TONY BLAIR INSTITUTE FOR GLOBAL CHANGE

Pass Time: Quantifying the Public-Health Benefits of a Covid Pass

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Published at https://institute.global/policy/pass-time-quantifying-public-health-benefits-covid-pass on July 6 2021

Summary

The government plans to lift all remaining Covid-19 restrictions on 19 July. The rollout of highly effective vaccines has transformed the risks of an exit wave of infections as restrictions are removed. But experts still anticipate millions of infections and tens of thousands of deaths over the coming months due to the higher transmissibility of the Delta variant.

This outcome could be substantially improved by temporarily mandating the use of the NHS COVID Pass in venues and settings that will open fully after 19 July, including sports matches, large outdoor events, indoor performances and nightclubs. Mandatory use would only be required when case numbers are high, with the option to turn the pass off at other times.

We model the effect of this policy and find that mandatory use of the pass at large events would slow the spread of the virus. We find that the NHS COVID Pass could prevent between a quarter and a third of the projected cases and reduce the number of deaths in England alone by between 6,000 and 12,000. The peak number of infections and hospitalisations would also be dramatically reduced, relieving pressure on the NHS.

The pass would also buy time for the vaccination of adolescents, which would further reduce the scale of the exit wave and save more lives, potentially lowering the number of cases and deaths by around 40 per cent. Given the marked shift in the balance of risks for young people in recent weeks, the government should also give serious consideration to relaxing restrictions on the use of the AstraZeneca vaccine among young adults in order to speed up the rollout.

Introduction

A little over a month ago, there was a reasonable expectation that the vaccination programme would put an end to the threat of further waves of Covid-19 infection. We would, in other words, be at or close to the herd immunity threshold, above which the virus struggles to find enough susceptible people to continue spreading.

The emergence of the Delta variant, which is thought to be between 60 to 70 per cent more transmissible than the previously dominant Alpha variant, has largely put paid to that hope. [1] The latest projections from the Scientific Pandemic Influenza Group on Modelling (SPI-M), released in early June, are much less encouraging and suggest that as restrictions are lifted, we will see a surge in infections even allowing for the government's decision to delay the final step of the roadmap until 19 July. According to Imperial College London's projections, we can expect to see a further 19 million infections in England, largely over the next ten weeks. The University of Warwick's analysis is more optimistic but still suggests we can expect millions more infections by the autumn.

There is huge uncertainty around the SPI-M projections. Nevertheless, on reasonable assumptions, modelling exercises by Imperial and the London School of Hygiene & Tropical Medicine both anticipate more than 40,000 deaths in England while Warwick's results imply around 10,000 deaths. In light of the protection provided by the vaccination programme, the new Secretary of State for Health and Social Care, Sajid Javid, has indicated that restrictions on social mixing will not be used after 19 July to control the virus spread, unlike in previous waves.

The Scientific Advisory Group for Emergencies (SAGE) modelling essentially tells us that a third wave is now inevitable. The policy challenge is therefore to mitigate it, to prevent it spiking so high that the NHS gets overloaded and to time the surge so that the health service is best placed to cope. In effect, this means avoiding any exit wave during the winter months, when other pressures on the NHS are inevitably greater.

Even though cases are currently rising rapidly, there is a risk that this pace will accelerate further once all remaining restrictions are lifted on 19 July. But this does not mean there is nothing to be done to mitigate the risks we face. This report explores the impact of one weapon in the government's armoury that could limit the scale of the exit wave and save lives while pressing ahead with the reopening timetable: mandating use of the NHS COVID Pass at all large venues set to reopen fully after the final stage of the government's roadmap.

How Should the NHS COVID Pass Be Used?

During the pandemic to date, restrictions intended to contain the spread of disease have necessarily been blunt. The difficulty of identifying those groups or regions in which there is most risk of virus transmission has meant that national lockdowns have been the main solution to curbing waves of infections. In the absence of a reliable method to stratify the population according to risk of disease, everyone must be assumed to be potentially contagious and lockdown restrictions must consequently apply to the entire country.

Vaccinations have changed this. Their effectiveness at reducing transmission means that different people now carry different risks when it comes to spreading the virus. Recent studies from Public Health England (PHE) suggest that individuals fully vaccinated with Pfizer or AstraZeneca acquire up to 80 per cent protection against symptomatic Covid-19 infections caused by the Delta variant, and up to 50 per cent protection against onward transmission of earlier variants. [2] Fully vaccinated individuals are also around 95 per cent less likely to die or be hospitalised than the unvaccinated, even after infection with the more dangerous Delta variant. [3]

This means that a much more targeted approach is now possible and there is no pressing need to maintain restrictions on those who are likely to be safe to return to pre-pandemic life. In a previous paper, TBI has advocated that fully vaccinated people, as well as those with test results proving they do not have Covid-19, should be allowed to certify their status so they can be released from mass restrictions. We called this certification a Covid Pass.

