Advice on the Relaxation of NPIs

Scottish Government Covid-19 Advisory Group

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Summary

In the light of the current and developing state of the pandemic, including progress with vaccination and potential risks from variants, there is now interest in the rate and pace at which NPIs can be relaxed and the harms associated with them minimised.

The C-19 Advisory Group ('the group') were asked:

1. If they endorse the now finalised paper 7b .which was taken at SAGE 87?
2. And if they identify any particular additional considerations for Scotland?

Group members were supportive of SAGE 87 paper 7b. and endorsed the key issues and tools identified in this paper.

Paper 7b. provides an extremely comprehensive review of the potential effects of different NPIs and their likely utility as we move into a phase of lower community prevalence of COVID-19. It sets out very clearly the different NPIs and how they might affect transmission. On balance, a cautious relaxation that keeps masks, some form of distancing, border control as outlined, testing/sequencing, and strong public health messaging should allow the benefits to society of reducing other measures without significant harms from increased COVID-19 prevalence. How these measures can be applied or varied in different settings will be a challenge.

A significant challenge associated with easing restrictions and 'opening up' is a shift in the burden of responsibility for judging safety onto the individual. To support this, it will be important to provide individuals with the tools to increase their understanding of how to recognise hazards and their ability to mitigate for these.

While paper 7b. touches on behavioural consideration, the group highlighted that SPI-B paper '*Sustaining Behaviours to reduce SARS-Cov-2 transmission*' should also be considered. This is included in Annex A.

Background and Modelling

Paper 7b. is best placed in context alongside the other SAGE papers on modelling the medium term impact of lifting the variety of restrictions currently in force aimed at reducing SARS-CoV-2 transmission (SAGE 88 Papers 4a-d). Importantly, these models have taken into account the more recent evidence of the effects of vaccines on reducing hospital admission and death, as well as effects on transmission. The different groups have used somewhat different estimates of real world vaccine efficacy against severe disease and transmission – the Warwick group puts these figures lower than the other estimates. The Imperial group used values that are taken from the most

recent data, such as provided by the SIREN study[1], the effects of the vaccine in Israel[2], and the data from use of the Oxford-AstraZeneca vaccine[3].

In particular, the SIREN study and data from the use of the Oxford-AstraZeneca vaccine show a reduction in transmission (any viral swab positive). The SIREN study showed a reduction of 72% in any infection (symptomatic or asymptomatic) 21 days after the first dose of the Pfizer vaccine and 86% seven days after 2 doses. The Oxford-AstraZeneca vaccine data showed an efficacy against any infection of 64% 22 - 90 days after one dose.

Even with complete relaxation, the Imperial model does not find hospitalisations will overwhelm the NHS. This differs from earlier SPI-M modelling referred to in paper 7b. that had indicated that "if the reduction [in transmission] achieved by baseline measures is only modest (rather than the 25% central scenario), hospital occupancy could reach levels comparable to previous peaks"[4]. This is not supported by the current modelling. In addition, on page 11 of paper 7b. when considering certification, paper 7b. states that "it is not yet certain if it [the vaccine] will reduce transmission". Again, this is not supported by the current evidence. The latest SPI-M modelling[5] is more optimistic than those in SPI-M-O's previous Roadmap modelling (note: this refers to the Roadmap for England). This is primarily due to recent evidence that vaccines significantly reduce onwards transmission from people who have been vaccinated but nevertheless become infected then symptomatic. This suggests that if baseline policies to reduce transmission are kept in place at the end of the Roadmap, behaviour does not return to pre-pandemic levels, and vaccine roll out progresses, there is an opportunity to keep the next resurgence very small.

The effects of the introduction of novel variants is difficult to model and thus the paper and the projections are suitably circumspect about the possible effects of a more transmissible or immunological escape variant. SPI-M's latest modelling paper for England's Roadmap notes that "Neither waning immunity nor the future emergence or dominance of variants of concern are accounted for in these central scenarios. Depending on its characteristics, a variant either with increased transmissibility or which substantially evades immunity could easily cause a significant wave of hospitalisations or deaths of a similar or larger magnitude than that seen in January 2021.[6]"

Reducing transmission

Paper 7b sets out clearly the balance of harms from relaxing all NPIs to those from keeping very strict NPIs. Importantly, at present with current vaccination those in younger age groups will remain susceptible and will experience an increase in

[1] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3790399
[2] https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)00947-8/fulltext
[3] https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)00432-3/fulltext
[4] SPI-M-O: Summary of further modelling of easing restrictions – Roadmap Step 2, 31 March 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/975909/S1182_SPI-M-O_Summary_of_modelling_of_easing_roadmap_step_2_restrictions.pdf
[5] SAGE 88 - 4a. 210505 DRAFT SPI-M-O Summary of modelling of easing roadmap step 3 restrictions for SAGE
[6] SAGE 88 - 4a. 210505 DRAFT SPI-M-O Summary of modelling of easing roadmap step 3 restrictions for SAGE

infection prevalence. While this will not lead to significant rises in hospitalisations in this group (though there will of course be some), group members agreed with the paper's conclusion that reducing transmission in this group will still be of benefit. As paper 7b. points out, lower rates of transmission will enhance the effects of Test and Protect, allowing earlier removal of localised outbreaks which could go on to effect more vulnerable groups who have lower vaccination rates. Lower transmission will also reduce the risk of variants arising and transmitting – it is worth noting that several variants have been detected in Scotland with no link to travel. Reducing infection rates will also reduce the levels of any post-COVID syndromes. Completion of vaccination of younger age groups will go on to reduce prevalence of infection further. The key question remains; which NPIs could be reduced without significant effects on transmission rates?

Effects of different NPIs

Paper 7b. adopts terminology used in safety risk assessment - the hierarchy of controls – and emphasises that any one measure on its own is unlikely to make a significant difference. It acknowledges the dearth of scientific evidence for many of the measures currently adopted. It is important to build a better evidence base for these measures given the important role they play in reducing the spread of the pandemic. Research into NPIs and IPC measures should be prioritised accordingly in future research calls.

The group was strongly supportive of the emphasis on the hierarchy of controls and noted the importance of awareness of this concept and the support needed for implementation of this approach.

