the elderly and other vulnerable populations, as well as those in low- and middle-income countries (LMICs).

Divergent policies

Many governments recalibrated their COVID-19 strategies in response to the global surge of infections with the SARS-CoV-2 Omicron variant, but considerable international variations in public health approaches remain. There are broadly three types of approach: removing all restrictions (exemplified by the United Kingdom); continuing to implement mitigation measures to protect the vulnerable (for example, South Korea); and pursuing a suppression, or 'zero COVID-19', approach (for example, Hong Kong and mainland China).

Where the transmission of Omicron rose sharply, but then decreased, governments relaxed mandates and limited population-wide intervention of some public health and social measures. In these populations, the relative epidemiological risk of COVID-19 to vulnerable groups to severe infection is likely to reduce, due to high levels of vaccine-induced and/or naturally acquired population immunity. This should also enable the effective reproduction number to stabilize below 1, with the potential to increase again if SARS-CoV-2 becomes a seasonal virus. For example, the overall seroprevalence was 73% in Gauteng, South Africa, before the Omicron wave[1]. In the United Kingdom, the proportion of adults who tested positive for antibodies across all nations is estimated to be around 98% (ref. [2]). Delta previously had a devastating effect on the United Kingdom, and so hospitalizations and deaths[3] were much lower for the Omicron BA.1 variant wave than for the Delta wave.

The UK government will see all public health and social measures abolished in England by Spring 2022, including the need to isolate and the availability of free testing[4]. The rationale for this is the substantial cost burden of maintaining COVID-19 policies, such as testing, and the adverse effect that these interventions have on other essential public services, such as education and mental health support[4].

It is possible that many other countries will adopt similar relaxation approaches as they emerge from Omicron waves. However, it should be noted that many groups in the world will remain vulnerable to severe infection, such as the elderly, the immunocompromised, and patients with medical conditions that include chronic kidney disease, chronic lung disease and cardiovascular disease[5].

From suppression to mitigation

Most governments have retained non-pharmaceutical interventions to mitigate infections. As of 12 February 2022, the use of face coverings in all public spaces was required in 152 countries, whereas mass asymptomatic testing was operational in 114 countries. Contact tracing continues in 136 countries, 77 of which perform comprehensive tracing of all cases[6].

Some governments, mainly in East Asia and the Pacific[7], are continuing with a suppression strategy to eliminate SARS-CoV-2 infections, but this is challenged by the transmissibility of Omicron. Given the large numbers of immunologically naive people, governments with a suppression approach may shift to a mitigation approach to protect the operational capacities of their national health systems[7].

Chile, Hong Kong, New Zealand and South Korea, all of which have large elderly populations, are all currently confronting substantial cases of the Omicron variant (Table 1). South Korea previously adopted a maximum suppression approach with success[8], but it has pivoted toward a targeted 'Living with COVID-19' strategy — one that prioritizes vulnerable and elderly patients for testing and free medical kits, and promotes treatment at home for mild cases and the use of designated clinics for more severe cases[9]. The onset of Omicron, coupled with the relaxation of several COVID-19 mitigation measures in South Korea, has seen cases rise, although high vaccine coverage has helped keep the number of hospital admissions and deaths to manageable levels.

New Zealand has had a similar experience, wherein the phasing out of a COVID-19-elimination strategy at the same time as the emergence of the Omicron variant resulted in a surge in cases. However, a recently highly vaccinated population and vaccine mandates for essential workers have helped minimize intensive care unit (ICU) admissions and deaths. In contrast, Hong Kong has continued to pursue a suppression approach but is experiencing substantial hospital admissions and the highest death rate from COVID-19 in the world. This is