Since the publication of our last paper, the NHS App has been updated to allow users to certify their vaccination status through the digital NHS COVID Pass tool. The NHS App shows the date, location and type of vaccination an individual has received. It has QR code functionality to allow users to gain access to venues that may choose to require it. There is also a separate QR code tool for international travel and an option to request paper copies of the pass by post.

Individuals are eligible for the NHS COVID Pass two weeks after their second dose, within 48 hours of a negative PCR or lateral flow test, or within six months of a positive PCR test after self-isolation (although the recovery status of someone with a positive test is currently not listed). The vaccination pass is valid for 28 days and then automatically renews, while the negative test pass is valid for 48 hours and the positive test pass for six months after results.

The pass is currently being trialled at certain mass events, including the Euro 2020 football finals. [4] Similar pre-testing was also used at the FA Cup Final and the BRIT Awards in mid-May, as part of Phase 1 of the government's trials in reopening large venues. [5] While Phase 1 results are inconclusive,

in part because the trial events took place before the Delta variant became dominant, the available data show that just 28 Covid-19 cases were detected out of 7,764 participants who completed the full testing requirements. [6] This gives grounds for optimism that tools like the pass will be effective at reducing Covid-19 transmission at mass events.

Mandating use of the NHS COVID Pass at large events and during periods of high caseloads could also bring significant economic benefits. Polling from the Office for National Statistics' Opinions and Lifestyle Survey in late April indicated that 41 per cent of the public are more likely to attend mass events that have passport-style pre-testing, while significant delays due to social distancing checks and a requirement to wear face coverings – in other words, alternative options to mitigate infection risk – significantly reduce desire to attend. [7]

Indications from the government so far, on current plans, are that use of any Covid Pass scheme will be voluntary for most businesses. With cases now rising at a rapid pace, well ahead of final easing, there is a strong case for revisiting this and making use of the NHS COVID Pass mandatory for large events and all settings that are affected by step 4 of the roadmap on 19 July. Indeed, in our view, the government should keep open the option of requiring use of the pass in a wider range of settings, should it become necessary. [8]

There are important implementation issues to be worked through to make sure that mandating the use of the pass is not unfairly discriminatory. For example, people with medical exemptions should be given the pass, and there may be other legitimate reasons for exemption. There are also practical challenges around the infrastructure required to make mandatory use at large venues viable and reduce the risk of non-compliance. But these are not insurmountable.

Nor would the mandatory use of a pass be a permanent requirement. We also propose that it be turned on or off depending on the severity of the Covid-19 situation at any given time: in a period of very low infections, the pass may not be necessary at all but could be resumed if cases begin to surge again. According to the current outlook, this might mean that the pass would operate for the next two or three months and be made voluntary again once case numbers drop in the autumn.

The TBI Covid Model

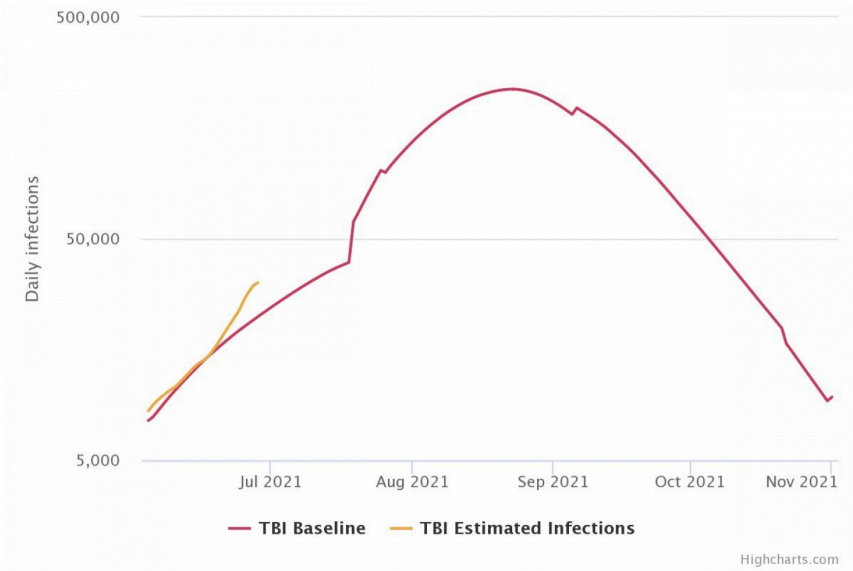
To assess how the mandatory use of the pass in step 4-related settings might affect the path of the virus in the coming weeks, we have developed a model based on the input assumptions of the Imperial team. A detailed explanation of the assumptions and inputs to our model is contained in the Technical Appendix, along with a comparison of our results with theirs for the various scenarios described in their paper. As this analysis shows, our model behaves in a similar way to the Imperial one in terms of the total number of infections as the various input assumptions are changed. This gives us confidence that the model is a useful guide to the likely effect of other policy measures that might change the inputs.

