Escaping COVID-19: Will vaccines be sufficient?

An assessment of how vaccines improve the outlook for activity

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Key points

- We conduct a detailed assessment of the impact of vaccines and viruses on a large number of countries
- We find that in only a handful of cases is collective immunity even plausible. In most cases it looks unlikely – and in several impossible – with the current vaccines. This suggests the virus could become endemic
- Vaccines appear highly successful in reducing virus severity. But even if perfect, which does not appear the case, hospitalisations of unvaccinated groups would likely be too large to allow the virus to spread freely
- This suggests an ongoing need for non-pharmaceutical interventions, even in mostly-vaccinated countries. Yet we see the risk of countries lifting restrictions too far
- This risks the re-emergence of the virus and a need to increase restrictions. Precautionary household and company behaviour would likely follow. We include this in our baseline forecasts for later this year
- A risk scenario where an immune-resistant new variant emerges also exists. This would require a return of more significant intervention, which would deliver a more material economic shock to baseline forecasts.

First step – vaccinate as many as possible

For months now, the economic and market focus has been on how quickly vaccines can be deployed. Some countries have done well: Israel was an early mover and currently has 59% of its total population fully vaccinated. The US has also rolled out the vaccine quickly with 60% of its adult population covered by first doses (47% by both). The UK followed a different approach with a 12-week gap between first and second doses – it has vaccinated 70% of its adult population with a first dose and 39% with both. Chile, Hungary and Iceland also have high coverage rates of first doses.

Other countries have been slower. The Eurozone saw a slow start to vaccinations, although the rate has stepped up recently with Germany vaccinating close to 5mn people a week. Japan still has a slow roll-out, with around 3% of its population having received first doses. Moreover, the vaccine has split the world into 'haves' and 'have nots' with the US only recently releasing additional vaccines to less developed economies. The population-weighted average vaccination rate in larger Latin American economies is 14%, 7% in Asia (excluding China) and 3% in Africa.

It has been obvious for a while that it will take time for the global population to be vaccinated. The risk associated with this delay is that while the virus continues to thrive in some parts of the world it could mutate to a form that may be able to evade human immunity generated either through catching the virus or vaccination. This has led to the aphorism that "nobody is safe until everybody is safe". However, underlying this assessment is a Panglossian hope that a global vaccination programme will allow the world to conquer COVID-19, and return to a pre-pandemic normality. In this note we take a closer look, not at which countries have or do not have access to the vaccine, but to a medium-term end-state where countries have complete access to vaccines. We assess how realistic the assumption is of a return to a pre-COVID-19 state. We also consider the economic and market implications of falling short of such hopes.

Collective immunity unlikely to be achieved

Our first conclusion is that collective immunity is unlikely in most countries. This is certainly the case for the rest of this year, but appears likely over the medium term. Collective immunity is reached when sufficiently large numbers of the population have immunity – either natural, after infection, or are vaccinated – so that the virus is left with too small a population to circulate. As such, its reproduction rate shrinks below 1, meaning it diminishes until it eventually dies out. This is the best outcome.

In our analysis, a number of factors are likely to combine to make this best outcome unachievable. This is in part a function of COVID-19 and more specifically its more recent variants – UK, South African, Brazilian and Indian – being highly transmissible. This allows the virus to continue to circulate in relatively small populations.

A shortfall in achieving the critical threshold for collective immunity is also a function of the size of the population that will not have immunity. This might be by chance, with vaccines not perfect[1], a small proportion of those that have been vaccinated will still be susceptible. Or it may be by choice: At the time of writing only the US, Canada and Algeria have chosen to vaccinate some children (12–18-year-olds), while most countries have no plans to vaccinate the under 18s – around one-fifth of most countries' total populations. Additionally, there are groups of varying sizes in different countries that are strongly opposed to having the vaccine.