Table 1 | COVID-19 profile and response measures in selected locations

Indicators		Chile	Hong Kong	India	New Zealand	South Korea	South Africa	United Kingdom	United States
Demographics	**Population total**	19,212,362	7,552,800	1,393,409,033	5,126,300	51,305,184	60,041,996	68,207,114	332,915,074
	Over 65 years of age (%)	11	16	6.0	15	14	5.3	19	15
Epidemiology	**Daily cases (per million)**	1,021	4,316	5.4	4,702	4,273	27	1,459	141
	Positivity rate (%)	28	0.15	1.2	26	32	7.7	5.3	5.3
	COVID-19 deaths (per million)	8.0	33	0.16	0	1.9	0.3	3.9	5.1
	Excess mortality (%)	18.19	2.99	NA	-3.74	1.16	22.94	10.24	16.07
Utilization of healthcare resource	**Hospitalization (cases per million)**	NA	932 (ref. [21])	NA	79 (ref. [22])	1.7 (ref. [23])	39 (ref. [24])	155	118
	ICU cases	1,079	60 (ref. [21])	NA	10 (ref. [22])	715	247 (ref. [24])	290	7,547
Vaccination	**Vaccination coverage, initial course (%)**	89.6	68.8	56.8	77.3	86.5	28.8	71.9	64.7
	Booster policy (offered to all adults unless otherwise specified)	Second booster (February 2022)	First booster (December 2021)	First booster only for HCWs, HRGs and people over 60 years of age (January 2022)	First booster (3 months after initial course) (February 2022)	Second booster for HRGs only (February 2022)	First booster (Febraruy 2022)	Second booster only for HCWs, HRGs and people over 75 years of age (March 2022; autumn 2022 booster planned)	First booster (November 2021)
	Vaccination for children (types, eligible age)	CoronaVac (children over 3 years of age)	BNT162b2 (children over 3 years of age)	BBV152 (children 15–18 years of age; those 5–15 years of age, under consideration)	BNT162b2 (children over 5 years of age)	BNT162b2 (children over 5 years of age)	BNT162b2 (children over 12 years of age)	BNT162b2 (children 5–12 years of age, and HRGs) Booster (children over 12 years of age (in England, Ireland and Wales) and HRGs (in Scotland))	BNT162b2 (children over 5 years of age; those 6 months to 4 years of age, under consideration)
Access to antivirals	**Ritonavir-boosted nirmatrelvir (courses)**	Excluded from licensing deal	≤3,000 (estimate)	Needs local clinical trials	60,000	31,000	Awaiting approval	2.75 million	20 million
	Molnupiravir (courses)	NA	≤3,000 (estimate)	Approved	60,000	Awaiting approval	Approved but not purchased	2.23 million	3.1 million
Current key public health measures	**Testing**	Antigen tests not widely available	Planning a compulsory universal testing	Antigen tests available in the private sector	Free antigen tests available when required	Prioritizing high-risk populations	Public testing free of charge	Free lateral flow and PCR test to cease on 1 April 2022 (England); limited tests available for HCWs and HRGs	Every household eligible to order four free tests
	Masking	Mandated	Mandated	Mandated but declining adherence	Mandated	Mandated	Mandated; loosening restrictions	No longer mandated	Lifted in many states
	Restrictions	Mobility pass required for interstate trips	Small curbs possible	Full vaccination required for entry into public places in some states	Opening schools and workplaces	Quarantine imposed on international travelers	Reopening schools	'Living with COVID' plans being implemented	Loosening in many states

Quantitative data were extracted from Our World in Data database (unless otherwise noted; https://github.com/owid/covid-19-data/tree/master/public/data) and refs. [21–25]. A comprehensive list of references for Table 1 is available (http://globalhealthgovernance.org/covid19). For the Our World in Data database, the variables included are as follows: population, aged_65_older, new_cases_per_million, positive_rate, new_deaths_per_million, excess_mortality_cumulative, hosp_patients_per_million, icu_patients, and people_fully_vaccinated_per_hundred. Excess mortality is defined as 'percentage difference between the reported number of weekly or monthly deaths in 2020–2021 and the projected number of deaths for the same period based on previous years'. Definitions for other variables also are available (https://github.com/owid/covid-19-data/tree/master/public/data). Data for daily cases, positivity rate, COVID-19 deaths, hospitalizations, ICU cases, and vaccination coverage were all obtained between 8 February 2022 and 5 March 2022; excess mortality data were obtained between 30 November 2021 and 20 February 2022. Vaccine sources: BNT162b2, Pfizer–BioNTech; BBV152, Bharat Biotech; CoronaVac, Sinovac. HCW, healthcare worker; HRG, high-risk group; NA, not available.