Since the Imperial paper, "Evaluating the Roadmap out of Lockdown: modelling step 4 of the roadmap in the context of B.1.617.2", was finalised in early June, ahead of the government's decision to postpone step 4, new evidence has come to light on the transmissibility of the Delta variant. We therefore depart from some of the Imperial assumptions here. While Imperial's central case assumed that the Delta variant has a 65 per cent transmission advantage over Alpha in terms of reproduction number (R excluding immunity), case growth since early June leads us to believe that this figure may be closer to 42 per cent. In addition, we note that a 42 per cent increase in Delta's R excluding immunity matches PHE's recent estimate of the Delta variant's secondary attack-rate gain over Alpha among non-household contacts. [9]

Analysis from PHE released after Imperial's paper suggests that vaccines are more effective against the risk of hospitalisation than was assumed in the SAGE modelling exercises. [10] On the other hand, PHE also believes that the risk of hospitalisation from Delta may be twice as high as from Alpha. [11] On balance, we assume that this good news and bad news may roughly cancel each other out, so we leave Imperial's estimates for hospitalisation and infection fatality unchanged.

Over the course of June, our model, updated with the latest assessment on transmissibility, seems to match the path of infections reasonably well (Figure 1), with daily positive tests growing at the same rate as projected infections. Plotted on a log scale, it's possible to see daily infection numbers continuing to grow but at a rate that slows as vaccine protection builds. After step 4, however, the rate of spread is projected to accelerate again, as R excluding immunity is anticipated to jump from 2.8 to 4.2 based on Imperial's assumptions – unless mitigating steps are taken. Clearly there is a huge amount of uncertainty around what effect the final easing step would actually have.

Figure 1 – Predicted path of Covid-19 infections versus actual cases



Note: Daily new infections are estimated by applying a 58 per cent detection rate to positive tests recorded in the UK government dashboard. This detection rate is calculated as the multiplier between ONS estimates for true infection incidence and dashboard positive tests in the last week of April, the most recent data available. Further details on the TBI baseline model are included in the Technical Appendix.

Source: TBI, Imperial College, ONS and PHE

How can mandatory use of the NHS COVID Pass in step 4-related settings be simulated in this model? Two channels are relevant.

First, because the pass would exclude those most at risk of being infectious from crowded spaces, it would likely reduce the R excluding immunity. If the passport was perfectly effective, it could in principle allow step 4 to go ahead without any increase in the R excluding immunity from the step 3 level. On Imperial's assumptions, setting aside the effects of seasonality and the school holidays, step 4 is expected to increase R excluding immunity from 2.8 to 4.2. So, the very maximum reduction that we could expect in this number as a result of deployment of the NHS COVID Pass is the difference between the two numbers, or 1.4 points. In practice its impact is likely to be less effective than this, not least because some of the activities step 4 will allow are private gatherings for which the use of the pass could not be mandated.

The second way in which mandatory use of the pass could slow the spread of the virus is through vaccine uptake. With full freedoms restored for pass holders, it is likely that it would encourage some vaccine-hesitant people, especially among younger demographics, to have the jab. The extent of this effect is hard to quantify but polling evidence from Israel suggests that perhaps a third of vaccine-hesitant people might be persuaded to have the jab with a passport-style system in operation. [12] The latest Imperial modelling assumes that vaccine uptake among the under-40s will be 80 per cent, and 90 per cent

among people in their 40s. If refusal to take the jab was reduced by a third, this would raise vaccine coverage among these age brackets to around 87 per cent and 93 per cent respectively.

These two effects – reducing the R number and raising vaccine uptake – are in tension with one another. If a pass encouraged a big jump in uptake, its impact on R would be limited as more people would then be eligible to attend step 4-related events. Meanwhile, if it had little effect on uptake, we could expect to see a bigger reduction in R as fewer people would attend mass events.

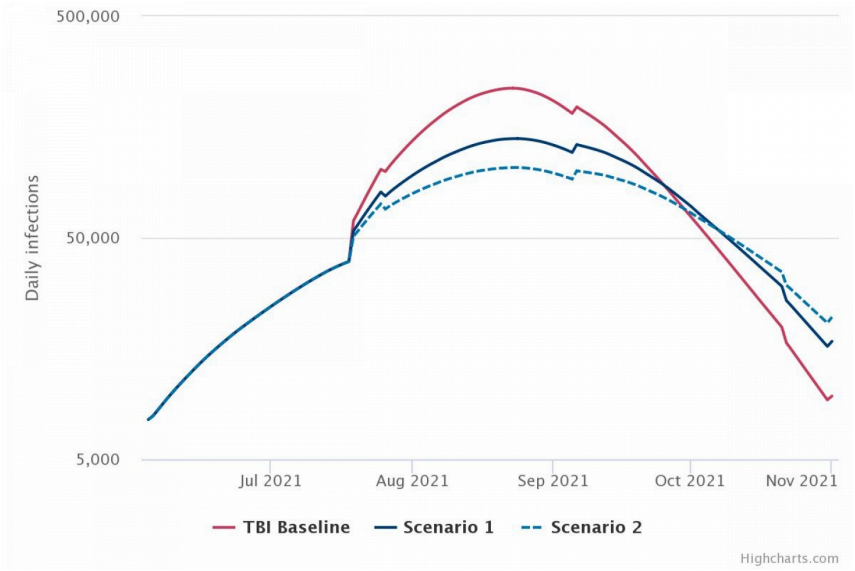
Which effect would dominate is uncertain, so here we model two scenarios: under the first scenario, refusal to take the vaccine is reduced by a third and R excluding immunity after step 4 is reduced by 10 per cent (roughly 0.4 points), while under the second scenario refusal is cut by a quarter and R excluding immunity reduced by 15 per cent (roughly 0.6 points).