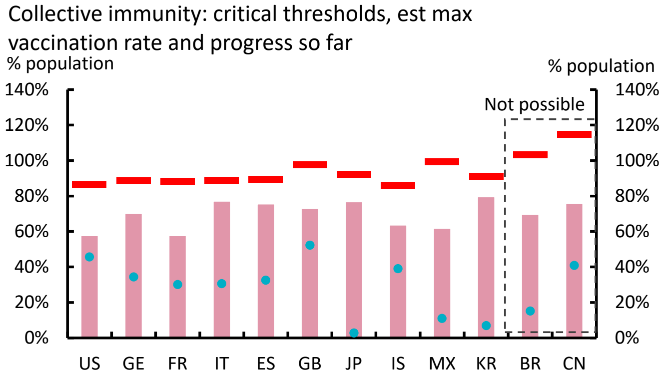
We estimate the critical threshold required for collective immunity. To do this, we combine data for a range of countries, using estimates of the virus's R0 – it's unconstrained reproduction rate[2] – calculating the average vaccine efficacy based either on vaccine distribution or supply, subject to available data; the proportion of non-vaccinated groups; and estimating the underlying spread of the virus to calculate the estimated critical threshold for collective immunity in different countries.

We then estimate the effective maximum proportion in each country that is likely to be vaccinated. We calculate this as the total population less the proportion of the population below minimum vaccine age in each country, less the size of the size of the "anti-vax" communities in each economy[3].

The difference between the estimated collective immunity threshold and effective maximum vaccination rate – allowing for those that are likely to have already had the virus – allows us to determine whether a country is likely to reach collective immunity through vaccination. In several cases, a simple collective immunity calculation returns a threshold of over 100% – clearly impossible – illustrating that the vaccine efficacy used in these countries is too low to achieve collective immunity given the transmissibility of the virus. This is the case for China, Turkey and Thailand, for example. For the vast majority of the countries we examine, this gap is over 10 percentage points (ppt) and we determine that these countries are "unlikely" to achieve collective immunity. A relatively small number of countries, including Greece, Taiwan and Malta, see a difference in thresholds of less than 10ppt and we deem that these could plausibly achieve collective immunity given the size of confidence intervals around our initial assumptions.

Exhibit 1 provides a chart summarising some of our key findings. Appendix chart A1 provides a chart with the full range of countries assessed. In our findings, collective immunity is deemed plausible in only 4 of the 58 countries assessed.

Exhibit 1: Collective immunity threshold and estimated maximum vaccine rates



Source: Our World in Data (OWID) and AXA IM Research, 12 May 2021

[1] The efficacy of each vaccine is less than 100%: Both Pfizer and Moderna's mRNA vaccines have estimated efficacies of around 95%, AstraZeneca's is a lower 75% and China's Sinovac efficacy has been reported at between 50-98% in different countries.

[2] This estimate is highly uncertain. We use estimates from Imperial University for original COVID-19 R0 assessments and for the UK variant. However, estimating R0 for new variants when they are not unique in a population and in environments that already practice non-pharmaceutical interventions is difficult. It is reasonable to accept variation around these estimates for the true value.

[3] Estimates for anti-vaccine groups are based on those strongly opposed to vaccines in an IPSOS poll, "COVID-19 vaccination intent has soared across the world", Feb 21.

We add two additional caveats to this conclusion, not included in our modelling. First, our models assume that vaccinated people stop transmitting the virus completely. However, Public Health England (PHE) showed[4] that, at least after one dose, transmissibility was only halved for the Pfizer and AstraZeneca (AZ) vaccines. Although we would expect a greater impact after full vaccination, or after contracting the virus, we have limited evidence: AZ's Phase III trials suggested transmissibility was reduced by 67% after full dosage[5]. Second, we do not allow for immunity to fade over time. A recent test in the New England Journal of Medicine showed that antibodies from the Moderna vaccine were still present six months after the second dose. However, over time, immunity from this or other vaccines, and from the virus itself, could fade, further reducing the immunity of sections of the population. If included, these caveats would make the prospects for collective immunity even less likely.

Of course, vaccine technology is set to improve, annual boosters will likely be a regular feature and vaccine holdouts will likely dwindle over time, particularly if the virus remains a threat. We address expectations of the dynamic developments of the virus and vaccine below.