Table 2 | Three possible scenarios for ending the pandemic

	Scenario 1: optimistic	Scenario 2: likely	Scenario 3: pessimistic
Global vaccination coverage	Adequate	Inadequate	Inadequate
Vaccination policies	Rapid development of vaccines against potential new variants	Inadequate supply chain, combined with vaccine hesitancy, leading to insufficient coverage in some states	The emergence of new variants that escape immunity
	Equitable distribution based on risk assessment	Nationalist vaccine policies	Global vaccine shortages
	Strong supply-chain management	New variants that disproportionately affect LMICs	
	Culturally sensitive policies to deal with vaccine hesitancy		
Antiviral policies	Available and equitably distributed at the global level	Available but not globally or equitably distributed	Not available and/or ineffective against future emerging variants
Public health policies	Agile policies based on types of variants, the level of immunity, and the population at risk	Relaxation of public health measures without risk assessment	Difficulty in re-implementing strong public health measures, despite the emergence of new variants
	Strengthening of health systems	Inadequate investment in health systems, leading to the collapse of the health service in some states	
End of the pandemic	Near and simultaneous in HICs and LMICs	Sooner in HICs	Not near

presumably due to relatively low population immunity in high-risk groups, either from past infection or from vaccination; only 30% of those over 80 years of age are vaccinated. Chile, a country that utilized strict non-pharmacological measures such as lockdowns throughout the pandemic, has also experienced high ICU admissions and death rates from Omicron. The halting or reduction of key public health measures in Chile, such as social distancing, testing and isolation requirements, has probably contributed to this fifth surge in cases.

New variants

The emergence of new variants remains a concern for all of the world. Although the existing vaccines remain effective against the emerging Omicron sublineage BA.2[10], and reinfection by sublineage BA.2 after infection with BA.1 appears to be rare[11], there is no guarantee that vaccines will work against future variants. Thus, governments that have relaxed restrictions, either partially or completely, will need to remain vigilant and agile in responding to situational changes, with a view to escalating mitigation measures in the event of resurgence. If a new variant emerges, high-income countries (HICs) that have robust health systems, access to effective antivirals such as ritonavir-boosted nirmatrelvir, and updated booster vaccines should be able to respond effectively. On the other hand, LMICs with fragile health systems and limited access to antivirals or vaccines will face a considerable challenge if a new variant becomes prevalent.

Unlike the United Kingdom or South Africa, the United States observed a record number of hospitalizations as a result of the Omicron variant, as one-third of the population had not yet been vaccinated and few booster doses had been administered. Furthermore, Omicron cases peaked while the Delta variant was still circulating. Vaccinations, the availability of antivirals and other treatments, free mass testing, and the use of stringent public health measures seem to have reduced the proportion of infected people admitted to ICU and the death rates, compared with past waves. A focus on vaccinations, boosters and targeted public health measures for addressing Omicron may provide an indication of future responses to new variants.

Scenarios for ending the pandemic

The trajectory of vaccination coverage and government responses signal three possible scenarios for an end to this global pandemic (Table 2). The most optimistic scenario is that the pandemic will end soon and simultaneously in both HICs and LMICs. A second, more likely scenario is that the pandemic will be less disruptive sooner in HICs than in LMICs. The worst scenario is the emergence of a new variant that is more transmissible and has considerable ability to evade the immune system, which prolongs the pandemic.

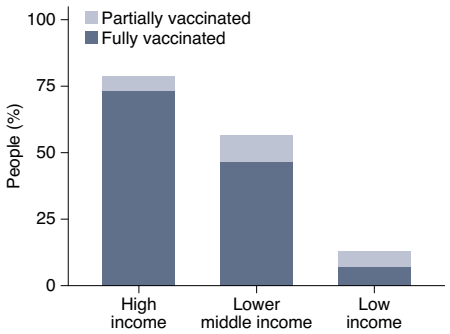

Fig. 1 | Vaccination coverage rates in high- and low-income countries. 'Partially vaccinated' indicates the proportion of people who have not completed an initial protocol, and 'fully vaccinated' indicates people who have completed an initial protocol. Our World in Data (https://github.com/owid/covid-19-data/tree/master/public/data), accessed 27 February 2022.

There are three priorities that governments should focus on to help end this pandemic in all countries, as well as to prepare for a worst-case scenario wherein the pandemic continues into 2023 and beyond.