Model Results

Both scenarios make a material difference to the number of infections and the size of the peak. In scenario 1, where a behavioural response driving higher uptake is strong and step 4-related R excluding immunity is cut by 10 per cent, the total number of infections over the next 12 months is cut by 22 per cent from 13.8 million in our baseline to 10.8 million. Daily infections peak at around 140,000 versus a peak of around 240,000 in late August on the baseline settings.

Scenario 2 shows stronger results, with total infections reaching 9.4 million, a 32 per cent reduction on the baseline, and peaking at around 100,000 per day in late August.

Figure 2 – The effects of the NHS COVID Pass on infections this summer through to autumn in TBI's two modelled scenarios



Source: TBI, Imperial College, ONS and PHE

Applying infection fatality rates implied by Imperial's results suggests that these scenarios would cut the number of expected deaths by between 6,000 and 12,000 in England and avert the risk of hospital overload.

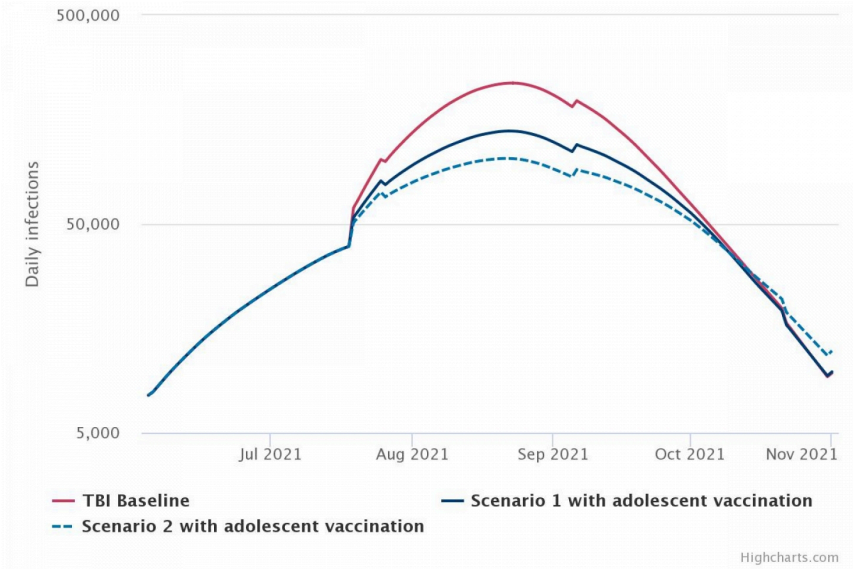
It may be possible to improve on this outcome still further. The decision of whether or not to vaccinate adolescents is a finely balanced one. Public-health experts such as Professor Martin McKee have called for vaccinating adolescents as a way to reduce Delta variant transmission to the elderly and vulnerable who, in spite of high vaccination coverage, are forecast to compromise the majority of additional deaths this summer. [13]

Paradoxically, based on the current outlook, that case is weakened since the timing of the infection surge means that herd immunity will likely be reached through infection before significant quantities of vaccines could be rolled out to young people, making inoculation somewhat redundant. But this picture changes if we can slow the pace of the virus through widespread use of the NHS COVID Pass. It buys time that can be used to inoculate adolescents and further reduce the scale of the exit wave.

Figure 3 shows the results of combining mandatory use of the pass for step 4-related settings with vaccination of over-12s. Now, total infections fall to 9.8 million in scenario 1 (where the NHS COVID Pass has a bigger effect on uptake and a smaller effect on R excluding immunity), representing a 29 per cent reduction on the baseline, and the wave has a broad flat peak from mid-August to mid-September at around 140,000 infections per day. For the second scenario, where the pass has a bigger effect on R excluding immunity and a smaller effect on uptake, total infections fall to 8.3 million, equalling a 40 per cent reduction, with a peak from mid-August to mid-September of 100,000 infections per day. Given

the strong efficacy of both main vaccines against hospitalisation, this is unlikely to overload health-care capacity.