Isolation and support of those who are symptomatic, with contact tracing, has not been as effective as might have been hoped as the paper points out, but still well worth supporting. Most contacts are household contacts, and if living with somebody who tests positive, many will find the segregation suggested impossible to maintain. The various measures proposed to reduce household transmission are valid, though may well be difficult to implement (e.g. out of home isolation).

Changes in ventilation, outside of opening windows, require extensive engineering which is not practical for most settings. Mask wearing is of some benefit and now has become acceptable to most. Group members were supportive of it remaining in place for the time being. The same is true for hand washing which can do little harm though its actual benefit is not clear. Extensive hand washing in schools during the pandemic has been linked to an increase in prevalence of eczema in children[7]. Distancing is supported by evidence, though the recently published study showing that 3ft is as effective as 6ft in schools where mask wearing is mandatory is worthy of consideration[8]. The group has previously provided separate advice on physical distancing[9].

[7] https://www.bbc.co.uk/news/uk-england-lincolnshire-56415838
[8] https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciab230/6167856?searchresult=1
[9] https://www.gov.scot/publications/covid-19-advisory-group-physical-distancing-advice/

Group members noted the approach taken in the United States of America (USA) by the CDC to relax restrictions for those who have been fully vaccinated. The group felt a similar approach should be considered in Scotland, recognising the challenges this would present and the dangers of excluding sectors of society. Further evidence in this area from the USA will be highly valuable.

With regards to travel the group recognised the importance of reducing importation of variants and were supportive restricting travel to and from regions with higher transmission rates and with a widespread presence of variants of concern. The decision to restrict all international travel is one the group has previously been asked for advice and this is included in Annex B. Paper 7b. notes that it is highly likely transmission will increase in autumn and winter. Consideration should be given to the impact of large movements of people in Scotland around this period, notably from tourism and the return of universities.

Behavioural considerations

The shift of the burden of responsibility onto individuals will present a key challenge to the potential easing of NPIs. When restrictions are in place there is a sense that the judgement as to a hazard has been made for us (by policy makers, guided by expert evidence). As formal restrictions are lifted the burden of responsibility for identifying hazards and judging risks shifts to fall on the individual. Such responsibility will be particularly difficult as interaction in the domestic environment becomes possible, especially given that individuals tend to regard the domestic sphere as safer than elsewhere. Following a COM-B theory of behaviour model, this shift in approach would involve three core elements:

1. **Communication:** In order to take this responsibility and exercise judgement, individuals will need a greater understanding of how to recognise hazards. Information that flags the variety of risks that individuals will encounter in everyday interaction as the formal rules are relaxed could be helpful in sensitising people to the hidden hazards that surround them. To some degree such information should make the familiar, strange. That is, it should lead people to look at everyday settings in a new light (such that when we walk into a friend's living room, we note the closed windows, the chair arrangements, etc. and register the risks).
2. **Opportunity:** The second element that is then needed to equip individuals with the right support and practical resources to remove or mitigate hazards. This can include understanding of how to negotiate social interaction in such settings. This is a delicate issue. If one is a guest in someone's house it is difficult to go about opening the windows, re-arranging the chairs, etc. It may be possible to offer individuals advice on how to manage such tricky interactional business. There are examples of analogous intervention projects in other areas of health – e.g. interventions designed to empower individuals to decline a cigarette, ask a sexual partner to wear a condom, etc. Managing interactions where other people have different ideas/assumptions about risk is tricky but there may be merit in public service advice on such issues.
3. **Motivation**: Messaging should reinforce the importance of the collective and keeping each other safe. This ties in with how, in getting vaccinated and

lowering community transmission we make it easier to lift restrictions for everybody. This remains very much a collective phenomenon and involves the whole community. That makes community engagement with those groups who feel marginalised and excluded ever more critical. Motivation is closely tied to trust and in that, the sense that Government views and treats then as a partner and not a problem. Public communication by the Scottish Government and Ministers should continue to reflect this.

Children

Group members noted the different approach that Scotland has taken with regards to the application of NPIs to children. The group suggested that the Scottish Government may wish to apply a similar 'child first' lens to the easing of NPIs/baseline measures. Examples of this could including easing of the policy that face coverings should be worn throughout the school day in secondary schools; supporting the return of musical, drama and expressive arts activities for children and young people; and easing some of the mitigations in place in childcare settings to enable a full return of children to childcare. The Education and Children's Issues subgroup is not advising any of these changes immediately, but subject to understanding the impact of the full return to school post-Easter, thinks that these issues should be further considered in relation to movement from May 17 to Level 2.

Annex A.

SPI-B: Sustaining behaviours to reduce SARS-CoV-2 transmission
30 April 2021

1. Key Points

SAGE has concluded that, as legal restrictions are eased, maintaining low levels of transmission will require continuing policies that promote Covid-protective behaviours[1,2,3–7]. These are everyday behaviours that involve spaces that we normally inhabit, including our homes, public spaces, educational facilities, businesses, and hospitality and leisure facilities. Evidence collected to date strongly suggests that as restrictions are eased, **Covid-protective behaviours will not be sustained without multiple co-ordinated interventions (high confidence)**.

- The direct evidence base on how to effect the long-term behaviour change needed to sustain lower transmission of SARS-CoV-2 is relatively sparse (though improving). **Further research is needed** to understand people's levels of understanding and mental models of Covid-protective behaviours, the barriers to change and the most effective approaches to overcoming them. Nevertheless, the extensive literature on broader public health and behavioural science is relevant and useful in developing strategies for achieving the desired behaviour change.
- Interventions aiming to achieve long-term behaviour **need to consider how people understand new phenomena and the risks associated with them,** including the differences in understanding and perception between communities, the role of anchoring to previous similar phenomena, and how the use of concrete metaphors can foster understanding (**medium confidence**).
- **Successful risk management involves: multiple layers of protection; a combination of physical, social and psychological measures; effective communication of risk and uncertainty; inclusion of the targeted groups in its development; continued monitoring and feedback (high confidence).**
- **Tracking of adaptation to change should be used to guide decision-making in an ongoing, iterative manner** before, during and after implementation, on potential negative as well as positive outcomes. Methods for gathering data include qualitative research, direct observation, routinely collected organisational metrics, randomised trials, natural experiments (with non-random comparators), and time series studies **(medium confidence)**.
- The wider evidence base underscores the need for people to have ongoing capability, opportunity and motivation if they are to engage in desired behaviours in a sustained way. **Strategies that promote these will make such behaviours normal, easy, attractive and routine (NEAR) (high confidence).**
- **Co-production and extensive stakeholder engagement** will be critical to the success of interventions and research and monitoring **(high confidence)**.
- Minority and socio-economically deprived groups face major barriers in applying risk-mitigating practices in their workplaces, communities, transport and domestic spaces. **Additional measures aimed at overcoming these barriers are required but need to avoid stigmatising the groups concerned.** This is best achieved by interventions that create environments to avoid or overcome barriers,

complemented where necessary with targeted, co-produced communication interventions **(high confidence).**