Vaccines reduce the severity of COVID-19 cases

Beyond reducing the chances of catching the virus, a major benefit of the vaccines is that they reduce the severity of symptoms. AZ's February press release also stated that it reduced severe cases of COVID-19 and the number of hospitalisations to zero, a 100% reduction rate. Exhibit 2 presents results from a large scale (600k people) study on Israelis that received the Pfizer vaccine. The bottom rows compare the number of those who contracted severe forms of the virus, were hospitalised or died, between vaccinated and unvaccinated groups 7 days and 14 days after the second dose (21 days after the first dose). This also showed a 100% reduction in severe forms of COVID-19 from Pfizer 14 days after the second dose.

In the best-case scenario, this suggests that a vaccinated population could see COVID-19 being passed around, but no longer resulting in severe cases. This could reduce the virus to something similar to the common cold, which would obviously not be as disruptive as the pandemic.

Yet this best-case scenario may prove too optimistic. In the Israel study, severity reductions may not be perfect. The Pfizer trial showed a large reduction in the severity of cases one week after the second dose – a reduction to 2 cases from 15 in the unvaccinated set (87%). By the second week, there were no reported severe cases in the vaccinated group, but the unvaccinated only recorded 3 cases. The 100% reduction may therefore be a rounding error (one case would have lessened the impact to 67%). Moreover, other large-scale studies of China's Sinovac vaccine from Brazil suggest that it reduced severe cases by 85%, while Indonesia suggested a 96% reduction in deaths. Finally, early evidence from the outbreak of the Indian variant in the UK have included that 5 of 19 reported hospitalised cases in Bolton had been vaccinated, at least one with both doses. If vaccines are highly effective at reducing the severity of cases, but not perfect, large numbers of the population could still catch severe COVID19, with hospitalisations and deaths likely to follow.

Exhibit 2: Large scale Pfizer results from Israel

Large scale Pfizer results from Israel

		Documented	Symptomatic	Hospital	Severe	Deaths
Cumulative cases						
Unvaccinated	28 days	5775	3433	244	157	27
	35 days	6053	3582	256	171	30
	42 days	6100	3607	259	174	32
Vaccinated	28 days	4405	2373	108	52	7
	35 days	4456	2387	110	55	9
	42 days	4460	2389	110	55	9
Change in cases						
Unvaccinated	28d - 42d	325	174	15	17	5
Vaccinated	28d - 42d	55	16	2	3	2
Relative reduction (%)		-83	-91	-87	-82	-60
Unvaccinated	35d - 42d	47	25	3	3	2
Vaccinated	35d - 42d	4	2	0	0	0
Relative reduction (%)		-91	-92	-100	-100	-100

Source: New England Journal of Medicine, AXA IM Research, Feb 2021

Moreover, even if vaccines were perfect in reducing severe cases of COVID-19, the unvaccinated – children and those who are anti-vaccine – will remain vulnerable. A British Medical Journal report[6] last August showed that in the UK, children were 4.8% as likely to be hospitalised with COVID-19 as adults[7]. Children represent around 15-20% of developed economies' populations (typically higher for emerging economies). In a country with a population of 50m, that equates to around 7-9k children being hospitalised[8], subject to how exposed the population already was to the virus, with around one-third of those requiring intensive care. Even if all countries vaccinated those aged 12+ year olds, this would still leave 10-15% of the population at risk. Meanwhile, there are wide-ranging estimates for the numbers that will refuse to be vaccinated. February's IPSOS poll estimated that 6% of the UK population were strongly opposed to vaccination, but in both France and the US it was around 20%[9].

[4] "Covid: One dose of Vaccine halves transmission – study", BBC News, 28 Apr. 2021

[5] Phase III trial press release, AstraZeneca, 3 Feb 2021.