Figure 3 – The effects of the NHS COVID Pass on infections combined with vaccination of over-12s in TBI's two modelled scenarios



Source: TBI, Imperial College, ONS and PHE

Figure 4 – Results of our modelled scenarios for June 2021 to June 2022 in England

	Total cases (reduction from baseline)	Peak daily infections (reduction from baseline)	Implied total deaths* (reduction from baseline)
Baseline	13.8m	240,000	29,000
Pass scenario 1: reduces R by 10%, jab refusal by 33%	10.8m (-22%)	140,000 (-42%)	22,400 (-22%)

Pass scenario 2: reduces R by 15%, jab refusal by 25%	9.4m (-32%)	100,000 (-58%)	19,600 (-32%)
Pass scenario 1 + adolescents	9.8m (-29%)	140,000 (-42%)	20,300 (-29%)
Pass scenario 2 + adolescents	8.3m (-40%)	100,000 (-58%)	17,200 (-40%)

** Implied total deaths are estimated using Imperial's IFR for the 150% Delta transmission advantage scenario with central vaccine efficacies (0.21%).*

Source: TBI analysis

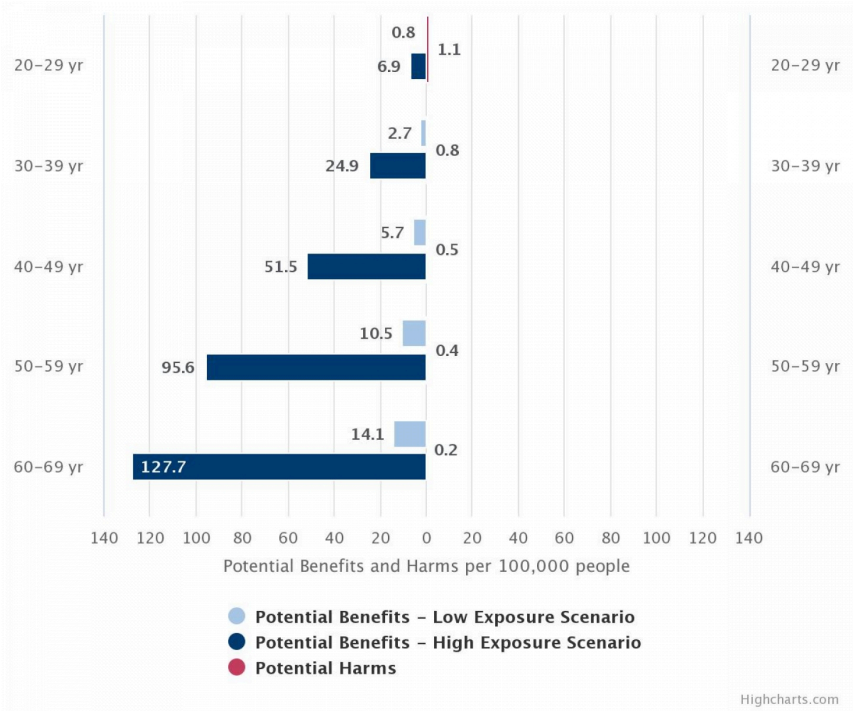
What this analysis suggests is that widespread use of the NHS COVID Pass could not only help to minimise the size and intensity of the exit wave but that it buys time for other interventions too, including the vaccination of adolescents, thereby further reducing the health costs. In the same vein, the government should continue to look at all options for speeding up the pace of vaccine rollout to adults, which has slowed significantly in recent weeks. One such option is to revisit the decision to restrict the use of the AstraZeneca vaccine in the under-40s.

Revisit the Risk Assessment for AstraZeneca in the Under-40s

In early May, the Medicines & Healthcare products Regulatory Agency (MHRA) recommended that those aged under 40 should be given an alternative to the AstraZeneca vaccine, following concerns about blood clots. The view of the UK regulator was that the benefits of the vaccine were not outweighed by the risk of a blood clot in young people.

The assessment of benefit was made when case numbers were low, with an estimated two new infections per week per 10,000 people. As can be seen from the light blue bars in Figure 5, when cases are at this level, the threat of a blood clot from an AstraZeneca jab may be higher than the benefits of a vaccine for those aged between 20 and 29, and only marginally lower than the benefits for those aged between 30 and 39.

Figure 5 – Weighing up benefits versus risks of the AstraZeneca jab



Note: Potential benefits are estimated as ICU admissions due to Covid-19 prevented every 16 weeks per 100,000 people. Potential harms are estimated as specific blood clots due to the AstraZeneca vaccine per 100,000 people. As the Winton Centre analysis was published on 7 April 2021, the figures do not factor the increased risk of hospitalisation with the Delta variant into the potential benefits side.