- The need for a multi-layered, multifaceted approach to long-term behaviour change requires the **coordinated participation of an array of public and private sector organisations rather than a series of separate interventions**. Governance of the design and implementation of policies is important in achieving this: each would benefit from being supported by technical expertise, a logic model, coproduction between internal and external stakeholders and a scientific evaluation plan **(medium confidence)**.

2. Background and aims

This report provides advice, based on public health and behavioural science theory and evidence, on strategies to sustain the everyday behaviours required to reduce Covid-19 transmission as the current restrictions are eased and beyond. It provides a framework for considering the maintenance of behaviours to reduce SARS-CoV-2 transmission, with a particular focus on: 1) maintaining physical distance, 2) wearing face coverings, 3) ensuring adequate ventilation, and 4) working from home.

This report does not directly address other crucial parts of the Covid protection strategy, particularly getting tested appropriately, self-isolating when infected or likely to be infected and accepting a vaccination when offered. SPI-B has already provided advice on these, including ensuring adequate financial and practical support to enable self-isolation[8,9].

3. 1. People's understanding of, and response to, risk

The ways in which people understand new phenomena and the risks associated with them are governed by a number of principles. Achieving sustained behaviour change requires taking these into account:

I. Individuals rarely come to their understandings alone or through private contemplation and calculation. Rather, they draw on **socially shared understandings that are current in their communities and society**. Consequently, different communities may see a phenomenon in different ways. For example, some ethnic minority groups have been historically exploited or neglected by medical authorities which can lead them to regard vaccination in terms of control rather than public health[10].

II. Understanding of new phenomena is usually **anchored by reference to previous phenomena** about which people believe they have a clear understanding[11]. Such anchoring can at times be misleading and lead to dysfunctional responses (e.g., seeing COVID as flu leads to ignoring asymptomatic spread and mixing when one does not have symptoms).

III. A potentially powerful way of embedding representations of new phenomena is through **objectification**[12]. This involves using a concrete, easily understood metaphor[13]. For instance, the process of aerosol spread can be likened to inhaling someone else's cigarette smoke and hence generate understanding of the contexts where this is likely and the measures necessary to avoid it.

IV. Social groups have **shared norms** for how one should respond to risks. Establishing the normative character of risk protection measures (and, specifically

of the behaviours under consideration in this paper) is key to their sustained enactment[14,15].

4. 2. Risk Management strategies

Achieving successful risk management across a wide range of settings has been found to follow several core principles that align with advice from the SAGE Environmental Modelling Group[16]. Together these constitute what may be termed an **enhanced risk management approach**.

I. **Employing multiple levels of protection**. In organisational safety, a key principle, characterised by the 'Swiss cheese' metaphor, involves recognising that any one layer of protection will allow failures but if one applies multiple layers, each with its own strengths and weaknesses, one can build a more resilient system that minimises the risk of failure while maximising the ability to operate effectively[17].

II. **Combining physical, social and psychological measures**. Maximising safety while preserving effective functioning in risky settings involves a combination of creating and providing safe environments and equipment, constructing implementable rules and norms, and providing people with the knowledge, skills and motivation to make and apply accurate risk assessments alongside the authority and capacity to act in response. Environmental modifications can enable protective behaviours in a way that makes them more likely to happen than relying on people's knowledge, skills and motivation[17].

III. **Involving all relevant actors**. Successful risk management involves ensuring that all key actors are involved: those working in shared spaces, those visiting the spaces, employers, managers, regulators and those involved in inspections. Participation ensures that management is locally appropriate and 'owned' by participants. A useful tool to enable the co-creation of an effective and appropriate "COVID-secure" risk management approach is the risk assessment framework (which includes a **hierarchy of control**)[18,19].

IV. **Effective communication of risk and uncertainty**. Behaviours in occupational, health and other areas of everyday life are strongly influenced by our understandings of and perceptions of risk[20]. Two-way communications with those most directly affected by risks can help characterise current risks, frame and implement practical safety measures, ensure effective uptake of behavioural measures, and identify remaining gaps in risk-reducing and safety-enhancing measures. In developing risk communications for behavioural measures, it is important to characterise and take account of people's existing beliefs or 'mental models' about the risk, and address misunderstandings or key gaps in knowledge[21]. Communications also need to be fully pre-tested for understanding and acceptability before implementation[22].

V. **Continued monitoring of risk levels and adjustment of protective measures according to those levels**. This involves setting expectations about the implementation of measures, monitoring whether these expectations are achieved and if not, amending practice to improve implementation of measures. Research has shown that, if risks are complex and changing or information is in part uncertain, staying safe involves proactive reflection on risks, ongoing evaluation of existing safety measures and adjustments where necessary[23]. This

will in in turn require action by multiple types of actors, including both individuals and organisations.

5. 3. Literature on sustained behaviour change and social practices

The research literature on sustained behaviour change (see Annexes) points to the need for people to have the necessary **capability, opportunity, and motivation** to engage in the desired behaviours. Examples of how this has been achieved in other domains is provided in Annex 3. The capability-opportunitymotivation-behaviour (COM-B) model is a simple and actionable framework for developing behaviour change interventions by national government and other sectors[24].

In terms of capability, it is imperative that people understand what they need to do, how to do it, and why it is important so that it is easy for them to do what is required when it is required[25]. Building capability will include teaching people how to negotiate social pressure to enter unsafe settings or to behave unsafely in social settings[25].

