# Minimising health harms during the COVID-19 pandemic: highlighting future strategic options, and underlying assumptions, to facilitate assessment of trade-offs for decision-making

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## Summary

### Background

By July 2020, the COVID-19 pandemic has resulted in substantial mortality within Scotland and around the world. The control measures implemented as a result have been very wide-ranging with a large number of unintended negative health, social and economic consequences. The future strategy for managing the pandemic will need to balance the benefits of more severe control measures in reducing COVID-19 direct mortality and morbidity with these unintended consequences. The strategy will need to clearly set out the assumptions underlying different strategic options so that informed decision-making can be undertaken as the evidence base deepens. This paper details the strategic options for the next phase of managing the COVID-19 pandemic, the assumptions underlying each, and the main trade-offs to be considered.

### Methods

We reviewed and extracted aims, objectives, theories, pathways and assumptions from UK and UK devolved nation government documents detailing the current approaches to managing the COVID-19 pandemic as 'lockdown' is eased. Using the extracted theories and background knowledge, a series of strategic options were identified and tabulated, with key assumptions, benefits and risks detailed. We supplemented this with the views of a small group of public health peers in Scotland to expand the list of strategic options, assumptions, benefits and risks.

### Results

We identified eight strategic options, four of which are more consistent with viral elimination: Test and Protect, Vaccination, Population immunity by natural infection and Border control; and four more consistent with the virus being endemic: Letting the virus spread, Universal mass testing, Targeted repeated testing, and Hammer and Dance (initial 'lockdown' followed by selective variation of these measures over time, place and setting). Many of these strategic options can be combined into an overall high-level strategy, or are more or less appropriate at different stages of the pandemic (or prevalence levels of infection). An important trade off with those strategic options that

involve physical distancing (i.e. which are combined with Hammer and Dance) is the balance of positive impacts this may have on direct COVID-19 mortality and morbidity against the negative social and economic and non-COVID health impacts, and through these the potential for substantial negative health consequences. Strategic options that are reliant on population immunity (either through exposure or immunisation) carry substantial risk given their uncertainties. A successful high-level elimination strategy using Test and Protect will require an effective Port health approach, and for the assumptions within that to hold. Those strategic options which seek to minimise physical distancing (Population immunity by natural infection and Letting the virus spread) carry the substantial risks of substantial direct COVID-19 mortality and morbidity but lower risks of unintended social and economic consequences of physical distancing.

**Conclusions**

Managing the COVID-19 pandemic to minimise the negative health consequences, and indeed to minimise the negative social and economic impacts, requires difficult decision-making in the face of a large number of important and substantial uncertainties. This paper summarises the main high-level strategic options, their assumptions, risks and benefits, and in doing so helps to clarify the key trade-offs to be made by policymakers and the most important questions for research to focus upon.

## Background

### What is the problem?

The COVID-19 pandemic has presented a substantial mortality challenge across many countries. In the initial phase of the pandemic in the UK, it was estimated that, in a fully unmitigated scenario, around 510,000 additional deaths would occur. However, if substantial physical distancing measures were implemented, it was estimated that this could be reduced to around 20,000 excess deaths.[1] Using an age-distribution based on the early Chinese outbreak, it was calculated that this would result in a loss of life expectancy of between -5.96 years and -0.33 years accordingly (assuming the excess deaths occurred within a single year). This is equivalent to the life expectancy that is lost due to inequalities over 1.7 years.[2] Although the mean number of years of life lost (YLL) with every COVID-19 death is estimated to be around 10 years in the UK,[3] the risk is very substantially higher with increasing age, with very few deaths in children or working age adults.[4]

The public health response to control COVID-19 has led to radical changes to how we live. This in turn has had profound impacts on the economy, education and social relations. These in turn are likely to have very substantial health and wellbeing impacts, most of which are negative. In addition, the reduced availability and demand (but not the need) for health and social care services are likely to have marked negative impacts on healthcare amenable mortality.[5] [6]

In designing and implementing an overarching strategy for controlling pandemic COVID-19, it is therefore essential that it achieves a balance between reduced mortality **and** morbidity due to the direct impacts of COVID-19, and the indirect health, social and economic impacts of the control measures.[7] Given that so much is uncertain as COVID-19 is a new pathogen, each strategy is necessarily based on a series of assumptions. Understanding these assumptions and the critical pathways for each strategic option is important as new evidence becomes available.

### What do we already know?

The initial stated aim of the pandemic control measures in the UK was to protect the NHS. This was in response to the news coming from Italy at the time which suggested that the infection would spread quickly and lead to a very large demand on Intensive Care Unit (ICU) facilities as people suffered from respiratory failure and required ventilation. By slowing the spread of the infection and 'flattening the curve' it was argued that the number of people requiring ventilation at any one time would be lower, and the capacity of the NHS to cope with demand would be maintained. In addition to physical distancing measures to slow the spread of the infection, additional ICU capacity was created and demands on ICU from routine planned operations reduced.

The relationship between the economy and health is complicated. It has been argued that effective pandemic control is essential to avoid long-term negative economic impacts (especially in pandemics impacting most on working-age adults).[8] However, it is also known that the lockdown measures, and the attendant impacts on health seeking behaviour, incomes, employment and the economy overall, as well as through social isolation, and loss of education, will be likely to have marked health impacts.5 The Scottish Government have sought to monitor these unintended consequences, framed as 'four harms' (direct COVID-19 health impacts; health service impacts; wider social impacts; and economic impacts).

### What is not known?

Although the initial phase of pandemic control was focused on reducing the speed at which the infection was spreading and increasing ICU capacity, it was less clear what the medium to long-term strategy for managing the pandemic has been. The scale of unintended health impacts of physical distancing, as well as the longer-term economic and social costs is also unknown. Other areas of uncertainty include:

- The likelihood of the virus undergoing a shift in strain such that it becomes more or less pathogenic
- how viral spread varies with changes in the seasons and weather
- the strength and duration of an individual's immunity post infection
- the long-term impacts of viral infection
- the likelihood of effective treatment or vaccination being developed
- population behaviour / commitment to control measures over a prolonged period

### What does this paper do?

This paper identifies the main control strategies that have been discussed in the UK context, the assumptions and critical pathways underlying the success of those strategies, and provides a basis for making trade-off decisions as we move through this pandemic.

## Methods

### Review of UK and devolved government documents

We reviewed UK and UK devolved nation government documents detailing the current approaches to managing the COVID-19 pandemic as 'lockdown' is eased published, namely:

- UK Government: *OUR PLAN TO REBUILD: The UK Government's COVID-19 recovery strategy*[9]
- Scottish Government: *Covid-19: Framework for Decision Making - Further Information; COVID-19: Framework for Decision Making - Supporting Evidence Paper;* and *COVID-19 – Framework for Decision Making - Scotland's route map through and out of the crisis*[10] [11] [12]
- Welsh Government: *Unlocking our society and economy: continuing the conversation;* and *Leading Wales out of the coronavirus pandemic - A framework for recovery*[13] [14]
- Northern Ireland Executive: *CORONAVIRUS: EXECUTIVE APPROACH TO DECISION-MAKING*[15]

Strategic aims and objectives, underlying theories for how the pandemic will be controlled and pathways for getting out of 'lockdown' were extracted. Assumptions that were explicit or inferred were also extracted.

### Creation of distinct strategic options

Using the extracted theories and the background knowledge of the authors, a series of strategic options were identified. These were to represent distinct ways of managing the pandemic at a high level rather than the detailed tactical considerations that are also clearly relevant and important.

The strategic options were not necessarily mutually exclusive but could be combined in different ways to create an overall strategy. We classified these into those which were broadly orientated towards elimination of the virus and those which were orientated towards managing the virus as endemic. However, some approaches could be used in both. In this case we classified according to the best fit.

**Identification of assumptions, benefits and risks underlying each approach**

Using the government documents and the background knowledge of the authors we detailed the key assumptions and anticipated benefits and risks of each strategic option. We did not seek to test these assumptions, or quantify the benefits and risks at this stage. This would clearly be a useful follow-on research project. We considered these assumptions, benefits and risks by way of small group work undertaken virtually where we discussed each strategic option and questioned each aspect in turn.

**Creation of framework for decision-making**

Having detailed all of the strategic options we then looked at those which were co-dependent, contradictory and complementary to describe the overall high-level strategies available to governments. We then detailed the key assumptions, risks and benefits of these in order to identify the critical pathways that would require to be followed to maximise their success. This also helped to identify the most important uncertainties that should be the subject of focused research and review work.

## Results

The consistently stated strategic objectives of the approach to controlling COVID-19 in the UK have been to preserve life and to protect the NHS. More recently, returning the economy either back to pre-pandemic activity levels (or using the opportunity to rebuild the economy differently) have become more important objectives. Appendix 1 provides the review of UK and devolved government documents detailing the current approaches to managing the COVID-19 pandemic as 'lockdown' is eased. The narrative of these documents, published from late April to May, was broadly that of controlling the virus and mitigating the impacts, until such a point that vaccination and/or treatments may potentially become available. In Scotland, it is clear that that aspiration has since changed to that of elimination.[16 20]

Figure 1 details the key pathways and assumptions of the identified distinct strategic options. Clearly, **the strategic options are not mutually exclusive and some are interdependent**. We have classified and described these in more detail in Table 1. Some of these strategic options are more orientated and consistent with elimination of COVID-19 as an aim, whilst others are more consistent with it becoming endemic. Although several of the strategic options can be useful for either an elimination or endemic situation, we found it helpful to have a more binary classification and have grouped the approaches into the more appropriate of these two overall aims.