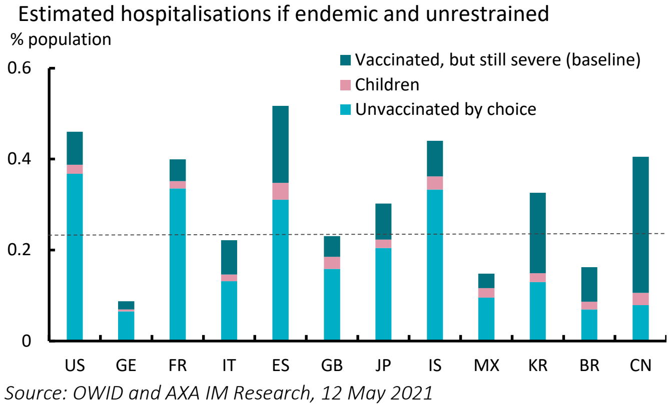
[6] Rubens J., Peart Akindele, N., Tschudy, M. and Sick-Samuels, A., "Acute covid-19 and multisystem inflammatory syndrome in children", The BMJ, 1 March 2021

[7] We estimate the adult hospitalsation rate at around 2-3% of the modelled total COVID-19 cases for countries where hospitalisation rates are readily available.

[8] For clarity, 15% of the population of 50mn* adult hospitalisation rate (est 2.6%) * child hospitalisation rate relative to adult (4.8%) * proportion of children not having caught the virus already (1 – 26%, population weighted average of numbers that have had the virus) = 6.9k.

[9] More recent surveys for individual countries suggest those strongly opposed to vaccinations has been falling gradually over time and may be

Exhibit 3: Estimated hospitalisations for selected countries by different vulnerable groups



Source: OWID and AXA IM Research, 12 May 2021

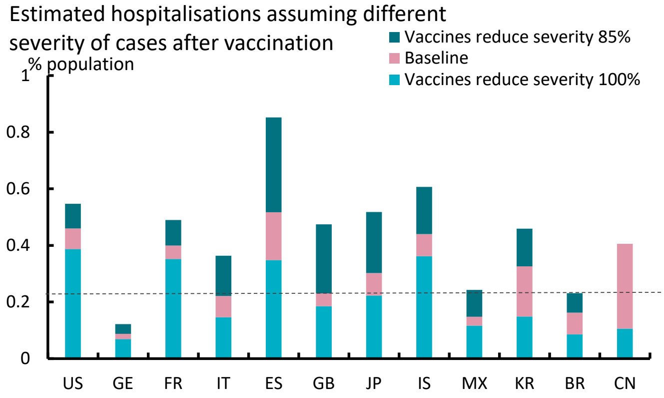
Exhibit 3 illustrates estimated hospitalisation rates for selected economies[10]. The estimate decomposes the hospitalisations into different categories: Children, anti-vax groups and vaccinated, but still severe cases. The last of these categories is estimated based on a weighted average of the distribution (or supply) of the vaccines used.

Some context is useful. For illustrative purposes we consider what this could mean for the UK. The impact of the vaccine will be critical. Depending on whether the vaccine reduced severity by 85% or 100%, the UK would see between 200k and zero hospitalisations from the more than 70% of its population that we estimate will have been vaccinated. Children below the age of 18 constitute 21% of the population, suggesting hospitalisations of just under 20k. Finally, the UK has an estimated 6% of people who are strongly opposed to the vaccine. This group could see hospitalisations of over 100k. Based on a weighted-average vaccine severity reduction estimate – high in the UK because of its greater use of the AZ vaccine – we estimate a total of 156k hospitalisations, or around 0.25% of the population. This would be around one-third of the 464k COVID-19-related hospitalisations since the start of the pandemic. Of course, whether this total was manageable or not would depend on how quickly the virus spreads: spread over a few years, the health service could cope; over a few months it could not.

Exhibit 4 illustrates the same exercise for selected economies for different impacts on severity reduction. The chart looks at three scenarios: Assuming the vaccine to be perfect at reducing severity, to be 85% successful or to be a baseline dependant on our assessment of the combination of vaccines used in each economy. Exhibit A3 provides a full version of this chart for all countries considered in the appendix.

below the February levels, for example "COVD 19 Vaccines: The End Game", Brookings Institute, 12 May 2021.