In terms of opportunity, people need an environment that allows them to do what is needed when it is needed[25]. This includes both the physical environment of the spaces they use and the 'social environment' of expectations and norms. Developing norms supportive of safer behaviours that substitute for more risky ones will be important. While some changes to the physical environment entail large-scale redesign of public and private spaces that will take place over the medium to long term, some alterations to the ways in which people use space can be made very rapidly.

And in terms of motivation, people must find it more attractive for whatever reason to do what is needed than not do it, and have it built into their habits and routines[25]. This includes generating or tapping into core self-identities and values that make the behaviours important to people. Self-identity has been found to be important in how people respond in disaster and emergency situations[26] and in helping people to stop smoking[27]. Fostering self-identities that value one's own safety and the safety of one's community could support lasting enactment of Covid protection behaviours.

Table 1. Implementation of behaviour change principles for infection control

Target	**Examples of strategies**

Capability	Build and sustain an understanding of infection risks and how to mitigate these through:
	• Multichannel information and comms campaigns, including in schools, workplaces, venues to explain why e.g. outdoors vs indoors or face coverings can reduce transmission.
	  ○ E.g. education and training in self-management has proved effective in achieving lasting improvements in diabetes self-management[28].
	  ○ E.g. informational campaigns have been found to be an important part of costeffective interventions to a range of improve health-related behaviours[25,29].
	• Education on infection risk management right across educational settings from schools to HE and professional training.

	○ E.g., training in use of resources as has proved effective in sustained improvement in hygiene behaviours in low income countries[30]. ○ E.g., continued education and training has been found to support sustained changes in GP prescribing patterns[31]. • Providing resources that are easily accessible and usable by all members of the community, taking into account the principles outlined in section 1, above. ○ E.g., simple post-it type pad for GPs to keep on their desks led to an increase in delivery of advice on smoking[32]. ○ E.g., checklists and templates developed to promote safe practice in surgery[33].
Opportunity	Ensure that all sectors of society and organisations work together to maximise opportunities for successful risk management by: • Providing practical, regulatory, and financial support for the creation of home, work, leisure and transport environments that enable adequate physical distancing, ventilation and wearing of face coverings when the need arises. ○ E.g., website with accessible information about ventilation status and opportunities as implemented by New York City Department of Education[34]. ○ E.g., MHCLG providing guidance for tenants, landlords and local authorities to reduce in-household transmission. Local authorities may be able to use their enforcement powers in relation to landlords to deal with a serious overcrowding hazard[35]. • Ensure people have sufficient and sustained financial and other resources, including employment protection, to be able to behave in ways that mitigate risks. ○ E.g., ensuring that there is adequate financial and material support during a period of self-isolation or quarantine[36]. • Building strong norms in the ways expressed in section **1.IV** around infection control behaviours such as physical distancing and mask wearing of the kind seen in some other countries. ○ E.g., effect of shaping social norms on a range of Covid-protective behaviours and environmental sustainability[14,37,38]. o E.g., formally engaging community leaders in a programme to achieve lasting changes in health-related behaviours[39]

Motivation	Ensure that people and organisations attach high value to infection control and how this is embedded into daily lives by: • Using all available communication channels to strengthen self-identities, values, and emotional responses around infection prevention and mitigation, and a sense of personal control. o E.g., large effect of a programme targeting emotional drivers of hand-washing with soap[40] • Specific community engagement initiatives with minorities and marginalised social groups o E.g., Scottish NHS co-production initiative for community health and MHCLG community champions scheme[41,42] • Providing training and resources to build habits and routines into people's lives, for example taking a face covering with you when leaving the home or opening a window when someone visits. o E.g., regular prime-time TV segment based on behavioural science principles[43] o E.g., habit building has proved effective across a range of health-related behaviours[25,29].

Table 1 gives examples of how the principles can be applied in relation to the behaviours that are the focus of this report. The strategies are all directed at making the desired behaviour **Normal, Easy, Attractive, and Routine (NEAR)**[24] by increasing multiple levels of capability, opportunity and motivation. The level of support and changes required to achieve this will differ depending on the cost or burden associated with particular behaviours; some behaviours (e.g., engaging with surge testing to stamp out outbreaks) may take more to make them NEAR than other behaviours (e.g., hand washing).

There is evidence[44] that a participative approach to identifying physical environmental and behavioural changes needed is more effective because: a) those within a setting are best placed to make sensible decisions about it and b) people are more likely to support changes if they have been involved in shaping them.

An important lesson from past large-scale behaviour change programmes is that interventions and infrastructure to sustain behaviours require sustained investment[45]. It is also crucial to monitor the impact of programmes because, as contexts change, policies and interventions often need to be adjusted. New behavioural routines can easily revert if not supported in the long-term. It is also evident from past largescale behaviour change programmes, such as England's tobacco control strategy, that individual components can operate synergistically if they are conceived as part of an organised system[46].

6. 4. Inequalities and Capacity to Follow Risk-Mitigations

There is evidence that minority and socio-economically deprived groups face several barriers in applying risk-mitigating practices in their workplaces, communities, transport, and domestic spaces[47]. These barriers have contributed to a higher age-standardised mortality rate in the first and second wave[48]. Examples of barriers are:

- *In workplaces,* less capacity to negotiate workplace safety due to precariousness of work, less ability to counteract instructions from managers or inherently poor

quality of the environment[49,50] (SPI-B report, 9 March 2021, available from SPI-B Secretariat).

- *In communities,* greater reliance on informal social support networks for care for children, the elderly and unwell, means that community members, particularly women, may face greater exposure. These are moral relationships and intimate situations where it may be difficult to enforce protective behaviours unless targeted advice is given on negotiating these[51].
- *In domestic spaces*, multigenerational households or houses of multiple occupation are environments where due to poor housing stock and density it is very difficult to self-isolate or maintain physical distancing[52].

Tackling these barriers may require additional, targeted measures, although there is limited evidence as to what works. Organisational-level and settings-based interventions are less likely to generate inequalities than individual-based interventions because they apply to all and are not dependent on individual choices or actions. e.g. covid-safe workplace practices; targeted communications for people providing care and domestic work on how to stay safe and negotiate this. There is past advice from the ethnicity subgroup and SPI-B on recommendations and examples that explores the complexity of this area and the potential for unintended stigmatisation of particular groups[53,9,54].