**Elimination strategies**

***1. Test and Protect***

The first strategic option is termed Test and Protect in Scotland, although it has different names across the UK nations. It essentially involves identifying cases and tracing the contacts of those cases. The contacts are then asked to self-isolate in order to prevent further spread. In the 'lockdown' phase of the pandemic, this was principally conducted as part of general public advice, by asking symptomatic people and their household contacts to self-isolate. As time has passed, this now involves antigen testing for any symptomatic person, regular screening in some settings (e.g. nursing homes) and continued active outbreak management. For this strategic option to lead to successful elimination, it requires there to be:

- a low number of cases
- good port health arrangements (including either low/zero travel from countries/nations with prevalent cases, including the rest of the UK, and effective quarantine arrangements for travel from areas with high prevalence rates)
- good public compliance with self-isolation orders (including financial arrangements to compensate people for lost earnings)
- low rates of asymptomatic or undetected cases
- a means for identifying contacts (which has included mobile phone applications).

***2. Vaccination***

A safe and effective vaccination will clearly make elimination of COVID-19 much easier as population immunity can be boosted quickly and easily. However, there are many uncertainties about whether a vaccine will ever become available, and if so, how soon. Furthermore, the vaccine may only be partially effective, or effective only for a single season or short time period. Finally, there may be challenges with public uptake of the vaccine. A strategic option dependent on effective vaccination becoming available, and/or one that requires extensive physical distancing to stop spread of COVID-19 until a vaccine is available, risks substantial unintended health, economic and social harms for a prolonged and uncertain period of time, and these harms may quickly outweigh the benefits of reduced COVID-19 transmission during lockdown.

***3. Population immunity by natural infection, whilst protecting the most vulnerable***

The concept of 'herd immunity' for COVID-19 was articulated early in the pandemic in UK by Patrick Vallance, the chief scientific advisor to the UK government, but the recommendation of this approach has been refuted by Public Health England.[1719] In a 'herd immunity' approach it is assumed that people will become immune after being infected with COVID-19 and that as a result, if the virus is allowed to spread, in time the population will develop 'herd immunity' such that there are insufficient people susceptible for the virus to spread. Under this strategy there is a need to reliably identify vulnerable groups and prevent them from becoming infected (i.e. through 'shielding') whilst the rest of the population become infected and then immune. There is also a need to avoid too many people becoming infected at once so as to avoid overwhelming the NHS capacity. It is similar to Endemic strategy 3 ('Hammer and Dance') as below, the difference being in this approach that population immunity is gradually built up.

### *4. Border Control*

Where the local viral prevalence is lower than other countries, the strategic aim is one of elimination rather than managing the virus as endemic, and there is not widespread population immunity (either through vaccination or exposure), having an effective port health system in place to reduce re-infection is essential. It requires there to be a means of identifying people coming into the country, including across land borders. In the absence of an effective means of identifying infectious individuals (which is made more difficult where there is asymptomatic spread and a pre-symptomatic time period) a robust quarantine regime is required. With the required quarantine period for COVID-19 being 14 days, this has considerable implications for the tourism sector but may also have implications for the transport and trade of goods. Issues include:

- Finding effective means of enforcing quarantine regulations is challenging and requires substantial public compliance.
- Consideration also needs to be given to the balance of having 'exemption criteria' for certain groups of individuals vs. countries of origin
- Role of air-bridges and what happens when they are breached.

## Endemic strategies

### *1. Letting the virus spread*

The logic for this strategic option is two-fold. First, that there is little that can be done in the long-term to avoid the whole population being exposed. As such the choice is simply around the timing and the intensity of the epidemic rather than the total number of people who become infected and who die. Second, that the health (and social and economic) impacts of extensive physical distancing measures are likely to be large, and larger than the health gain from reducing the speed at which the virus spreads (and therefore the number of people who benefit from healthcare intervention). There are more or less cautious versions of this strategy depending on whether it involves enhanced hygiene measures, some physical distancing measures and some shielding. This approach is less compatible with a Test and Protect strategy as it is likely that a large number of people will become infected at once and this will overwhelm the capacity of contact tracing systems. It is distinct from Elimination strategy 3 (Population immunity by natural infection) in that there is no assumption here that the population become immune after exposure, under which circumstances, mortality from the infection would unfortunately become a permanent phenomenon. Arguably the more cautious version of this strategic option is close to that adopted in Sweden and the USA government; the less cautious version is more similar to the approach being taken by the Brazilian government and that proposed by some commentators.[18]

### *2. Universal mass testing (screening)*

A strategy of universal, weekly, COVID-19 testing was proposed by Julian Peto and colleagues.[19] The key benefit of this approach is that it could reduce the need for physical distancing, and as a result there would be a reduced risk of negative unintended health, economic and social impacts. There are two distinct potential types of test: an antigen test which detects the presence of the virus and indicates recent infection; and an antibody test which detects previous exposure.

The use of an antigen test assumes that there is very substantial testing capacity and a very high degree of public collaboration in the testing regime. It also assumes that the tests produce a low false negative and false positive rate or that the impacts of such false test results are acceptable. The operational sensitivity and specificity must be clarified.[21] In addition, the pre-test probability is the other important factor and is contingent on the prevalence of the disease in the population and the clinical presentation of the patient.[22] This approach is compatible with elimination strategies but is normally talked of as a means to reduce spread in a context where there is a large number of cases.

The key assumption of antibody tests is that a positive test confers immunity. If this assumption is true it could facilitate 'immunity passports' to allow immune individuals to participate more fully in society in the knowledge that they are at very low risk of either spreading or catching the virus. This also requires very substantial testing capacity, although once people are found to be positive, they could be removed from the regular testing approach. There is an important risk that some people may seek to become infected deliberately in this scenario, or obtain a positive test result through other means, in order to be able to participate more widely in society.

***3. Targeted repeated testing (i.e. targeted screening)***

This strategic option involves repeated testing of specific groups. It is usually discussed in relation to workers in particular sectors such as health and social care, or those living in communal accommodation with vulnerable individuals such as nursing homes and specified outbreak scenarios. Similar assumptions, risks and benefits apply to this approach as to Universal mass testing above. This approach has the particular potential benefit of reducing the risk for high risk groups who may be shielding.

***4. Hammer and Dance***

The 'Hammer and Dance' refers to the policy of bringing the transmission of the virus down (with an R0<1) using severe physical distancing measures in the first instance (the 'Hammer') and then selectively releasing these measures over time, perhaps with regional variation, in response to the R0 value (the 'Dance').[20] This implies flexibility along a spectrum of lockdown from small scale to mass lockdown. In this way, the virus is prevented from overwhelming the NHS with COVID-19 cases, and over time physical distancing measures can be reduced (and with them the unintended health, economic and social consequences). As the R0 number approaches or goes over 1, physical distancing measures can be reintroduced to bring the number of cases back down. This then buys time for additional NHS capacity to be put in place, and for treatments and a vaccine to be developed. Arguably, this is the approach taken across the UK up to now.

**Generic uncertainties**

Interacting with the strategic options, there are uncertainties and issues which apply generically. First, there is substantial uncertainty about the future ways in which the virus will change over time. It is possible that it will become more or less pathogenic, or spread more or less quickly. This may in turn depend upon the prevalent weather conditions and thus may vary by season. Thus, the apparent progress in reducing the spread of the virus over the spring and into summer might in part reflect changes in the weather patterns.

Second, there are specific issues and uncertainties in relation to children, although they are at very substantially lower risk of mortality.4 There is also building epidemiological evidence that children are not an important source of transmission of SARS-CoV2.[23] However, it is not known that closing school and restricting the movement of young children has benefit in terms of preventing mortality among vulnerable sections of the population. This has important implications for adjusting physical distancing regulations because the closure of schools creates a need for childcare within families and thereby reduces the available workforce. The interplay between the spread of virus through children, the closure of schools, and economic activity is therefore important across all the strategic options.

**Combining strategic options and determining critical pathways**

Elimination of COVID-19 could more easily be achieved in the long run if a large proportion of the population became immune either through vaccination (Elimination 2) or exposure (Elimination 3: Population immunity by natural infection). However, key assumptions of both of those strategies remain uncertain at present and so would represent highly risky approaches if pursued without other complementary strategies.

It is also possible that a combination of Test and Protect (Elimination 1) and Border control (Elimination 4) could achieve elimination of the virus, although this is made more likely when combined with Hammer and Dance (Endemic 4, the imposition of widespread and then diminishing and variable physical distancing measures). There are substantial risks to this combination of approaches, in particular the need for long-term physical distancing measures with all the unintended social and economic consequences (and through those routes, health consequences) and the need for workable measures in place across the border with England. The balance of risks and benefits therefore needs to be carefully considered and monitored for this combination.

The Hammer and Dance strategic option is the most compatible with others. It is compatible with strategic options Elimination 1 (Test and Protect), Elimination 2 (Vaccination), Elimination 4 (Border control), Endemic 2 (Universal mass testing), and Endemic 3 (Targeted repeating testing). Indeed, it is also compatible with the 'soft' versions of Elimination 3 (Population immunity by natural infection) and Endemic 1 (Letting the virus spread) in which there is some, limited, physical distancing measures introduced. Again, the main risk of a strategy centring on physical distancing measures to reduce viral spread is the unintended economic and social consequences, and through these routes, health impacts.