Exhibit 4: Estimated hospitalisations for selected countries assuming different impacts on severity by vaccines



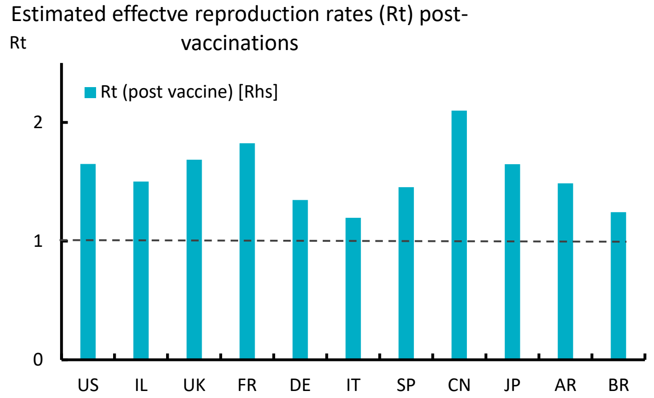
Source: OWID and AXA IM Research, 12 May 2021

We conclude that simply returning to pre-pandemic normality in terms of removing social-distancing, mask wearing, track & tracing etc and accepting that the virus will become endemic risks a significant rise in hospitalisations – primarily in unvaccinated groups, but also in children and potentially even in vaccinated groups if vaccines are not perfect in reducing the severity of infection or immunity fades over time.

Ongoing measures to reduce the virus spread

We have identified a gap in most countries between the effective maximum vaccination rate of the population and the critical threshold for collective immunity. However, the vaccinated population should reduce the effective reproduction rate of the virus (Rt). Our estimates of this post-vaccinated rate are illustrated in Exhibit 5.

Exhibit 5: Estimated reproductive rates of the virus



Source: OWID and AXA IM Research, 12 May 2021

In the cases above (and 84% of the total sample), estimates of the reproduction rate are above 1, meaning that the virus will continue to grow if left unrestrained. However, the

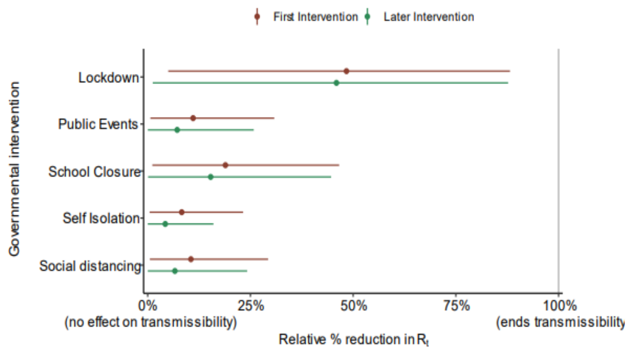
[10] A full version of this chart for all of the countries we consider is available in Exhibit A2 in the appendix. Both highlight the UK case as a proportion of the population for context.

estimated effective reproduction rates in vaccinated populations are significantly lower than the initial rates we assumed for COVID-19 and its more transmissible variants.

This suggests that countries that fully remove non-pharmaceutical interventions to return to a pre-COVID-19 normality would see virus cases begin to grow again. Exhibit 6 provides an illustration of the impact of some of these non-pharmaceutical interventions on the virus' reproduction rate. Other measures have also included mask-wearing, track-and-trace procedures and enforced quarantine. Given that our estimates of the effective reproduction rate after full vaccination would be much closer to one, it would only take continuation of some of these additional restrictions – that need not have significant economic impact, such as mask wearing – to maintain a reproduction rate that is below 1.

Second, the lower value of Rt suggests any problem might be slower to emerge. We consider the case of the UK during the emergent phase of the UK variant in Q4 2020. Our empirical estimates suggest that the Rt rate rose to 1.5 in the UK from September to mid-October. Then as the UK emerged from its second lockdown in November it rose again to 1.3. Even at this level, cases in the UK doubled in three weeks from the start of December, resulting in the UK government first cancelling its planned Christmas relaxation and then imposing a more restrictive third lockdown in January.