Any risk mitigation interventions or communications should avoid stigmatising particular communities, regions or groups[55]. Stigma contributes to disengagement from health-protective behaviours and can directly contribute to perverse, negative health-effects[56]. Stigma is likely to be mitigated by adequate coproduction and pilot testing with affected communities. Greater social cohesion has been shown to generate more trust in Covid-19 government measures, which leads to greater adherence to health measures and therefore would increase engagement with risk mitigation[57].

7. 4. Research and Monitoring

Foundational research is needed to establish baseline levels of understanding, people's mental models, and practical facilitators and barriers to adoption of Covid protective behaviours. There is a need for appropriate research methodologies to identify predictors of behaviours in this pandemic given the paucity of rigorous past data and the challenges posed by the dynamic nature of the situation. Such data should be used to guide decision-making in an ongoing, iterative manner before, during and after implementation, gathering evidence on potential negative as well as positive outcomes. Methods for gathering data to monitor behaviour and evaluate behavioural interventions include surveys, direct observation, qualitative research to bring to light experiences of secondary stressors and barriers, routine organisational metrics, experimental studies with randomised control groups, and where this is not feasible or acceptable it is important draw on natural experiments (non-random control groups) or time series studies (internal control group only)[58]; all should involve public engagement in co-production.

As strategies are deployed, it will be vital to monitor the effects of these strategies across a range of settings and populations. This should involve triangulation using a variety of methods including, for example:

- metrics of behaviour from available sources such as mobility and spending patterns, employee records,
- adding items to current surveys which include measures of behaviour[59,60],
- a range of qualitative and quantitative methods, including ethnographic approaches with underserved communities[61],
- observation, e.g., using proxies such as soap dispenser use, CCTV in highly-used public spaces or mobile phone mobility measures[62,63], or experimental tests of potential interventions with behavioural outcomes,
- using randomised experiments where possible and natural (non-random) experiments or timeseries where randomisation is unfeasible or unacceptable,
- high-resolution transaction data using sources such as spending patterns and employee records.

The need for rigorous monitoring and evaluation will depend on whether the intervention in question is expensive/controversial/challenging as opposed to cheap/popular/easy. If the former then more investment is needed to ensure a rigorous evaluation. Evaluations should be centrally planned and strategic, involving specialist expertise to address the practical and ethical challenges of effective experimentation in the real world and real time. Monitoring of behaviours designed to reduce Covid-19 restrictions should pay close attention to potential biases. For example, recent analyses of adherence to self-isolation have reported inconsistent results. The most likely explanation is methodological differences leading to different degrees of selection and social desirability bias. In order to be confident in study results it is important to triangulate across studies using different methods[64].

8. 5. Integrating findings in the context of the Social Distancing Review

Each of the four behaviours considered here has its own issues and challenges. With regard to *distancing*, we have to consider the physical spaces that people inhabit, social norms and rituals, and emotional needs. Some occasions impart a strong imperative to be physically close to people whereas at other times it can be more discretionary. Current evidence shows that people intend to engage in more close contact in a variety of settings as restrictions are eased[58] but that there is a generally high understanding of things that can be done to mitigate risk[58]. There appears to be less understanding of the role of limiting the size or frequency of gatherings or of meeting outdoors[58].

With *face coverings*, we have seen from other cultures that these can be embedded into social norms. In the UK in December 2020 approximately half of people in national surveys reported that they strongly supported continuation of measures such as wearing face masks into Autumn 2021 at least[65]. As vaccine rollout continues, risk perceptions will affect norms determining the potential for conflict between those with differing expectations and perceptions of risk.

The scope for achieving adequate *ventilation* varies from setting to setting. In some cases, it will be simple and inexpensive to radically improve ventilation while in others it may require expensive structural changes such as retrofitting new ventilation systems or introduction of air-cleaning technologies. Decision-making will often lie with employers or those in control of premises, but it will be equally important to ensure that people use the available opportunities for ventilation where these exist. For this to be successful it is important that people have access to information on why

ventilation is important, what they should do to ensure adequate ventilation and how ventilation works in their building and homes. This is an urgent task: whilst natural ventilation is often possible during the summer, we need to begin making changes now in time for the autumn.

With *working from home* there will be important competing priorities and it is likely that regulation will be needed to ensure that the health of workers is protected whether working in the office or home, extending health and safety legislation where needed[66]. Existing H&S legislation covers working from home:
employers are required to assess and manage any risks they create (including home working). It will also be necessary to reverse norms around 'presenteeism' – going to work when sick[67].

A set of criteria that could help to guide selection and evaluation of particular policies and interventions in a systematic and transparent way is 'APEASE': Acceptability (How far is it acceptable to all key
stakeholders?), Practicability (Can it be implemented as designed within the intended context, material and human resources?), Effectiveness (How effective and cost-effective is it in achieving desired objectives in the target population?), Affordability (How far can it be afforded when delivered at the scale intended?), Side-effects (How far does it lead to unintended adverse or beneficial outcomes?) and Equity (How far does it increase or decrease differences between advantaged and disadvantaged sectors of society?)[24,68].

Several common themes emerged from the existing literature. These can be subsumed under the concept of an **enhanced risk and safety management approach**. It was evident that communications would be an important part of the approach but would not be sufficient to achieve the sustained behaviour change required. The complexity and size of the task points to the need for dedicated co-ordinating function to develop, implement, monitor, and commission independent evaluation of interventions. This kind of strategic approach has proved highly successful in other behavioural domains such as tobacco control[46].

9. Annex 1: Background and methods

Background

There is extensive research on how people understand and respond to emerging discoveries[69] and how this influences responses to risk[70]. There is also an extensive research literature on risk and safety management covering transport, healthcare, construction and other sectors where there is risk of damage, injury or infection[71]. Embedding Covid protective behaviours into everyday lives presents very similar challenges to the ones addressed by this literature. The literature points to the importance of building organisational and individual resilience alongside anticipatory risk assessments[72], processes of continuous learning about incidents and safety[73], and the importance of social interaction (e.g. work teams supporting each other) in developing an effective safety or high-reliability culture[74,75]. In combining these literatures, we propose an approach which is equally applicable to both the public and the private spheres in which we move.