Combining Hammer and Dance with either the Endemic 2 (Universal mass testing) or Endemic 3 (Targeted repeated testing) seeks to reduce these unintended consequences by reducing the number of people having to isolate and/or the degree of physical distancing required (and thereby reducing the social and economic consequences). However, these additional strategic options have substantial assumptions and risks consistent with those of any screening programme, not least in relation to the accuracy of the tests.

**Figure 1 –Strategic options and underlying assumptions**

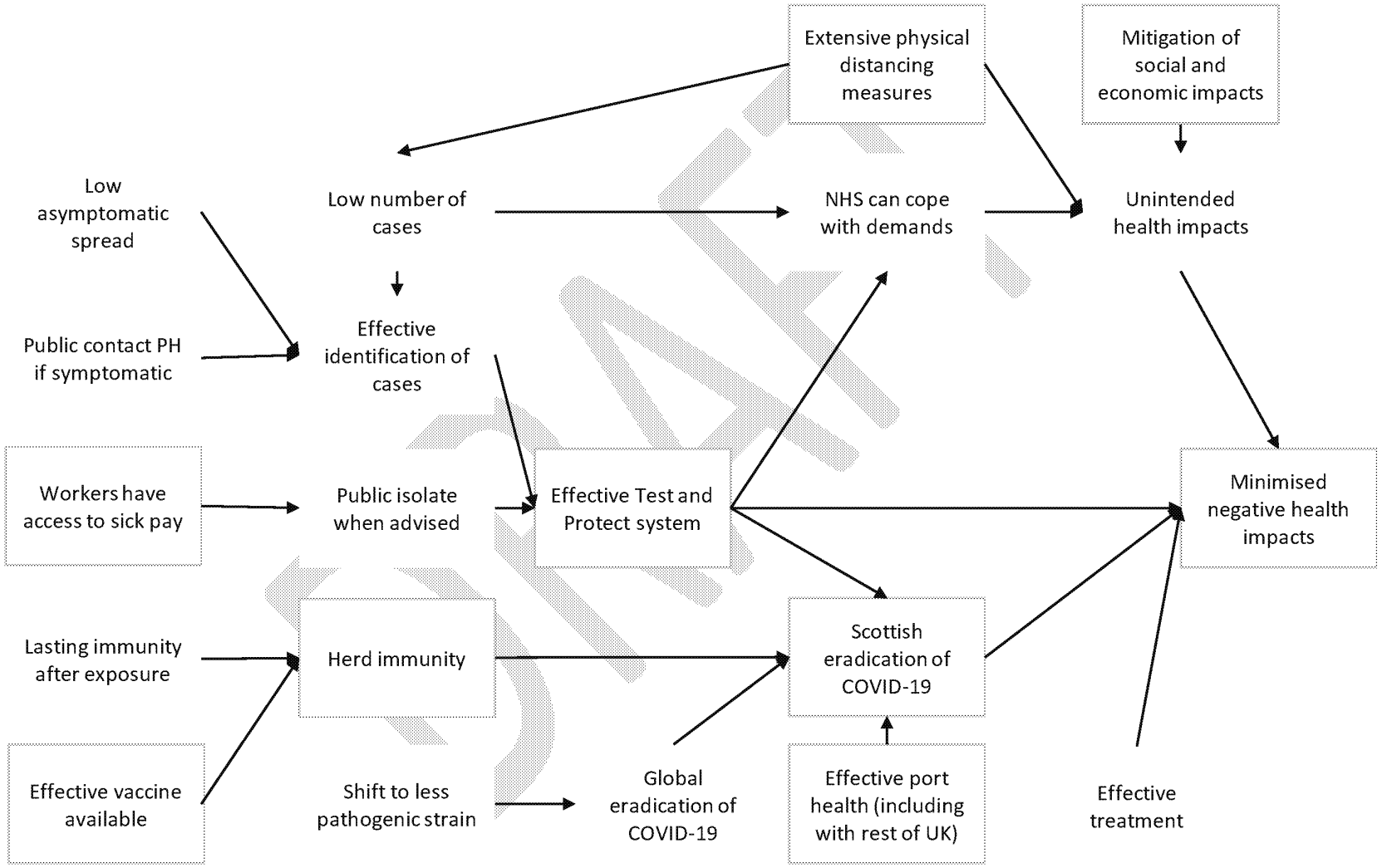


**Table 1 – The key assumptions, risks and benefits of the range of strategic options**

| Strategic option | Key assumptions | Risks | Benefits | Comment |
|---|---|---|---|---|
| Elimination 1: **Test and Protect** | Low number of cases in the community (thus requiring ongoing physical distancing measures until elimination) | Public fatigue with isolation messages could make this strategy less effective over time. | The short-term economic and social costs of isolation are borne only by cases and contacts, potentially reducing the unintended consequences in comparison to other strategic options. | In isolation, for test and protect to lead to effective elimination of COVID-19 in Scotland, it would require effective port health measures (Elimination strategy 4, below). There are also particular political and reputational risks in delivering a co-ordinated and effective testing system that should be recognised with this strategic option. |
| | The system is accessible (e.g. health literacy, technological capacity of the patient, access to transport if required) acceptable for the public, and co-ordinated between the local, Scottish and UK systems | | | |
| | Cases and contacts can be easily identified (including low proportion of asymptomatic spread, public seek testing if symptomatic) | Physical distancing measures generate substantial unintended negative health consequences (e.g. through loss of income or social isolation). | | |
| | Cases and contacts adhere to isolation (including arrangements being in place for people to be paid when isolating or off work caring for a child who is isolating) | | Long-term negative impacts from physical distancing measures are avoided when elimination occurs. | |
| | The available tests have a low false positive and false negative rate | | | |
| Elimination 2: **Vaccination** | A vaccine is able to be created rapidly for COVID-19 (i.e. it becomes available within the required timescale) | Rushing the development process may reduce the safety or efficacy of the vaccine. | Long-term negative impacts from physical distancing measures are avoided when elimination occurs. | It is uncertain whether a vaccine (or a series of vaccines if the virus evolves) will become available with sufficient efficacy and longevity to be effective. The international availability of the vaccine and the likely unpopularity of a vaccine programme with some |
| | Vaccination confers lasting immunity for a sufficient proportion of the population (i.e. the vaccine is effective) | | | |
| | There is sufficient availability of the vaccine | | | |
| | There is sufficient take-up of the vaccine | | | |

| Strategic option | Key assumptions | Risks | Benefits | Comment |
|---|---|---|---|---|
| | There is sufficient capacity to deliver the vaccine across the population | | | sections of the population will present additional challenges. |
| | The vaccine is safe. | | | |
| Elimination 3: **Population immunity by natural infection, whilst protecting the most vulnerable** | Infection confers lasting immunity | Almost all the population will be exposed to infection and without effective treatment could lead to substantial mortality and illness, especially amongst vulnerable groups. | Long-term negative impacts from physical distancing measures are avoided when elimination occurs. | This strategy (sometimes termed 'herd immunity') could be combined with physical distancing measures to limit the speed of spread of infection to reduce the demands on the NHS. It is also similar to the *'Endemic 1 (letting the virus spread)'* strategy detailed below, except that in this the population gain immunity over time and steps are taken to protect the most vulnerable. |
| | Vulnerable populations can be protected from the spread of the virus across the majority of the population (e.g. through effective shielding policies) | If a large section of the population is infected simultaneously the NHS could be overwhelmed with demand (at a time when many staff are also infected) and treatment could be less effective for COVID-19 and non-COVID-19 conditions. | The unintended negative consequences on health through the control measures (e.g. loss of income due to unemployment) will be less. | |
| | | Having a large proportion of the population infected would reduce economic activity and social support and may as a result have unintended negative health consequences. | | |

| Strategic option | Key assumptions | Risks | Benefits | Comment |
|---|---|---|---|---|
| | | Vulnerable populations may be shielded for a long time with associated health and wellbeing risks as a consequence isolation | | |
| Elimination 4: **Border control** | There are legal, ethical and logistical means to control all borders with higher prevalence nations, including the rest of the UK | Quarantine measures have particularly negative impacts on some economic sectors such as tourism | Likely to reduce the number of imported outbreaks | Effective port health measures are essential to achieve elimination of the virus unless there is already global elimination or population immunity. This strategic option is therefore an essential component of the Test and Protect strategy. |
| | The public adhere to quarantine advice, and/or there is means of enforcing this | The transport of goods and trade is slowed with the consequent impacts on the economy and the availability of goods | | |
| | There is a means of identifying those at risk of carrying the virus into the country | Exempt groups of workers may travel from high prevalence countries | | |
| | | Risk of 'indirect routes' of travel to wilfully evade quarantine | | |
| | | Risk of reputational damage as consequence of enforcement of quarantine (political, public health and law enforcement) | | |