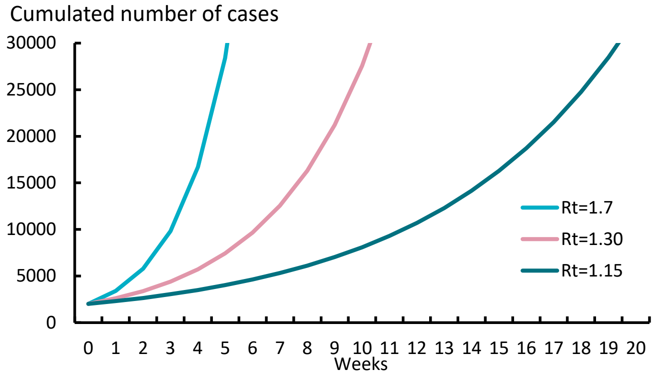
Exhibit 6: Estimated impact of non-pharmaceutical interventions



Source: Imperial College, Report 13, March 2020

Our estimate of the reproduction rate in a post-vaccinated UK with no other restrictions is 1.7. Exhibit 7 illustrates the difference in emerging new cases that would result from the virus spreading at this rate, compared with lower rates if additional interventions remain. In December, the rate of new cases was on track to hit 30k before the government reversed its policy. We can see that small changes in the UK reproduction rate can lead to very different timescales on the emergence of new cases from the current caseload. Lower rates of reproduction may lead to only small initial changes. The possibility of only a slow increase in cases might result in complacency in some countries and result in restrictions being eased too far. But the good news is that with a lower reproduction rate, countries should not have to resort to extreme interventions or lockdowns to stop the virus spreading, particularly if countries react quickly after the first signs of revival.

Exhibit 7: Different reproduction rates can lead to very different case numbers



Source: AXA IM Research, 12 May 2021

From an economic perspective, any revival of the virus and restrictive measures from governments may come as an unwelcome surprise to households and businesses and may trigger a return to more precautionary behaviour. This could involve households being more cautious in how quickly they spend any excess savings and firms reducing their investment appetite. We include some of this risk of rising precautionary behaviour in our baseline forecasts for global growth as we move past the summer of this year.

There is also a risk that some governments act too slowly, repeating mistakes from governments around the world that have not wanted to disrupt economies with swift responses, only to have to undertake far larger interventions to resolve a much bigger problem later on.

The future for vaccines and the virus

As with the progress of the pandemic so far, the outlook is uncertain. Despite our cautious expectation for the positive impact of vaccines, we also believe that future progress in the development of vaccines will only improve this outlook.

Vaccine production will rise over time, not only allowing every country greater access to vaccines, but increasingly letting them select vaccines that best suit individual needs based on efficacy, impact on severity or distribution. Moreover, as with seasonal flu vaccines, we are already seeing pharmaceutical companies tweaking vaccines to better target new variants and planning to include these in annual booster programmes, which looks likely to be a necessary feature for the future. This should both address new variants and any issues of fading immunity.
Moreover, more fundamental developments may also help. First, trials are ongoing into the use of vaccines on children, beyond those few countries that have authorised use for 12

to 15-year-olds. In the future, it is possible that vaccines will be available for the very young, significantly reducing their susceptibility to catching and spreading the virus. Further, trials are also underway to look into the benefits of vaccine cocktails – mixing different vaccines. Mature vaccination programmes including BCG and Hepatitis A systematically use vaccine cocktails to broaden the effect and improve vaccine efficacy. In the future it is possible that cocktails will lead to similar improvements for coronavirus vaccines.

We may also see a reduction in anti-vaccination sentiment over time. In surveys of those opposed to vaccination, many were concerned about how quickly the vaccines had been developed. More long-term studies of vaccine safety may reassure these groups. Moreover, an increased use of vaccine passports – as suggested by the EU, for example, to govern the return of leisure travel – would create incentives for vaccination (including cost reduction and greater social inclusion).