First, equitable production, supply and distribution of COVID-19 vaccines is critical for expanding full vaccination coverage and building immunity across countries (current vaccination rates, Fig. 1). Vaccine donations are commendable but not sustainable[12]. The low vaccine uptake in LMICs is slowing

the end of the pandemic (scenario 2, Table 2). As of 25 February 2022, the projected vaccine coverage (at least one dose) was 61% globally, but this rate dropped to 15% in the World Health Organization African Region, although vaccine supply provided by the vaccine-access facility COVAX has finally exceeded demand. Lack of vaccine equity suggests that COVID-19 will continue to affect LMICs disproportionately, even if HICs observe an end of regional epidemics.

Local and regional vaccine research and manufacturing needs to be supported and strengthened in LMICs through emergency waivers of intellectual property rights and licenses, as well as the sharing of technicological know-how[13]. The mRNA technology hub in South Africa is facilitating the transfer of technology and licenses to manufacturers in LMICs and is a leading exemplar of much-needed global collaboration for vaccine equity[14]. Research on vaccines that prevent infection with variants and provide longer immunity needs to be funded and made accessible globally. While building capacity for locally produced vaccines will take time, governments can mobilize resources to produce essential equipment, medicines and devices without intellectual property limitations, and to diversify supply chains, repurpose medicines and encourage public–private partnerships[15]. Rapid, low-cost testing that accurately detects SARS-CoV-2, combined with the provision of low-cost antiviral pills, such as molnupiravir and ritonavir-boosted nirmatrelvir, that are readily accessible to the public, will potentially be a game-changer to end the pandemic in LMICs.

Second, individual governments need an evidence-based public health plan[16] that can rapidly respond in the event of a potential threat from an emerging variant. This should include the following: regular risk assessment through surveillance; the ability to reintroduce effective and low-cost public health measures such as masking; preventing disruptions to essential health services; and, most importantly, rebuilding public trust in government[17] through transparent, timely and clear risk communication. Within countries, provinces, states or devolved nations might lack the ability to implement timely actions because of federally made financial decisions, so plans for decentralized decision-making need to be supported with fiscal autonomy.

Third, the most vulnerable must be protected. This is both an ethical imperative and essential for ending this pandemic. Two types of vulnerable populations should be considered: those who are more susceptible to SARS-CoV-2 infection (such as healthcare workers), and those who are at risk of severe COVID-19 (such as the immunocompromised). In addition to prioritizing those who are vulnerable to severe infection, healthcare workers must also be safeguarded; they have suffered from stress, anxiety, burnout, depression, insomnia and other mental and physical health consequences, both from the risk of infection and from an increased workload[18]. Governments and healthcare institutions need to safeguard healthcare workers through occupational health support, ensuring rest and practical support, proactive organizational policies and a culture of support[19]. Resources must also be allocated to address post-acute consequences of infection, the so-called 'long COVID', including a multidisciplinary approach to assessment and management of disease, appropriate support systems, especially at the primary care level, as well as employment rights, sick-pay policies and disability benefits[20].

Pandemics do not end with a parade or a negotiated armistice. They end when the disease fades into the background and other, more pressing daily concerns come to the forefront. Ultimately, countries will need to define and decide what levels of transmission are acceptable and how to control the virus without burdening health systems and avoid adverse health and socio-economic consequences, all in an interconnected world. ❐

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Data used in this paper are open access under the Creative Commons BY license and are available from *Our World in Data* (https://github.com/owid/covid-19-data/tree/master/public/data). Replication code and a comprehensive list of references for Table 1 are available at http://globalhealthgovernance.org/covid19. This Comment is dedicated to the memory of Paul Farmer, given his dedication to addressing health inequities across the world and the importance of a social justice approach to ending epidemics.

Author contributions

M.M. conceptualized the study, performed data analysis and contributed to writing and editing throughout. I.H. conceptualized the study and contributed to data analysis, writing and editing throughout. G.F. contributed to the gathering of data, analysis, drafting and editing the final draft. L.K. contributed to writing, commented on and edited the final draft. J.P. contributed to writing and editing the final draft and validating the data. D.S. conceptualized the study and made revisions on the final draft.

Competing interests

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