| Strategic option | Key assumptions | Risks | Benefits | Comment |
|---|---|---|---|---|
| Endemic 1: **Letting the virus spread** | The unintended health impacts of extensive physical distancing for COVID-19 are greater than the health impacts of COVID-19 with prioritised treatment. | NHS services are overwhelmed by demand as a large proportion of the people become unwell at the same time.<br>If there is no lasting immunity, COVID-19 morbidity and mortality become a long-term problem. | The unintended health, economic and social impacts of COVID-19 are minimised, including reduced impacts on individual freedoms. | This is a similar strategy to 'Elimination 3: Population immunity through natural infection', although in this approach there is no assumption of immunity over time. In this way the decision is that the negative consequences of physical distancing outweigh the impacts of the virus. As above, there are more and less cautious versions of this strategic option depending on the extent to which it is combined with hygiene measures, limited physical distancing and shielding. |
| | The NHS can be protected by prioritising treatment and managing more people outside hospital/ICU, or the additional capacity now available is sufficient. | | | |
| | Increasingly effective treatment becomes available. | | | |
| | The NHS and other services can manage with the number of people ill due to COVID-19 at any one time; or the health gain from treatment for COVID-19 is small. | There are a large number of deaths amongst vulnerable groups. | | |
| | In the more cautious version of this approach assumes that shielding, hygiene measures and limited physical distancing are sufficient to reduce the harms of the virus. | The impact of additional COVID-19 mortality and morbidity outweighs the economic and social benefits. | | |
| Endemic 2: **Universal mass testing (screening)** | The available tests have low false positive and false negative values (or it is possible to deal with the consequences of high numbers of false test results). | As prevalence comes down, even a small false positive rate will create a seemingly long-running endemic position (for antigen testing). | This approach would be compatible with a much-reduced physical distancing regime, and with that a reduced risk of unintended health, economic and social impacts. | This approach is compatible with elimination strategies. It would require a very substantial increase in testing capacity and a high degree of public support and collaboration. |
| | It is possible to create testing and contact tracing capacity to test, and act upon the results of, population-wide testing. | | | |

| Strategic option | Key assumptions | Risks | Benefits | Comment |
|---|---|---|---|---|
| | The public adhere to self-isolation advice and there are arrangements in place to pay for foregone income. | The impact of this strategic option could be unsustainable | | |
| | The public comply with weekly testing and avoid falsification of negative tests. | People misunderstand test results such that they assume they are not infected (e.g. with a negative antigen test at a particular point in time) or are immune and can neither catch nor spread the virus (i.e. with a positive antibody test). | This could reduce the number of people who have to isolate or adopt physical distancing measures, releasing people to work (including in areas of high potential exposure such as with immunocompromised patients or in nursing homes). | |
| | For the antibody testing form of screening, there is an assumption that a positive test confers immunity. | Some people may seek to deliberately become infected or obtain a positive antibody test through other means in order to be allowed to participate more widely in society. | | |
| | | Ethical considerations – achieving true informed consent (e.g. vulnerable groups, understanding of individual vs. population benefit) | | |

| Strategic option | Key assumptions | Risks | Benefits | Comment |
|---|---|---|---|---|
| Endemic 3: **Targeted repeated testing (screening)** | The available tests have low false positive and false negative values. | As prevalence comes down, even a small false positive rate will create a seemingly long-running endemic position (for antigen tests). | This could reduce the number of people who have to isolate or adopt physical distancing measures, releasing people to work (including in areas of high potential exposure such as with immunocompromised patients or in nursing homes). | This approach involves repeated testing for particular workers or in particular settings (e.g. care home workers or healthcare staff), rather than for the whole population. It has many similarities to the Endemic 2 (Universal mass testing) approach. |
| | The screened groups comply with repeated testing and adhere to self-isolation advice and there are arrangements in place to pay for foregone income. | People misunderstand test results such that they assume they are not infected (e.g. with a negative antigen test at a particular point in time) or are immune and can neither catch nor spread the virus (i.e. with a positive antibody test). | | |
| | For the antibody testing form of screening, there is an assumption that a positive test confers immunity. | Ethical considerations – achieving true informed consent (e.g. vulnerable groups, understanding of individual vs. population benefit) | | |

| Strategic option | Key assumptions | Risks | Benefits | Comment |
|---|---|---|---|---|
| Endemic 4: **Hammer and Dance** (initial 'lockdown' followed by selective variation of these measures over time, place and setting) | The unintended negative consequences of physical distancing are less than the health gain from flattening the epidemic curve (and more people with COVID-19 getting ICU care). | Without some means of eliminating COVID-19, the unintended consequences of physical distancing accumulate over time and will ultimately become larger than the benefits gained. | This approach is compatible with multiple other strategic options and has been used initially to 'buy time' to gather more information. | This is arguably the approach taken across the UK up to now. It focuses on reducing the R0 value and the number of prevalent cases to a level where the NHS can cope, and then selectively reducing the physical distancing measures such that the R0 rises slightly, but manageably. It is a compatible approach with Test and Protect (and elimination), mass testing, herd immunity and vaccination approaches. The success of the strategy depends upon achieving the optimum balance of benefits from reduced mortality and morbidity from the virus with minimised unintended consequences from physical distancing. |
| | Public compliance with measures | It is possible that this strategy neither achieves the reduction in mortality and morbidity from the virus nor minimises the unintended consequences of physical distancing measures. | This could balance the benefits of reducing mortality and morbidity from the virus with the minimum of unintended consequences from physical distancing measures. | |

## Discussion

### Main results

The intended aim of an overarching strategy must be clear (both in terms of political and public health outcomes). We identified eight strategic options to controlling the COVID-19 pandemic. Four were more orientated towards elimination of the virus (Test and Protect; Vaccination; Population immunity by natural infection; and Border control), whilst the others were more aligned to managing the virus as endemic (Letting the virus spread; Universal mass testing; Targeted repeated testing; and Hammer and Dance). We also identified a number of important factors that will influence the success or otherwise of different strategic options; these include, the impact on children and their propensity to spread the virus; the seasonality of the virus; and any changes over time in the pathogenicity or ability of the virus to spread.

However, several of the strategies were compatible with one another, or could represent an earlier or later phase of the others. Each strategic option relies upon a number of assumptions, some of which are less certain and more crucial than others. In particular, the Vaccination strategy relies upon an effective vaccine being developed over a reasonable timeframe and any approach based solely on this happening carries a large risk of accumulating negative consequences (e.g. through the unintended consequences of physical distancing) over a long time period. The Herd immunity strategy relies upon the crucial assumption of people becoming immune after infection. Although this remains uncertain, it should become clearer soon. Other strategies carry large risks, such as 'Letting the virus spread' (reliant as it is on herd immunity), and 'Hammer and Dance' (the dominant strategic option thus far across the UK, which is accumulating unintended negative consequences through physical distancing measures).

It is important to note that the identification of the strategic options, their assumptions, and the assessment of the benefits and risks of each will evolve over time as more evidence and data becomes available. The summary provided here should be interpreted in that context.

### Strengths and limitations

The strength of laying out the strategic options in the way that we have done here is that the assumptions underlying each become clearer and more testable by researchers. It also becomes clearer what the co-dependencies between strategic options are, and which are less compatible. The balance or risks and benefits to each option also becomes clearer and quantifiable as more evidence is generated over time. In this way, the description of the strategic options provided here could provide a framework for options appraisal to be undertaken in the future as the pandemic enters new phases.

There are also a number of limitations of this work. We have not undertaken a systematic review of strategic options and thus we may have missed some. There is also a question of the level at which strategic options are defined. It would, for example, been possible to have detailed a wider range of options for targeted testing (e.g. within nursing homes, schools, etc.), but we took the view that these were best summarised together for the purposes of brevity and to avoid conflating strategic with tactical considerations. Most of the options, assumptions, benefits and risks were derived through group discussion rather than from government documents. Our report is also UK, and

indeed Scottish-centric, and would require adaptation for other contexts. Finally, we have not sought to find and synthesis the evidence around the assumptions detailed here, nor have we attempted to quantify the risks and benefits. Thus, more may be known on each of these aspects than we have provided here. Indeed, what is known on each of these will change quickly as more research becomes available.

### How this fits with the literature

The potential for unintended consequences of the pandemic control measures have been well described.5 6 7 However, we are not aware of any attempt to detail all of the strategic options and their assumptions, risks and benefits in the UK.

### Implications for policy, practice and research

Policymakers should continue to consider the strategic options available to them, the assumptions underlying the success of those options, and the risks and benefits of each. As more evidence becomes available this should be revisited to ensure that the option which minimises harms is pursued. A dynamic options appraisal process that quantifies each of these and allows for them to be traded-off against one another may be a helpful approach.

Researchers and research funders should focus on reducing the uncertainties in the key assumptions and critical pathways underlying the strategic options. Although there is clearly very marked academic interest in the COVID-19 pandemic, critical questions around population immunity, vaccination, wider social and economic harms, and how to maximise public co-operation with public health guidance and regulations, should be considered priorities.

### Public engagement

In terms of implications and recommendations around these strategic options, we need to start explicitly exploring some of this with the public to inform policy. There is an evolving evidence base but realistically some unknowns will not be resolved quickly, and as a population we need to be able to start thinking about preferences on these issues within those knowledge gaps. Even starting to understand what gaps people feel most uncomfortable with might help inform some of the research priorities. The social implications of the strategic options necessitate early discussion outside of the 'expert' fora.

## Conclusion

Managing the COVID-19 pandemic to minimise the negative health consequences, and indeed to minimise the negative social and economic impacts, requires difficult decision-making in the face of a large number of important and substantial uncertainties. This paper summarises the main high-level strategic options, their assumptions, risks and benefits, and in doing so helps to clarify the key trade-offs to be made by policymakers and the most important questions for research to focus upon.