Cutting across these challenges is the issue of inequalities. We have already seen wide variation in adoption of the behaviours of interest by different groups in society, with marginalised groups and those with greatest financial hardship tending to have lower rates of adoption. Environmental and structural constraints appear to play an important role in this[76,77]. Lack of space within the home for social distancing and poor ventilation are most common in low-income households and workplaces, which is likely to contribute to inequalities in transmission risk. Members of these households are also less likely to work from home. Even where working from home is possible, younger members of a team may have less room at home to set-up a workstation (risking musculoskeletal harm) and may suffer more from loss of interaction with more experienced co-workers. Increasing inequality is both ethically problematic and reduces societal resilience along many dimensions; it is therefore imperative that strategies to sustain infection control behaviours address this issue, taking into account differential agency across social groups[78].

Methods

We examined the risk and safety management literature for principles that would be relevant to Covid protective behaviours and on which there is broad agreement in the field.

We also reviewed previous SPI-B reports, theoretical approaches to risk management and also theory and evidence on sustained behaviour change.

Our review of evidence on sustaining behaviours used the search terms 'sustained behaviour change' and 'sustained social practice' in Google Scholar and building a list of behaviour change principles until no new principles were identified using this method. The reason for using this search engine is that it covers reports from think tanks and government agencies as well as the mainstream academic literature and it sorts the results using an algorithm that prioritises relevance and usage.

The principles were reviewed by the authorship team and organised according to whether they primarily targeted people's capability (e.g., knowledge and skills), opportunity (e.g., provision of resources and shaping of social norms) or motivation (e.g., targeting emotional responses or retraining habits). For each principle, the source in the review was identified together with the behavioural domain to which it had been applied.

We examined evidence on inequalities as they relate to these behaviours in the light of the above and developed a set of principles for addressing these.

Finally, we drew on experience of previous monitoring and evaluation exercises in public health and behaviour change to develop a set of principles for doing this effectively in this context.

The principles were collated and discussed among the authorship team to arrive at a set of proposals.

10. Annex 2: Review of SPI-B reports

SPI-B emphasised that information needs to be provided at two levels. One is to do with an overall understanding of the pandemic and of the processes of infection transmission (mental models and social representations). The other is to do with the identification of hazards and mitigations where clarity and specificity are critical, and people need both to know what to do and to be able to do it.

When considering strategies for sustaining adherence to infection control behaviours, SPI-B recommends providing positive feedback on behaviours; emphasising that everyone has a role to play; promoting positive alternatives to restricted activities; helping people change their environments and to identify risky situations; focusing on reducing infection risk rather than compliance; and providing targeted information and practical support for adherence[79].

SPI-B also noted that there are emotional barriers to social distancing and mask wearing that may interfere with personal interactions[51]. Interventions need to be co-designed with families and communities to create acceptable strategies for reducing risk while avoiding excessive burden and maintaining family and community cohesion[80]. There is more likely to be a positive response to interventions if the reasons behind changes are fully explained and understood. Clear communications are required to avoid interventions being seen as arbitrary or discriminatory. Communications should emphasise care rather than punishment and be culturally appropriate. They should be co-created and delivered with trusted community voices to maximise engagement and make it clear that interventions are for the benefit of, and endorsed by, the community, rather than the result of external enforcement [81].

When considering workplace infection control, SPI-B emphasised the importance of co-creation in designing layers of protection (as opposed to single solutions). Co-creation requires full consultation with all key stakeholders [82]. It also noted the importance of clear risk communication to empower individuals to protect themselves and colleagues and to be vigilant at all times, including during breaks in work (risks from social interaction in staff rooms were noted) and commuting. Engagement and education will be needed for both relevant occupations and the general public [83].

SAGE noted the benefits of the Community Champions programmes in identifying and facilitating contextspecific solutions and in reaching isolated or marginalised groups to communicate health messages and offer support[79,84]. They are likely to be effective in contexts where trust in government is low and where community engagement is required to build trust, address disinformation, and ensure interventions are appropriate to local contexts. To achieve this, Community Champions need autonomy to secure participation and identify activities that meet the needs of the community, and sustained resourcing and financial and practical support (,e.g. access to settings, equipment).

11. Annex 3: Table of behaviour change approaches

This table sets out examples and evidence of how behaviour has been changed in other settings, many of which could be relevant to embedding COVID-protective behaviours (see also Table 1).

Candidate behaviour change approaches for achieving sustained behaviour change	**Behaviour change domain**
Capability	
Maintain education to maximise knowledge	Hygiene[85], Diet[86], Diabetes self management[28], GP prescribing[31], Water conservation[37]

Attempt to build and maintain psychological resources	General[87], Impulsive behaviour[88]
Maintain instruction in action planning	Diabetes self management[28], Weight management[89]
Maintain instruction in goal setting	Diabetes self management[28]
Maintain education in how to perform the behaviour	Diabetes self management[28], Neonatal care[90], Weight management[89]
Promote sustained self-monitoring of behaviour	Diabetes self management[28], General[87], GP prescribing[31]
Maintain education on how to overcome barriers	Diabetes self management[28], General[87]
Promote rehearsal of the behaviour	Diabetes self management[28]
Maintain demonstrations of the behaviour	Diabetes self management[28]
Educate in experimenting to solve problems	Diabetes self management[28]
Promote pro-active coping with challenges	Weight management[91], Impulsive behaviour[88]
Train in use of tools or resources	Hygiene[85]
Opportunity	
Provide tools and resources	Hygiene[85], Physical activity [92,93], Medication adherence[94], Smoking cessation[94]
Maximise usability of tools or resources	Hygiene[85], Product use[95], General[87],
Ensure maintainability of tools and resources	Hygiene[85]
Change living, working and travel spaces	Hygiene[85]
Change built environment	Hygiene[85]
Provide continuing leadership	Hygiene[85]
Develop ongoing social support	General[87], Child rearing[96], Weight management[89]
Attempt to change behavioural norms	Hygiene[85], General[87], Environmental sustainability[38], Child rearing[96], Water conservation[37]
Attempt to change social roles	Hygiene[85]
Motivation	
Attempt to shape cultural identity	Hygiene[85]
Attempt to change cultural values	Hygiene[85], Covid transmission[97]
Promote behavioural goal setting	Weight management[89]
Attempt to create sustained emotional responses	
Desirability	General[87], Neonatal care[90], Child rearing[96], Health behaviours[98]

Enjoyment	General[87]
Anxiety	Hygiene[85], Covid transmission[97]
Disgust	Hygiene[85]
Attempt to create sustained sense of personal control	General[87], Hygiene[85]
Maintain financial incentives	Physical activity[92,93,99], Water conservation[37]
Shape or harness identity or values	General[87], Neonatal care[90]
Attempt to promote co-ownership of practices	Hygiene[85]
Attempt to change habits	Hygiene[85], Diabetes self-management[28], General[87], Active transport[100]

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Annex B.