Of course, vaccines are a 'public good'. They benefit society more greatly than just the benefit they bring to the individual. In the short term, we do not expect governments to mandate COVID-19 vaccinations. However, many do for other diseases[11] and this could change over time. In the shorter term, employers may enforce vaccine take-up to fulfil their obligations for health and safety requirements in the workplace[12]. In many ways, future developments look likely to increase the numbers vaccinated above the level we deem as the likely effective maximum for now.

That said, the evolution of the virus is also dynamic. The overriding material downside risk to our outlook for global growth is the emergence of a variant of the virus that is immunity resistant. It is not possible to estimate a probability for such a scenario, so in our economic forecasts we treat this as a separate risk scenario – rather than including it in our central forecasts. However, we recognise that this probability is a positive function of how quickly the virus is spreading across the world. This is an additional incentive to accelerate vaccinations and maintain an appropriate level of restrictions to suppress the spread of the virus in all areas of the world.

Exhibit 8: Economic forecasts in a vaccine skipping variant scenario

Risk scenario new variant in %, May 2021

	Base case		Risk case - new variant		Change to forecast	
	2021	2022	2021	2022	2021	2022
US	6.9	4.5	6.7	1.6	0.2	2.9
Euro area	3.8	3.6	3.6	1.7	0.2	1.9
UK	6.1	6.5	5.9	2.8	0.2	3.7
Japan	2.7	2.9	2.1	2.1	0.6	0.8
China	8.2	5.5	8.1	4.8	0.1	0.7

Source: AXA IM Research, 12 May 2021

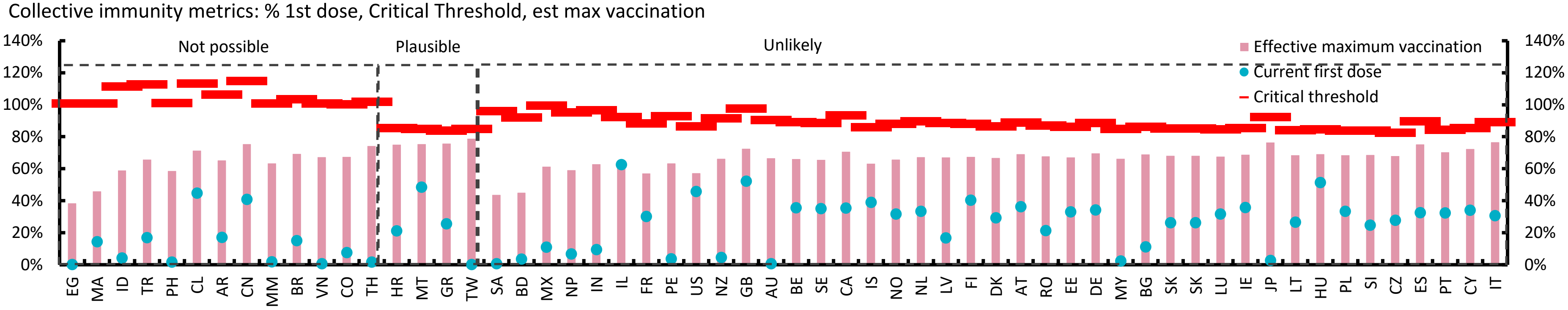
Exhibit 8 illustrates a risk-case scenario for selected countries should a worst-case, immunity-skipping variant emerge. In this illustrative scenario, we assume the virus variant emerges in Q4 2021 and results in a renewed lockdown in Q1 2022 in many major economies. Compared with our baseline forecasts, which already include some precautionary behaviour re-emerging over the second half of this year, these forecasts are significantly lower. This is despite the assumptions that most economies' adaptions to severe restrictions persist, avoiding as severe an impact as at the onset of the pandemic, and that a new vaccine to target such a new variant could be designed, tested and distributed within around 12 months. Any signs of the emergence of such a new variant would have a material impact on economies and financial markets alike. Moreover, financial markets will be cautious with any new variants that arise until they are sure that they do not avoid current immunity.