# Appendix 1 – Analysis of UK and devolved government documents and the assumptions underlying the different pathways out of 'lockdown'

## 1) OUR PLAN TO REBUILD: The UK Government's COVID-19 recovery strategy (HM Government, 11 May 2020)

### Strategic aim and objectives

- Overall aim
  - *"return life to as close to normal as possible, for as many people as possible, as fast and fairly as possible...in a way that avoids a new epidemic, minimises lives lost and maximises health, economic and social outcomes"* (p.15)

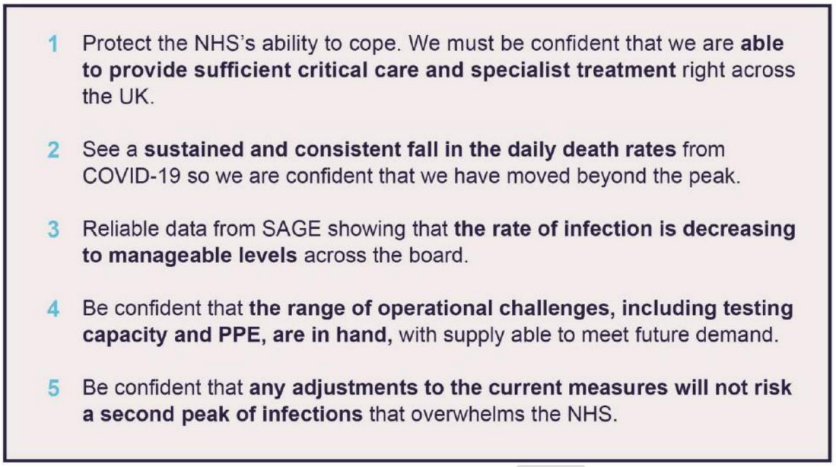
- Objective – to prevent overwhelming the NHS
  - *"If we get this right we will minimise deaths – not just from COVID-19, but also from meeting all our non-COVID-19 health needs, because our (bigger) NHS will not be overwhelmed"* (p.5)
  - *"In the near term, we cannot afford to make drastic changes. To successfully keep R below 1, we have little room for manoeuvre. SAGE modelling suggests that either fully opening schools or relaxing all social distancing measures now, will lead to a resurgence of the virus and a second wave that could be larger than the first. In a population where most people are lacking immunity, the epidemic would double in size every few days if no control measures were in place."* (p.12)

- Objective – to promote economic and societal recovery
  - *"We will maximise our economic and societal bounce-back: allowing more people to get on with more of their normal lives and get our economy working again."* (p.5)
  - *"The longer the virus affects the economy, the greater the risks of long-term scarring and permanently lower economic activity, with business failures, persistently higher unemployment and lower earnings. This would damage the sustainability of the public finances and the ability to fund public services including the NHS. It would also likely lead to worse long-run physical and mental health outcomes, with a significant increase in the prevalence of chronic illness."* (p.10)

- Objective – to build a sustainable long-term response to the virus
  - *"Then, as vaccines and treatment become available, we will move to another new phase, where we will learn to live with COVID-19 for the longer term without it dominating our lives."* (p.5)
  - *"This is not a short-term crisis. It is likely that COVID-19 will circulate in the human population long-term, possibly causing periodic epidemics. In the near future, large epidemic waves cannot be excluded without continuing some measures."* (p.12)

### Theories

- "five tests for easing measures" (p.11)



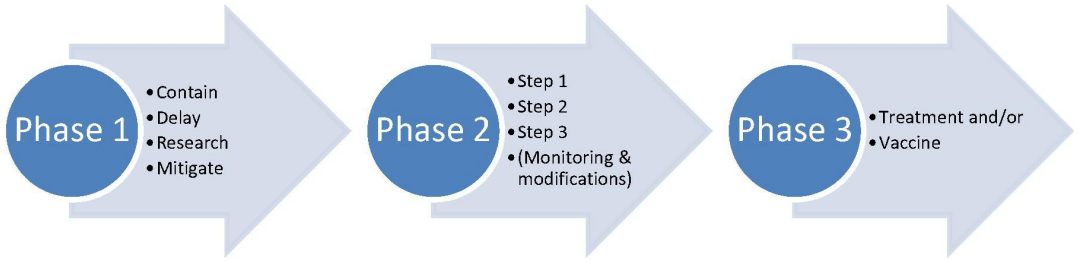
1. Protect the NHS's ability to cope. We must be confident that we are **able to provide sufficient critical care and specialist treatment** right across the UK.
2. See a **sustained and consistent fall in the daily death rates** from COVID-19 so we are confident that we have moved beyond the peak.
3. Reliable data from SAGE showing that **the rate of infection is decreasing to manageable levels** across the board.
4. Be confident that **the range of operational challenges, including testing capacity and PPE, are in hand,** with supply able to meet future demand.
5. Be confident that **any adjustments to the current measures will not risk a second peak of infections** that overwhelms the NHS.

Source: p.11, HM Government, 2020. *OUR PLAN TO REBUILD: The UK Government's COVID-19 recovery strategy.* Available from: *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/884760/Our_plan_to_rebuild_The_UK_Government_s_COVID-19_recovery_strategy.pdf [Accessed 10 Jun 2020].*

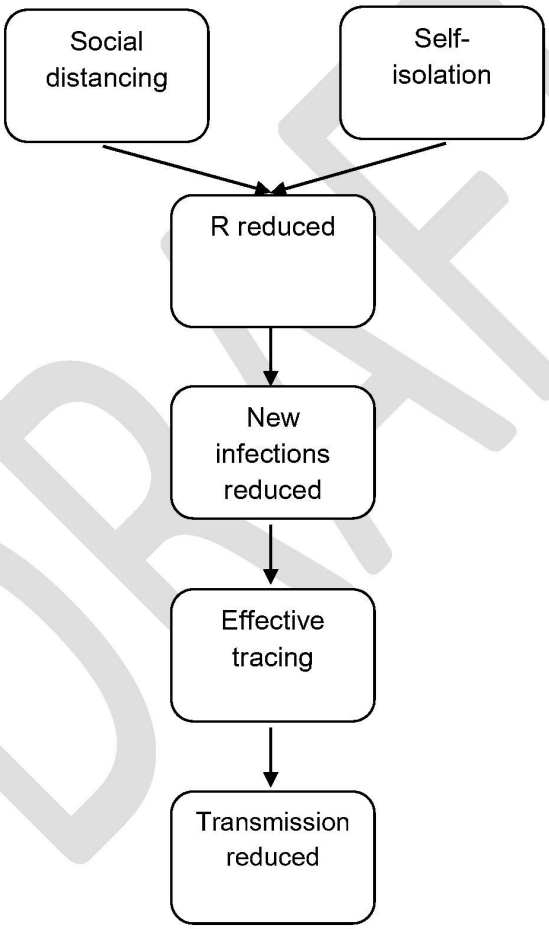
- Factors to be considered (pp.15-17)
  - *"Health effect...*
    - *Direct COVID-19 mortality...*
    - *Indirect harms arising from NHS emergency services being overwhelmed...*
    - *Increases in mortality or other ill health as a result of measures...*
    - *The long-term health effects of any increase in deprivation..."*
  - *"Economic effect...*
    - *the short-term economic impact...*
    - *the country's long-term economic future...*
    - *the sustainability of public finances...*
    - *financial stability...*
    - *the distributional effects..."*
  - *"Social effect...*
    - *the number of days of education children lose;*
    - *the fairness of any actions the Government takes...*
    - *the importance of maintaining the strength of the public services and civic organisations..."*
  - *"Feasibility...*
    - *including...technological risk...timelines...ability to work with global partners...experimental technologies"*

## Pathways

- Overall approach (p.19)




- Minimising the reproduction number (pp.7-8, 13)



## 2) Covid-19: Framework for Decision Making - Further Information (5 May 2020, updated 11 May 2020), Supporting Evidence Paper (7 May 2020) and Scotland's route map through and out of the crisis (21 May 2020) (Scottish Government)

### Strategic aim and objectives

- Objective
    - *"Our first objective and absolute necessity is to contain and suppress the virus. Beyond that, our challenge is to minimise broader harm to our health, society and economy and to restore as much normality to everyday life as possible."* (Scottish Government, 2020a, p.7)
    - *"We are clear that our primary objective at this point in time is to ensure that the reproduction rate of the virus (the R number) remains less than 1 and that cases remain within NHS capacity."* (Scottish Government, 2020b, p.3)

### Theories

- Approach
    - *"Suppress the virus through compliance with physical distancing and hygiene measures, ensuring that the reproduction number remains below 1 and that our NHS remains within capacity*
    - *Care for those who need it, whether infected by the virus or not*
    - *Support people, business and organisations affected by the crisis*
    - *Recover to a new normal, carefully easing restrictions when safe to do so while maintaining necessary measures and ensuring that transmission remains controlled, supported by developments in medicine and technology*
    - *Protect against this and future pandemics, including through effective testing, contact tracing and isolation*
    - *Renew our country, building a fairer and more sustainable economy and society."* (Scottish Government, 2020a, p.6)

- Assessment Framework
    - *"1. Options for physical distancing measures – easing, maintaining, (re)introducing – are technically assessed using the best available evidence and analysis of their potential benefits and harms to health, the economy, and broader society so as to minimise overall harm and ensure that transmission of the virus is suppressed.*
      *2. Potential options – individual and combinations of measures – are assessed for their viability, for example taking account of how easy they are to communicate and understand, likelihood of public compliance, the proportionality of any impact on human rights and other legal considerations.*
      *3. Broader considerations also include equality impacts and consideration of tailoring measures, for example to specific geographies and sectors.*
      *4. Assessments will inform the required reviews of the Coronavirus regulations and collective assessment and decision-making with the UK Government and other Devolved Administrations as appropriate."* (Scottish Government, 2020b, p.4)