Source: Winton Centre for Risk and Evidence Communication, University of Cambridge

This is not the situation the UK finds itself in today. The rate of new cases has risen steadily to late January levels, with the numbers only set to accelerate in the weeks ahead. This scenario is best encapsulated in the dark blue bars in Figure 5, which plot the MHRA's assessment of the benefits of AstraZeneca in a situation similar to the peak of the second wave in December 2020. As can be seen in Figure 5, the benefits of receiving an AstraZeneca vaccine appear to far outweigh the risks for every age group in this context.

Given the changing balance of risks and the benefits of increasing the pace of vaccine rollout, serious consideration should be given to lifting the restrictions on AstraZeneca for at least some groups among the under-40s. This would see younger people being fully vaccinated quicker, protecting them and reducing transmission overall. It would also alleviate pressure on the Pfizer and Moderna vaccines – the constrained supply of which are now seen as the main limiting factor in the vaccination programme. [14]

Conclusion

There is huge uncertainty over the path of the virus in the coming months. Will the current surge in cases continue or will it abate? On the best available assumptions, it is likely that daily case numbers will continue to accelerate and likely peak in August.

Vaccines are proving highly effective both at preventing infection and hospitalisations among those who do get infected, even in the face of the Delta variant. But if case numbers get into the tens of millions, as the SAGE models foresee, there will inevitably be a large number of hospitalisations and a significant increase in the number of deaths over the coming weeks.

Even if step 4 of the roadmap is taken on 19 July, as currently planned, there are steps we can take to substantially reduce the health consequences, save lives and alleviate pressure on the NHS. Mandatory use of the NHS COVID Pass in all settings affected by step 4 could save lives both by encouraging vaccine uptake among the hesitant and limiting the contact of unvaccinated or Covid-positive people at times when case numbers are high.

Our analysis shows that such a measure could cut cases and deaths by a quarter to a third as well as flattening the curve to make the case numbers more manageable. What's more, deployment of the pass would buy time for the wider rollout of vaccines, especially adolescents if it is deemed safe to do so.

Nor would mandatory use of the pass be a permanent requirement. Mandatory use could be required only at times when case numbers are high, with no such requirement when they fall below a certain threshold. This could mean that the pass would only be required until the autumn, albeit with the option to reintroduce it should a further winter surge occur.

With the success of the vaccination programme, it is time for the era of blanket restrictions on social mixing and economic activity to come to an end. But that doesn't mean that the health threat is over. With the NHS COVID Pass now up and running, we have the technology to individualise restrictions at moments when the virus is spreading fast. Doing so could save thousands of lives while allowing the remaining restricted parts of the economy to reopen with confidence.

Technical Appendix

The TBI replication of the Imperial College London model matches most of the assumptions set out in their paper submitted to SAGE on 9 June 2021, entitled "Evaluating the Roadmap out of Lockdown: modelling step 4 of the roadmap in the context of B.1.617.2". Figure 6 below shows the results of our attempt to match Imperial exactly, while Figure 7 underneath reports sensitivities for the policy effects from a Covid Pass, along with our updates to the baseline Imperial model to reflect the latest research around the Delta variant.

For our own forecasts, we slightly update Imperial's vaccine efficacies against infection to reflect the latest research from PHE around symptomatic infection. [15] In keeping with Imperial's central scenario, we assume that vaccination reduces the risk of onward transmission by 33 per cent in our own central scenarios. We model onward transmission effects by estimating the proportion of newly infected individuals on any given day who have already been vaccinated, and we assume that a relevant subset of these newly infected are not themselves contagious due to vaccination protection against onward transmission.

On the mix of vaccines used in the population, we follow Imperial's approach of taking the observed vaccine split to date for people aged over 50 (roughly 67 per cent AstraZeneca and 33 per cent Pfizer at the time the priority first-dose rollout for over-50s concluded in May [16]). We also assume a 60:40 split between Pfizer and AstraZeneca for those aged between 40 and 49, and that those aged under 40 are currently being offered Pfizer or Moderna only. In our baseline forecast, we match Imperial's estimates of final adult uptake by age group as reported in Table 3 of their paper, varying these rates for the Covid Pass policy as described in the text. For scenarios where we include vaccination of adolescents, we assume that this commences after the first-dose rollout for adults is complete in early August, and that baseline adolescent uptake is 80 per cent (in the absence of any Covid Pass).

We replicate Imperial's vaccine rollout speed of 2.15 million doses per week until 25 July, and 2 million doses thereafter. In replicating Imperial's approach, we assume that efficacy after vaccination begins 21 days after the first dose and 7 days after the second, and we factor an 11-week gap between first and second doses into the rollout schedule. For our baseline model, we then change this to an eight-week gap from June onwards to reflect new government guidance. [17]

Figures for the R number without immunity align with Supplementary Table 1 of the Imperial paper, and we replicate the study's seasonality factor, adjusting transmission rates +/-10 per cent from winter to summer. As outlined above, while Imperial's central case assumes that the Delta variant has a 65 per cent transmission advantage over Alpha in terms of the R number excluding immunity, case growth since early June leads us to believe that this figure may be closer to 42 per cent in light of recent PHE

estimates of the Delta variant's secondary attack-rate gain over Alpha among non-household contacts (albeit this observed figure combines the effects of higher raw transmission advantage and vaccine escape). For the TBI model, we therefore change the transmission advantage figure to 42 per cent.