Scottish Government Covid-19 Advisory Group
Advice on Travel and Borders
28 January 2021

Key Points

1. The impact of measures to safeguard against importation by international travel on R*t* is highest when prevalence is low.

2. Given the high level of interconnectivity of the UK and the lower sequencing capacities of other countries, it is probable that new variants will already be in the UK by the time these are identified.

3. Analysis by the University of Edinburgh[1] and in the New York Times[1] has shown that no country has been able to effectively suppress covid-19 without travel restrictions in place.

4. Unless all international importation is controlled with either a complete closure of borders, or the mandatory quarantine of all visitors upon arrival in designed facilities, irrespective of testing history, the impact would not be the eradication of importations, but to delay and slow down the importation and establishment of new and potentially dominant strains.

5. Clear public communication about the rationale and anticipated consequences of any decision about borders will be essential

The SG Covid-19 Advisory Group drew on SAGE materials and in particular SAGE 77 paper 'DRAFT - International importation and border/travel measures'. This in included in Annex A.

The Group was not consulted about a single set of restrictions but on the considerations associated with international travel. In discussion the Group did not agree a single position but noted in response to the questions put to it that:

1. What do we know about the impact of imported covid-19 cases and strains in Scotland?

In strict epidemiological terms, when prevalence is high the impact of imported cases on R*t* of SARS-CoV-2 is low. This can be seen in the LSHTM study published in the Lancet on 'Effect of international imported cases on internal spread of COVID-19'.[10]
This study concludes that imports accounted for <10% of September 2020 cases in 125/136 (92%) countries (incl. UK). The same study concludes that "stringent travel restrictions might have little impact on epidemic dynamics". The impact of measures to safeguard against importation by international travel on R*t* is actually highest when prevalence is low.

There are additional considerations with regards to the importation of potentially more virulent strains and/or strains that are not targeted by vaccines. Genetic sequencing data has shown multiple introductions into the UK and Scotland over time. Some lineages persisted over the summer but there were new introductions from abroad which contributed to the re-seeding and spread the virus in Scotland and the UK[11].

The Group recognised that unless all international importation is controlled with either a complete closure of borders, or the mandatory quarantine of all visitors upon arrival in designed facilities, irrespective of testing history, the impact would not be the eradication of importations, but to delay and slow down the importation and establishment of new and potentially dominant strains. That potentially buys time to adjust and deploy tailored intervention, though given the high level of interconnectivity of the UK and the lower sequencing capacities of other countries it is probable that new variants will already be in the UK by the time these are identified.

Delaying the importation of cases and variants could allow time to build better vaccine coverage, testing and quarantine protocols and therefore move towards a position when sufficient control of the virus and associated disease might be achieved. Without a system that makes international travel as safe as possible the risk would be that a strategy premised on preventing new variants or importations alone would either be ineffective or have no clear exit point.

[10] Effect of internationally imported cases on internal spread of COVID-19: a mathematical modelling study - The Lancet Public Health
[11] Two new reports to SAGE on the genomic analysis of epidemic waves of COVID-19 in Scotland and Wales – COG-UK Consortium (cogconsortium.uk)

2. What are the possible risks to vaccination, testing and NHS capacity from continued importation of new cases and strains in 2021?

Viruses mutate naturally and Covid-19 has already demonstrated a capacity to generate new variants which carry a greater risk. Capacity for genomic sequencing elsewhere is the world is well behind UK capabilities so it is unlikely that any problematic variants would be identified in other countries before they can be spread by international travel.

There would therefore be a large and constant risk in the absence of travel restrictions, especially given the number of new variants of concern recently detected outside the UK. There are currently concerns over immune responses to the 'South African' (501Y.V2) and 'Brazilian' (P.1) variants, as well as their potential ability to spread more readily and/or cause more severe disease. New strains could potentially be more transmissible, cause more severe disease, or affect younger populations, putting further strain on the NHS.

Further new strains of SARS-CoV-2 will continue to be detected. Some of these may have transmission advantage, more severe impacts on health, or resistance to current vaccines, or combinations of these characteristics. They may also evade detection using our current diagnostic tools. We have already seen the spread of the more transmissible and possible more virulent 'Kent' (B.1.1.7) strain originating from the South-East of England.

Once vaccination globally is at a higher level, any variants with resistance to the vaccine immune response will have a fitness advantage and will undergo positive selection and thus spread. Realistically, such variants could arise anywhere in the world, and may not be recognised for some time, which will allow their spread by travel. Unless international travel is effectively controlled, it will be virtually impossible to avoid such strains being imported into the UK (and hence under current policy assumptions Scotland). As things stand, any importation and travel strategy needs to consider not just international travel but importation into Scotland from other parts of the UK and through ROI and CTA.

At the moment, as prevalence is so high, effective Test and Protect pathways will struggle to find all cases and the ability to apply whole genomic sequencing to all travel on viable and useful timescales will continue to be a challenge. The current adherence to quarantine is understood to be below 100%. With the new limitations to international travel, the risk has been reduced, but given the need for international travel for trade, it will not be zero.

In the future, the inadvertent introduction of a case with a novel variant of concern may lead to considering a ring vaccination policy – vaccinating not just contacts but contacts of contacts. This of course pre-supposes that transmission of such a variant will be abrogated by vaccination. This was a very effective measure in controlling smallpox and more recently Ebola[12].

[12] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4696719/

3. What international evidence is available on the effectiveness of border restrictions to prevent importation and seeding of cases?