- Three-weekly reviews

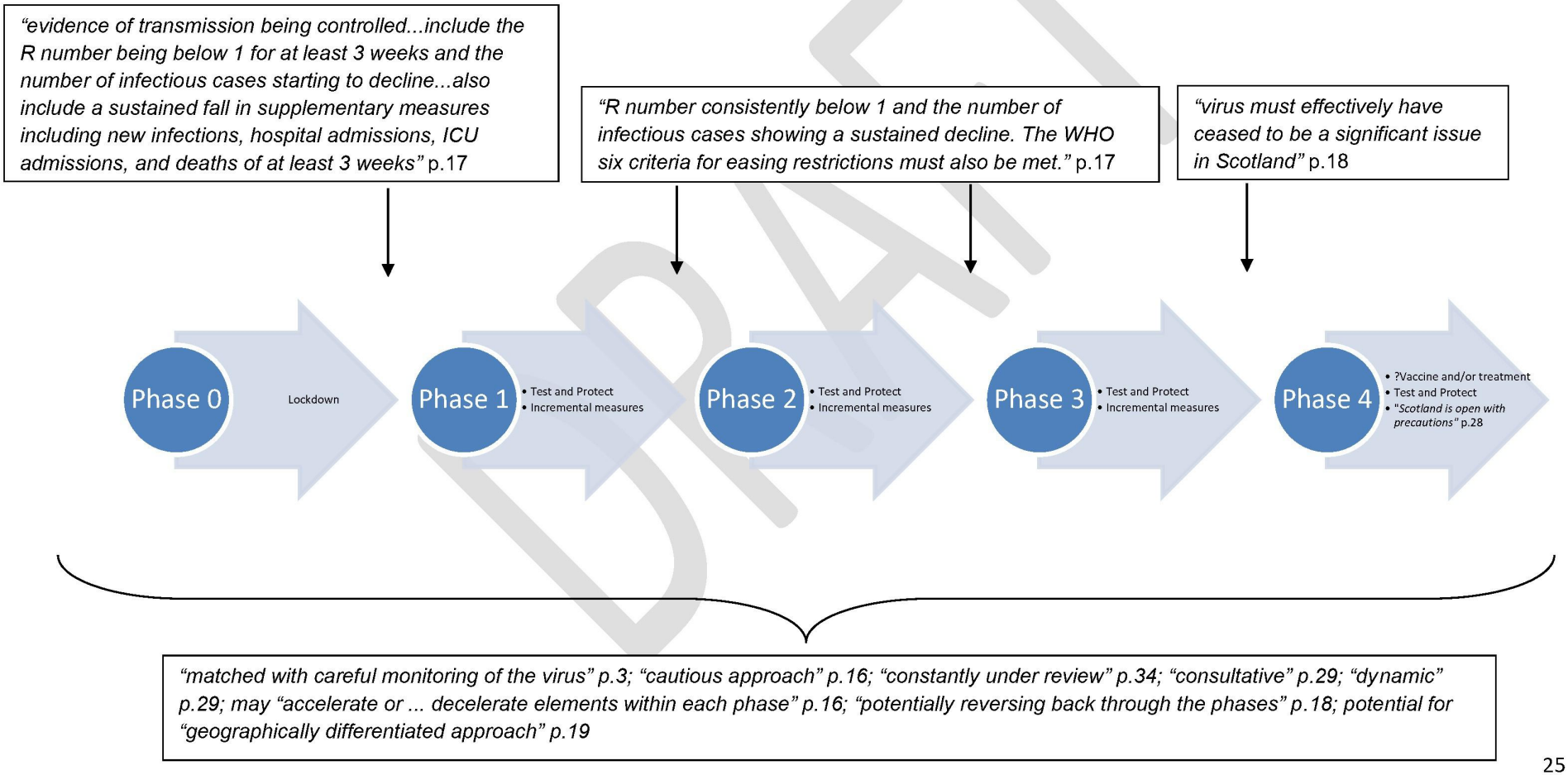
- *"The COVID-19 regulations must be reviewed every three weeks. This ensures that they remain proportionate to the need to tackle this public health emergency, and the absolute necessity of suppressing the virus, but also recognises the broader harms to health, the economy and society that are the side-effects of these measures."* (Scottish Government, 2020a, p.7)

- Epidemiological measurements influence decisions on control measures (Scottish Government, 2020a, p.9-14), including
  - Number of new cases – caveat noted that this affected by changes in testing policy
  - Number hospitalised with COVID-19
  - Number in intensive care
  - Number of deaths – caveat noted of delay in reporting
  - (and rate of change of these – *"Sustained continued evidence of the ratio staying below one will be required to be more confident that transmission is falling, and that numbers of new cases per day are falling, to the extent that is required for key elements of pandemic response – including Test, Trace, Isolate and Support – to be effective."* Scottish Government, 2020a, p.9*)*
  - Community surveillance
  - Use of such measures to estimate numbers with COVID-19 and reproduction number
  - R number acknowledged to be higher in care homes and hospitals
  - R number against estimated number of infectious people chart for estimating risk for overwhelming COVID hospital bed capacity – imprecision in measures noted

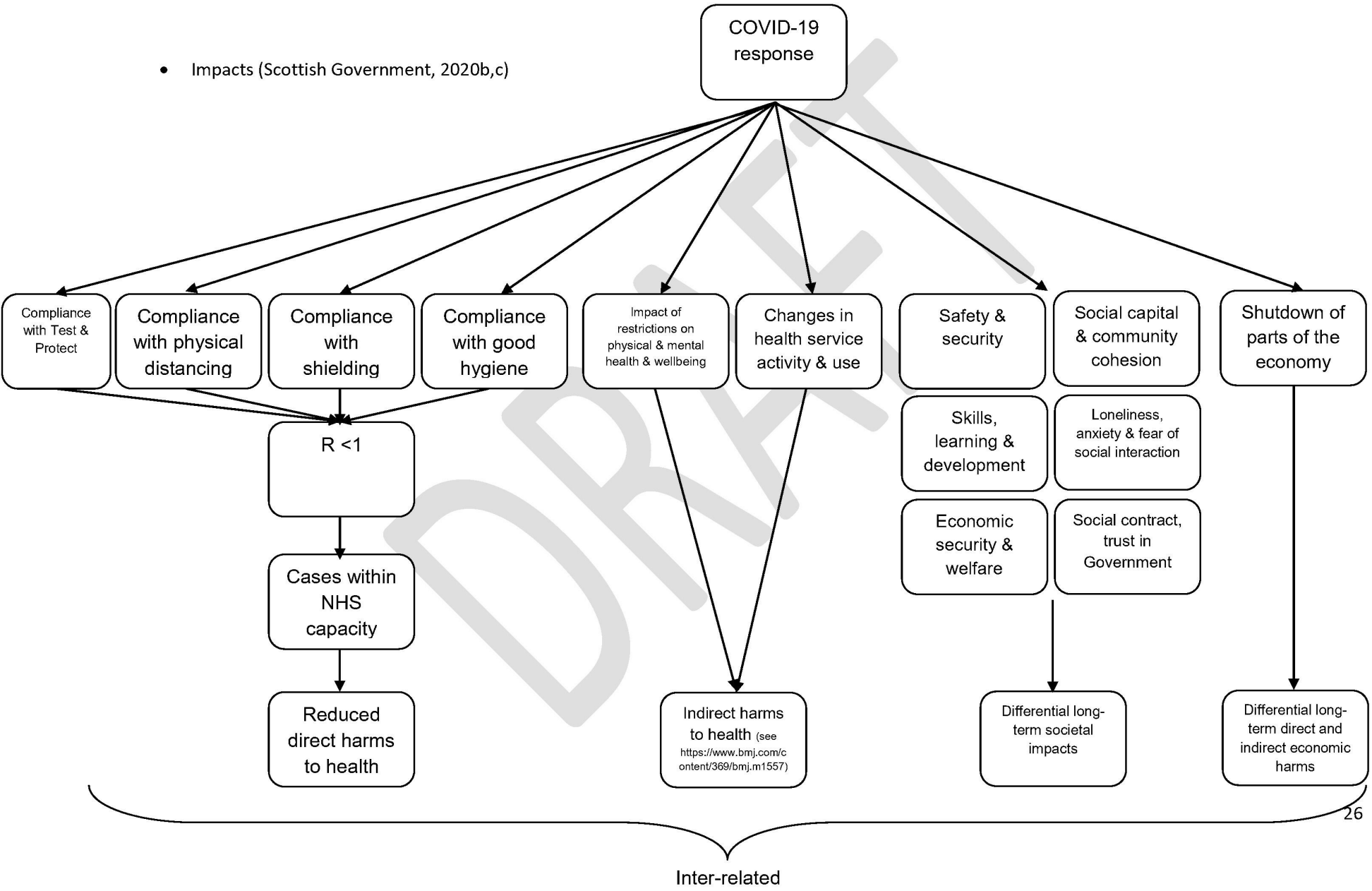
- WHO criteria
  - *"**Box 2: World Health Organisation: Six key criteria for easing restrictions***
    *1. Evidence shows that COVID-19 transmission is controlled.*
    *2. Sufficient public health and health system capacities are in place to identify, isolate, test and treat all cases, and to trace and quarantine contacts.*
    *3. Outbreak risks are minimized in high vulnerability settings, such as long term care facilities (i.e. nursing homes, rehabilitative and mental health centres) and congregate settings.*
    *4. Preventive measures are established in workplaces, with physical distancing, handwashing facilities and respiratory etiquette in place, and potentially thermal monitoring.*
    *5. Manage the risk of exporting and importing cases from communities with high-risks of transmission.*
    *6. Communities have a voice, are informed, engaged and participatory in the transition"* (Scottish Government, 2020c, p.18)