In keeping with the Imperial approach, we model vaccination rollout and the spread of the disease in each of the seven NHS England regions separately before combining figures to arrive at England-wide totals. This is because Imperial estimates different prior infection rates across regions at the start of the modelled period, which results in different subsequent transmission dynamics. Our starting values for cumulative infection numbers are calibrated to match estimates provided in a previous Imperial paper submitted to SAGE on 5 May 2021. [18] To estimate cumulative infections between 5 May and 4 June, the start date of Imperial's latest model, we obtain a multiplier between observed positive tests and total infection incidence estimated by the ONS for the last week of April – the latest data available – and apply this multiplier to the positive tests in each English region recorded in the government dashboard over May. We use the same method to estimate actively infectious cases in the five days preceding 4 June, which feed into our SIR model for each region.

Imperial assumes that prior infection with the Alpha variant or wild-type Covid-19 results in 85 per cent immunity protection against Delta, waning exponentially over three years. As a simplification, we assume that prior Alpha or wild-type Covid-19 infection provides 73 per cent immunity protection for the duration of the modelled period, except when otherwise stated in sensitivities. This adjustment was calculated by taking the weighted average of immunity wane across the population from the previous two Covid-19 waves in spring and winter 2020, using the latest Cambridge Nowcasting cumulative infection incidence curves and Imperial's immunity wane decay curve as inputs. Although these numbers are inevitably approximations, recent field research has suggested that prior Alpha or wild-type Covid-19 infection provides weakened immunity to Delta. [19] In all scenarios, we assume that prior Delta infection provides 100 per cent immunity protection.

We assume the same R excluding immunity rates for all regions during the modelled period and distribute future vaccines proportionately by population. Unlike Imperial, we do not use an age-stratified, stochastic model but rather a parametric SIR model where vaccination rollout proceeds by age-group priority until the eligible adult population in a region willing to be vaccinated has received two doses. We assume a constant disease recovery rate of 0.15 across all demographics based on prior literature. Our effective R number in early June is 1.5, in line with Imperial's Delta estimate.

As discussed in the text, while Imperial's model does not adjust for increased hospitalisation risk from the Delta variant compared to Alpha, it also assumes lower vaccine efficacy against hospitalisation than subsequent PHE research suggests so, on balance, we assume these factors cancel each other out and we leave these inputs unchanged. Finally, fatalities are calculated based on Imperial's estimated infection fatality rate for their most relevant scenario (50 per cent Delta transmission advantage, central immunity escape).

The table below compares the total projected new infections between 4 June 2021 and 1 June 2022 from the Imperial paper to the results from TBI's equivalent scenarios. The comparison shows that the TBI central case and sensitivity tests project similar numbers of cases as the Imperial ones, suggesting that the model behaves as expected. Inputs are calibrated to match Imperial's assumptions exactly.

Figure 6 – Imperial's June SAGE model and TBI replication compared

Immune escape scenario (Table 1 of Imperial paper)	**Transmissibility of Delta relative to Alpha** (Table 5 of Imperial paper)	*R lift* (Supp. Table 1 of Imperial paper)	*Step 4 opening date*	**Imperial result** (m of infections)	**TBI replication** (m of infections)
Central	65%	Central	26 July 2021	19.4m	19.2m
Central	65%	Central	21 June 2021	25.2m	23.1m
Central	65%	Central	05 July 2021	23.0m	21.6m
Central	65%	Central	07 December 2021	15.5m	13.1m

Central	65%	High	26 July 2021	30.0m	24.4m
Central	50%	Central	26 July 2021	16.7m	17.2m
Central	50%	Central	21 June 2021	21.7m	20.6m
Central	50%	Central	05 July 2021	19.6m	19.0m
Central	50%	Central	07 December 2021	14.5m	14.7m
Central	50%	High	26 July 2021	27.8m	23.5m

Central	80%	Central	26 July 2021	21.7m	20.8m
Central	0%	Central	26 July 2021	3.5m	4.0m
Low	50%	Central	26 July 2021	10.8m	11.5m
High	40%	Central	26 July 2021	26.7m	25.1m

The table below reports sensitivities for Covid Pass policy effects on expected infections between 4 June 2021 and 1 June 2022, as well as our adjustments to the base Imperial model to reflect the evolving context of the UK pandemic, as previously described. The comparison shows that the effects of the NHS COVID Pass are robust to a range of potential pandemic outcomes over the next year.