[11] Over 100 countries have national mandatory vaccine programmes requiring one or more vaccines. 59% of these apply financial or educational (school exclusion) penalties for failure to comply. "Global assessment of national mandatory vaccination policies and consequences of non-compliance", Nov 2020, Science Direct.

[12] Gotbaum, J., "Governments won't get us herd immunity. Businesses can", Brookings Institute, May 2021.

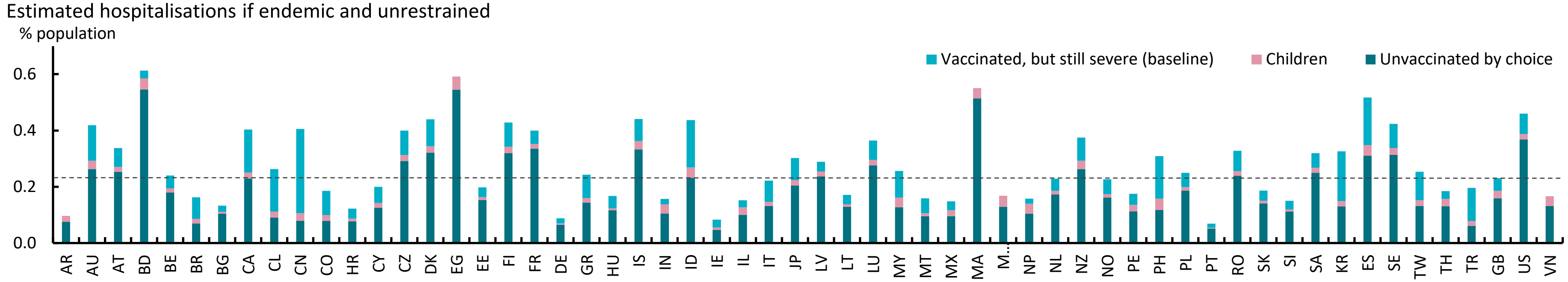
Appendix

Exhibit A1: Collective immunity threshold and estimated maximum vaccine rates



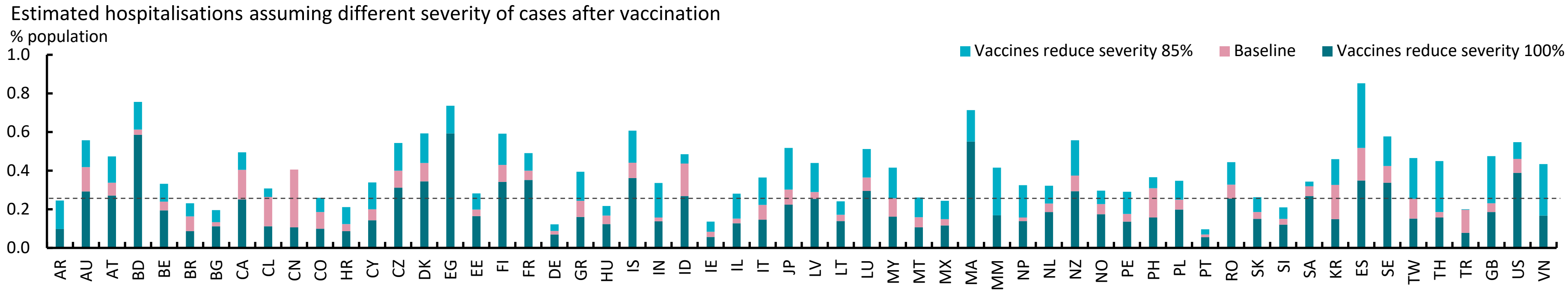
Source: OWID and AXA IM Research, 12 May 2021

Exhibit A2: Estimated hospitalisations for selected countries by different vulnerable groups



Source: OWID and AXA IM Research, 12 May 2021

Exhibit A3: Estimated hospitalisations for selected countries assuming different impacts on severity by vaccines



Source: OWID and AXA IM Research, 12 May 2021

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