Pathways

- Overall approach (Scottish Government, 2020c)



- Impacts (Scottish Government, 2020b,c)



### 3) Unlocking our society and economy: continuing the conversation (15 May 2020) & Leading Wales out of the coronavirus pandemic - A framework for recovery (24 April 2020) (Welsh Government)

#### Strategic aims and objectives

- Aims
    - *"we will lead Wales out of this crisis in a way that keeps everyone safe and revitalises our economy as quickly as possible"* (Welsh Government, 2020b, p.3)
    - *"we, like countries across the world are able to start to think about how we can move out of the lockdown. But it is essential as we do so that we realise that this is not a short-term crisis. Until there is a vaccine or effective treatments, we will have to live with the disease in our society and to try to control its spread and mitigate its effects."* (Welsh Government, 2020a, p.2)

#### Theories

- Three *"pillars"*
    - *"This framework, therefore, is based on three pillars.*
        1. *Firstly, it sets out the measures and evidence by which we will judge the current infection level and transmission rates for coronavirus in Wales.*
        2. *Secondly, it sets out a series of principles by which we will examine proposed measures to ease the current restrictions, grounded in both scientific evidence and wider social and economic impacts.*
        3. *Thirdly, it sets out how we will enhance our public health surveillance and response system to enable us to closely track the virus as restrictions are eased, and how this system will protect people's health. Wales has maintained a National Public Health system, with a strong local presence in every part of Wales, and we will build on these strengths."* (Welsh Government, 2020b, p.3)
- Pillar 1
    - *"Some of the factors to consider in lifting restrictions will include:*
        - *Evidence of a sustained decrease in key metrics such as COVID-19 hospital admissions for at least 14 days.*
        - *Evidence that we can cope with the expected increase in healthcare needs for at least 14 days if the infection rate goes above 1 and the virus is spreading widely once again. This is how long it will take from locking down to stopping the increase again.*
        - *Assurance that we have enough PPE to provide for all frontline workers who need it in order to deliver our recovery plan.*
        - *Robust international evidence of the impact of lifting the restrictions on the spread of the virus, engaging with countries across the world to learn from their measures, and close engagement with other devolved administrations and the Mayor of London."* (Welsh Government, 2020b, p.5)
- Pillar 2
    - "We will evaluate these options against the following principles, in order to test risk and potential benefit.

        - To what extent would easing a restriction have a negative effect on containing the virus? ...
        - Is the measure at the low end of risk of further infection? ...
        - How can it be monitored and enforced?...
        - Is it capable of being rapidly reversed if it has unintended consequences?...
        - Is it a measure of relatively high positive economic benefit? ...
        - Does it have a high impact on social and psychological well-being?...
        - Does the measure have a high positive equality impact? ..." (Welsh Government, 2020b, pp.6-7)

- Pillar 3 - harms
    - *"COVID-19 related-harm to the people of Wales can occur in four key ways:*
        - *direct harm...*
        - *harm caused if services including the NHS became overwhelmed...*
        - *harms from non-COVID illness...*
        - *socioeconomic and other societal harms"* (Welsh Government, 2020b, p.8)

- Pillar 3 – public health response
    - *"improved surveillance, effective case identification and contact tracing, learning from international experience and engaging with the public."* (Welsh Government, 2020b, p.8)

- Approach
    - *"Before we take any action, we will;*
        - *Assess the potential impact of our decisions on containing the virus*
        - *Assess what measures we can put in place to reduce the effect of our decisions on containing the virus*
        - *Assess the impact of our decisions on general public health*

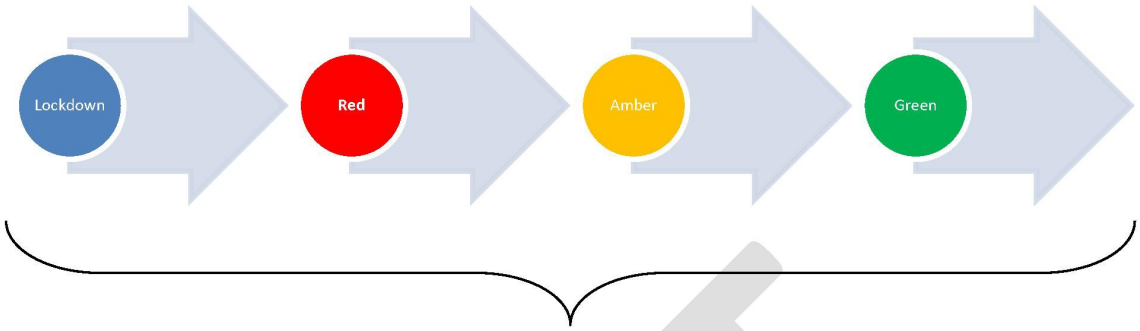
      *Only when we have considered all of the above, will we assess any social, economic or environmental impacts of our decisions."* (Welsh Government, 2020a, p.10)

- Consultation with public and partners (Welsh Government, 2020a, p.16)

- Addressing inequality (Welsh Government, 2020a, p.17)

### Pathways

- Overall pathway (Welsh Government, 2020a, pp.12-15)




*"not move wholesale from one phase to the next...carefully and slowly... dependent on continued progress in containing the spread of the virus, as well as developing further guiDance...effective contact tracing...move more quickly in some areas than others as the evidence changes and we understand more about the risks and how they can be managed in different settings... 'circuit breakers' that will trigger the re-imposition of measures if the growth of COVID-19 becomes unacceptable and could not be controlled...continuing to work collectively on a four-nations basis wherever possible"* (Welsh Government, 2020a, p.12)

## 4) CORONAVIRUS: EXECUTIVE APPROACH TO DECISION-MAKING (Northern Ireland Executive, 12 May 2020)

### Strategic aims and objectives

- Purpose
  - *"The public health analysis relating to the pandemic will always be the most important consideration, and we are committed to maintaining our approach of minimising the harm caused by the pandemic and avoiding the Health and Social Care system being overwhelmed as a result of an increase in people falling seriously ill. However, the pandemic will also cause severe social and economic damage. As such, action is required on both fronts to suppress the virus and mitigate the negative impact on livelihoods. That will become more acute as and when current support mechanisms from Government are tapered down or end."* (Northern Ireland Executive, 2020, p.6)

### Theories

- *"The Executive has agreed that the ongoing reviews of the Regulations will consider the following criteria;*
  *i) Evidence and analysis relating to the pandemic, including the latest medical and scientific advice, the estimated level of transmission and the impact of relaxations on the future trajectory of the pandemic;*
  *ii) Capacity of the health and social care services to deal with Coronavirus cases as well as the need to resume normal services;*

*iii) Assessment of the wider health, societal and economic impacts of the Regulations, including identifying the areas where greatest benefit and lowest risk would result from relaxation."* (Northern Ireland Executive, 2020, p.6)

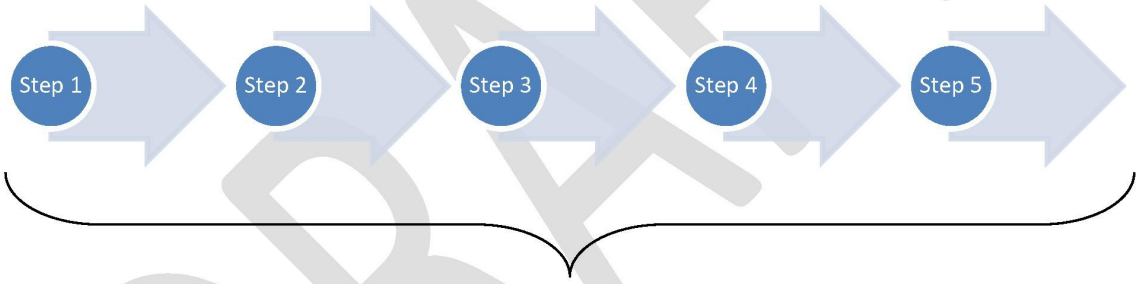
- Guiding principles
  - *"Controlling transmission...*
  - *Protecting healthcare capacity...*
  - *Necessity...*
  - *Proportionality...*
  - *Reliance on evidence..."* (Northern Ireland Executive, 2020, pp.6-7)

- WHO 6 criteria for easing restrictions (Northern Ireland Executive, 2020, p.7)

- Partnership working (Northern Ireland Executive, 2020, pp.7-8)

### Pathways

- Overall pathway (Northern Ireland Executive, 2020, pp.8-11)




*"Evidence... only decide to relax restrictions when we are sure that that is in the long term interest of the health and wellbeing of the population....sharing with you as clear a future approach as we can...flexibility...dynamic...review"* (Northern Ireland Executive, 2020, pp.8-9)

## Assumptions extracted from government documents – explicit and inferred

- Vaccine or treatment development
  - *"It is clear that the only feasible long-term solution lies with a vaccine or drug-based treatment"* (HM Government, 2020, p.4)
  - *"A mass vaccine or treatment may be more than a year away. Indeed, in a worst-case scenario, we may never find a vaccine. So our plan must countenance a situation where we are in this, together, for the long haul, even while doing all we can to avoid that outcome."* (HM Government, 2020, p.4)
  - *"Researchers may find some effective treatments imminently – for example from repurposing existing drugs – or might not do so for a long time. Not all treatments that have an effect will be game-changing; the best scientific advice is that it is likely any drugs that substantially reduce mortality or are protective enough to change the course of the epidemic will have to be designed and developed specifically for COVID-19, and that this will take time, with success not guaranteed. However, notwithstanding that many of these will fail, the economic and societal benefits of success mean the Government will do all it can to develop and roll-out both treatments and vaccines at the fastest possible rate; the second phase is a means of managing things until the UK reaches this point."* (HM Government, 2020, p.24)
  - *"We will harness developments in treatments and vaccines when the scientific advice tells us it is safe to do so. But we do not know if or when these will be available. We hope it will be sooner than shown but we will not count on them in our planning."* (Scottish Government, 2020a, p.21)
  - *"Until there is a vaccine or effective treatments, we will have to live with the disease in our society and to try to control its spread and mitigate its effects."* (Welsh Government, 2020a, p.2)