Figure 7 – TBI baseline model and Covid Pass policy effects (millions of infections)

Scenario	TBI baseline model	Scenario 1 Covid Pass (reduction)	Scenario 2 Covid Pass (reduction)	Scenario 1 Covid Pass and vaccinate adolescents (reduction)	Scenario 2 Covid Pass and vaccinate adolescents (reduction)

Central (42% Delta transmission advantage)	13.8m	10.8m (-22%)	9.4m (-32%)	9.8m (-29%)	8.3m (-40%)
50% Delta transmission advantage	15.3m	12.6m (-18%)	11.3m (-26%)	11.9m (-22%)	10.5m (-31%)
65% Delta transmission advantage	17.8m	15.6m (-12%)	14.5m (-19%)	15.3m (-14%)	14.1m (-21%)
20% Delta transmission advantage	9.5m	6.1m (-36%)	5.0m (-47%)	3.5m (-63%)	2.5m (-74%)
21 June Step 4 opening	16.7m	14.9m (-11%)	13.9m (-17%)	14.8m (-12%)	13.8m (-17%)
5 July Step 4 opening	15.0m	12.5m (-17%)	11.2m (-25%)	12.1m (-20%)	10.8m (-28%)
2 August Step 4 opening	13.1m	9.8m (-25%)	8.7m (-34%)	8.0m (-39%)	6.7m (-49%)

6 September Step 4 opening	12.6m	9.8m (-22%)	9.1m (-28%)	6.4m (-49%)	5.6m (-56%)
Early December Step 4 opening	13.8m	9.0m (-35%)	7.2m (-48%)	3.8m (-73%)	2.5m (-82%)
Imperial Low immunity escape scenario, 42% Delta transmission advantage	10.0m	6.9m (-31%)	6.0m (-40%)	5.1m (-49%)	4.0m (-60%)
Imperial High immunity escape scenario, 42% Delta transmission advantage	25.4m	23.2m (-9%)	21.9m (-14%)	23.1m (-9%)	21.8m (-14%)
85% Delta past infection immunity	16.2m	12.5m (-23%)	11.0m (-32%)	11.2m (-31%)	9.5m (-42%)

Charts created with Highcharts unless otherwise credited.

Footnotes

1. ^ This figure reflects the fact that the Delta variant is both more transmissible than Alpha, but also somewhat better at evading vaccines. Subsequently in this piece we model these two effects separately.
2. ^ https://www.medrxiv.org/content/10.1101/2021.05.22.21257658v1; https://www.gov.uk/government/news/one-dose-of-covid-19-vaccine-can-cut-household-transmission-by-up-to-half
3. ^ https://www.gov.uk/government/news/vaccines-highly-effective-against-hospitalisation-from-delta-variant
4. ^ https://www.nhsx.nhs.uk/covid-19-response/using-the-nhs-covid-pass-at-an-event-in-england-as-part-of-the-events-research-programme/; https://www.gov.uk/government/publications/information-for-ticket-holders-attending-the-euro-2020-events-research-programme-matches/information-for-ticket-holders-attending-the-euro-2020-events-research-programme-matches
5. ^ https://www.gov.uk/government/publications/guidance-about-the-events-research-programme-erp-paving-the-way-for-larger-audiences-to-attend-sport-theatre-and-gigs-safely-this-summer
6. ^ https://www.gov.uk/government/publications/events-research-programme-phase-i-findings
7. ^ https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandwellbeing/bulletins/coronavirusandthesocialimpactsongreatbritain/14may2021#attitudes-to-attending-events
8. ^ https://www.ft.com/content/4047f4cc-5d0b-4635-adeb-e8fe85548a91
9. ^ Calculated from Table 7, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/994997/Variants_of_Concern_VOC_Technical_Briefing_16.pdf
10. ^ https://www.gov.uk/government/news/vaccines-highly-effective-against-hospitalisation-from-delta-variant
11. ^ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/993879/Variants_of_Concern_VOC_Technical_Briefing_15.pdf
12. ^ https://jamanetwork.com/journals/jama/fullarticle/2777686
13. ^ https://www.gov.uk/government/publications/imperial-college-london-delta-b16172-transmission-in-england-risk-factors-and-transmission-advantage-1-june-2021

14. ^ https://www.thetimes.co.uk/article/5982798e-d90a-11eb-8f14-0bb645f59db0?shareToken=8d54d9544444267c7f69ce12388a2dc6

15. ^ https://www.medrxiv.org/content/10.1101/2021.05.22.21257658v1

16. ^ https://web.archive.org/web/20210525232804/https://www.gov.uk/government/publications/coronavirus-covid-19-vaccine-adverse-reactions/coronavirus-vaccine-summary-of-yellow-card-reporting

17. ^ https://www.gov.uk/government/news/over-half-of-uk-adults-vaccinated-with-second-dose

18. ^ https://www.gov.uk/government/publications/imperial-college-london-evaluating-the-roadmap-out-of-lockdown-step-3-5-may-2021

19. ^ https://www.researchsquare.com/article/rs-637724/v1

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