- Epidemiology of the virus
  - *"The world's scientific understanding of the virus is still developing rapidly. We are still learning about who is at greatest personal risk and how the virus is spread. It is not possible to know with precision the relative efficacy of specific shielding and suppression measures; nor how many people in the population are or have been infected asymptomatically."* (HM Government, 2020, p.13)
  - *"We need to continue learning about the disease and to understand how it is spread. In particular we need to understand who is at greatest risk, what proportion of those who become infected do not show symptoms, when the risk of someone who has been infected passing on the disease is greatest and 'what works' in terms of specific shielding and suppression measures."* (Welsh Government, 2020a, p.3)
  - *"That evidence, which will include an analysis of actions taken in other countries and jurisdictions who are further along in this wave of the pandemic, is constantly evolving."* (Northern Ireland Executive, 2020, p.8)

- Imprecision and assumptions around the epidemiological measures

- *"While precision on the R number is difficult, it is likely to lie between 0.70 and 1.0 (horizontal axis). This remains too high to be confident that case numbers will continue to fall."* (Scottish Government, 2020a, p.12)
- *"**Box 1: What affects the reproduction number R?***

  *The reproduction number (R) is affected by several factors:*

  - *the underlying infectiousness of the organism;*
  - *how long people who have Covid can infect others;*
  - *the number of people in the population that the affected patients are in contact with, and how intense that contact is.*
  - *Assuming there is a level of immunity once you have had the virus, R should decrease over time: as people become infected in a population there are fewer susceptible people left as they are either infected, have recovered, or have died.*
  - *If policies have the effect of reducing the number of people someone comes into contact with, that would in turn reduce R."* (Scottish Government, 2020c, p.9)
- *"The evidence that we will need to relax the current measures is complex, but it is becoming clearer"* (Welsh Government, 2020b, p.5)

- Basis of decisions on the emerging data on broad impacts of COVID-19
  - *"We have drawn together data and evidence on the various harms and wider impacts – health, societal and economic – caused by the crisis. Much of this evidence is still emerging, and the scale and nature of the impacts will change over time."* (Scottish Government, 2020b, p.3)
  - *"Societal harms may be more hidden, less tangible, more subjective, and less quantifiable than other harms. We therefore need to draw on a wider range of data and intelligence to understand them."* (Scottish Government, 2020b, p.13)

- Data needs to be critically analysed to be fully understood
  - *"Police Scotland also stated that they are seeing a slight decrease in domestic abuse incidents but are also acutely aware this may not reflect what is happening behind closed doors and that people do not always report abuse immediately[13]."* (Scottish Government, 2020b, p.14)
  - *"There has been a reduction in referrals to children's services during the lockdown period (likely linked to reductions in contact with education and universal health services), with consequent concerns about at risk children not receiving the support and protection they need"* (Scottish Government, 2020b, p.14)

- Public compliance with measures
  - *"The plan depends on continued widespread compliance. So far people have adhered to the measures well, as depicted in Figure 5 below. However, to avoid R tipping above 1 and the epidemic increasing in an uncontrolled manner, very high continued levels of compliance are essential. The risk is an unbalanced one; if the UK tips back*

*into an exponential increase in the spread of the infection, it could quickly get out of control."* (HM Government, 2020, p.13)

- *""Test, trace, isolate and support" can only work with the support and co-operation of people across Scotland, who may be asked to give samples for tests, share information about their recent contacts so that those at risk of infection can be traced and tested, and to isolate for long enough, potentially several times, to ensure that they have not contracted the virus."* (Scottish Government, 2020a, p.19)
- *"High levels of compliance with the core measures of physical distancing, good hygiene, and shielding of those most vulnerable to the harmful effects of the virus, need to be sustained."* (Scottish Government, 2020b, p.3)
- *"Data collected through the Ipsos MORI Global Advisor dataset and YouGov weekly surveys of respondents in Scotland provides polling data on public knowledge, attitudes and behaviours[4]... Behavioural science research highlights the challenges involved in sustaining behaviour change over a prolonged period of time. A range of factors are important, including the perceived benefits of the behaviour and the personal costs (financial, social, and to health) that are incurred. The establishment of environments and cultural norms that support and normalise the desired behaviours is an important part of the process."* (Scottish Government, 2020b, p.8)
- *"The biggest single factor in all of this will be how well we continue to observe advice designed to control the virus. Continued hand washing, cough hygiene and physical distancing will be essential – so too will compliance with our test, trace, isolate and support system."* (Scottish Government, 2020c, p.4)
- *"Any steps we take depend on continued widespread compliance."* (Welsh Government, 2020a, p.4)
- *"we ask that you would continue to abide by those restrictions that are considered necessary. We must do this if we are to minimise the risk of needing to reintroduce restrictions at a later stage."* (Northern Ireland Executive, 2020, p.3)

- There will be global partnership
  - *"We also recognise that a global problem needs a global solution. This is why the United Kingdom has been at the forefront of the international response to the virus, co-hosting the Coronavirus Global Response Summit on 4 May, pledging £388m in aid funding for research into vaccines, tests and treatment including £250m to the Coalition for Epidemic Preparedness Innovations, the largest contribution of any country."* (HM Government, 2020, p.4)
  - *"It means a huge national effort to develop, manufacture and prepare to distribute a vaccine, working with our friends and allies around the world to do so."* (HM Government, 2020, p.5)

- Partnership with UK devolved administrations
  - *"Different parts of the UK have different R figures. The devolved administrations are making their own assessments about the lifting of measures in Scotland, Wales and Northern Ireland. All governments continue to work together to ensure a coordinated approach across the United Kingdom."* (HM Government, 2020, p.12)

- *"Any meaningful variation in the R estimates among the four nations could be a significant factor in co–ordinating decision making across the UK."* (Scottish Government, 2020a, p.14)
- *"We will continue to keep an open mind about the potential for geographical variation in our approach, guided by the evidence. This geographical variation could occur across the UK although, as stated in the Framework, we will only do that if the evidence and our judgement indicates that this would best meet Scotland's particular needs and circumstances. We will continue to engage in the collective Four Nations process."* (Scottish Government, 2020a, p.20)
- *"Because the challenges we face are common to all parts of the United Kingdom, we, as a Government, have always strongly supported a four-nation approach to the lifting of the lockdown... But this has to respect the responsibilities of each Government to determine the speed at which it is safe to move and the balance to be struck between different forms of 'easement"* (Welsh Government, 2020a, p.4)
- *"As we face the same challenges as others, we are working closely both on a four nations basis within the UK and on a North/South basis with the Irish Government... It is anticipated that the approach to be taken as the restrictions are relaxed will continue to be based on common principles across these islands, although there may be times when there are nuanced differences of approach as a result of the circumstances in differing jurisdictions or of the timing of decision-making."* (Northern Ireland Executive, 2020, p.7)

- R number may be higher in Scotland
  - *"There is some evidence that the current R number in Scotland is slightly above that elsewhere in the UK, though comparative estimates depend on models used and are subject to a significant degree of imprecision and variation over time as new data become available. If the R number is higher, this perhaps reflects the fact that our first cases came later than England's and so we may be at a different – and slightly earlier – stage of the infection curve. Differing population characteristics of Scotland relative to other parts of the UK, such as age structure and population density will also affect the measurement of R."* (Scottish Government, 2020c, p.9)

- Projected sharp increase in unemployment and fall in GDP
  - *"The OBR [Office for Budget Responsibility] has published a 'reference' scenario which suggests that, if the current measures stay in place until June and are then eased over the next three months, unemployment would rise by more than 2 million in the second quarter of 2020.[13] The OBR's scenario suggests that GDP could fall by 35% in the second quarter of this year – and the annual contraction could be the largest in over 300 years.[14]"* (HM Government, 2020, p.10)
  - "*Our analysis shows that 22% of the economy is strictly closed which has impacted over 900 thousand jobs and over one third of the business base (including the self-employed). We estimate a 33% fall in GDP if the current distancing measures were to be in place for three months (see Figure 15). Over the year this equates to a 12% decline in GDP. These estimates are similar to those produced by the OECD as well as*

*other organisations such as the Office for Budget Responsibility."* (Scottish Government, 2020b, p.22)

- *"Initial assessments put the overall output within the NI economy at 25-30% below normal...At these rates, every month of lockdown will reduce annual output at the end of the year by around 2% to 3%... A baseline scenario modelled by EY estimates that 78,000 jobs could be lost over the year, with 175,000 furloughed or lost at the peak of the crisis (Q2). If the outbreak is prolonged, then EY forecast 132,000 jobs could be lost over the year and 257,000 furloughed or lost at the peak of the crisis (expected to be Q3 if prolonged); The Ulster University Economic Policy Centre (UUEPC) have estimated that the unemployment rate could reach 6%."* (Northern Ireland Executive, 2020, p.5)

## Appendix 2 - Testing (strategy)

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