Analysis by the University of Edinburgh[13] and in the New York Times[14] has shown that no country has been able to effectively suppress covid-19 without travel restrictions in place. These could include asking for pre-departure testing, testing on arrival and 5 days later and enforced quarantine for 10 days (such as in government facilities). Current travel restrictions will slow but not stop the introduction of new cases/strains of SARS-CoV-2.

As per SAGE 77, scientifically no single intervention, other than a complete, preemptive closure of borders, or the mandatory quarantine of all visitors upon arrival in designated facilities, irrespective of testing history, can fully prevent the importation of cases or new variants.

The European Union implemented a policy of controlled travel restrictions. Given the current status of infection levels across Europe it is reasonable to conclude that these measures have been ineffective.[15]

The WHO has also set out successive public health advice in respect to international travel[1617]. They currently state that travel poses "no substantial risk of potential impact on the current epidemiological situation" unless the country of arrival is experiencing transmission of lower intensity. Longstanding WHO advice is that travel bans delay but do not prevent. The WHO is advocating for maximum suppression and keeping numbers as low as possible, including through guarding against the import of new strains and variants. While the WHO have not used the term 'national elimination' they have showcased countries taking this approach and warned against approaches such as the UK and Sweden have taken.

The length of delay (i.e. time gained) from travel restrictions depends on the rate of imported cases (cases per day), reduction in rate achieved by ban (never 100%) and probability that a case will establish (=1-1/R). For example, if R=3 and 1 case per day is imported and a ban reduces the rate by 50% then we get 1.5 more days before 80% chance of successful introduction. If ban is 90% effective then we get 13 more days.

A combination of measures such as pre-departure testing and self-quarantine will certainly limit introduction of new cases and possible variant virus. However, they are unlikely to stop such introductions altogether. Once prevalence is low, the Test and Protect pathway should be well equipped to identify new imported cases. In

[13] COVID-19+Policy+Border+Control+GHG+29+May+2020.pdf (squarespace.com)
[14] Opinion | This Is Why We Couldn't Control the Pandemic - The New York Times (nytimes.com)
[15] Maps in support of the Council Recommendation on a coordinated approach to the restriction of free movement in response to the COVID-19 pandemic in the EU/EEA (europa.eu)
[16] Public health considerations while resuming international travel (who.int)
[17] Statement on the fifth meeting of the International Health Regulations (2005) Emergency Committee regarding the coronavirus disease (COVID-19) pandemic (who.int)

addition, epidemiological data and genomic and other surveillance measures need to be brought together. Every effort must be made to support those who are asked to isolate as cases or contacts. Demanding pre-travel testing is reasonable but in practice how airlines can establish the veracity of any documentation is highly questionable. A day 5 test and release policy is more likely to be followed than a 10 day period of selfquarantine. Previously, discussions regarding the testing of arrivals were constrained due to the existing capacity/infrastructure at the time. The possibility of testing arrivals should be reconsidered where this is feasible. Consideration will also need to be given to the exit strategy for travel restrictions.

4. What are the relative risks associated with international travel, compared to the maintaining free movement across the Common Travel Area (CTA), and to what extent might the actions to mitigate risks from the former be undermined by the latter if common policy is not adopted across the UK? What evidence do we have to calculate this risk?

Should Scotland reach a position of low case numbers, international travel will become a major risk for reseeding cases and the introduction of new variants. Even with high numbers, there is potentially significant risk from the importation of new variants.

Borders are porous and given the land borders between Scotland and England, and between the Northern Ireland and the Republic of Ireland, any measure, whether it be travel restriction, pre-travel testing or strict quarantine, needs to be co-ordinated across the UK, and possibly also with the Republic of Ireland for it to be effective.

Several group members discussed the policy 'choice' between domestic and international restrictions. Notwithstanding the point that at the current high prevalence means international restrictions would be unlikely to have a material impact on the current second wave, the importance having more Covid secure borders in an effort to prevent the impacts of a third wave was a point made by several group members.

Finally, the Group noted that there are significant equalities issues in the choices made here – the decisions made about the 'balance' between international and domestic restrictions will impact on wider socioeconomic questions relating to trade, education and minority ethnic issues.

Annex A – SAGE/DoT DRAFT – International importation and border/travel measures.

Note - SAGE Covid materials are shared with the Scottish Government on a reciprocal basis, and the attached materials may not yet be endorsed by SAGE. Published papers from SAGE Covid can be accessed on the SAGE website; any other SAGE Covid materials and their contents must not be used outwith the

Scottish Government and shared within policy areas only on the understanding that the information is treated sensitively.

Please contact CMO's office if you are in any doubt and they will liaise with SAGE Covid secretariat to secure any required permission. CMO's office can also ask the SAGE Covid secretariat to provide additional and supporting material discussed at SAGE Covid meetings and subgroups.

International importation and border / travel measures

Executive summary

Countries can expect travellers infected with SARS-CoV-2 to arrive through air, land and sea borders. There is an increasing number of options available for consideration to prevent the importation of infection, given the emergence of a number of variations of concern. This paper considers the evidence behind different approaches, and highlights remaining unknowns and determinants of effectiveness. Infected travellers have the potential to be detected at different points: through screening or testing before departure, through testing on arrival, testing during or after quarantine, or through becoming symptomatic at any point prior to travel up to the end of any period of quarantine.
Building upon the previous SAGE paper (S0943 3a at SAGE 71), that considered "Quarantine and testing strategies to prevent onwards infection from travellers returning to the UK", this paper provides a summary of evidence related to the following questions:

- How does the effectiveness of different measures (e.g. pre-departure testing, follow-up isolation, etc) vary by the effectiveness of each component of the intervention (e.g. percentage of travellers who are tested (do not have exemptions, arrive through another source); sensitivity of test used; level of compliance with quarantine / isolation upon arrival, etc.)? What is the combined (whole system) effect of a combination measures and how do they interact?
- What does empirical evidence suggest about the effectiveness and sustainability of travel bans, as a means to reduce the risk of importation of cases?

Key assessments

1. The UK has a high level of international connectivity, driven by extensive international connections, a population with a high propensity to fly, the UK being a popular destination for business and tourism, as well as via its connectivity as a hub for international travellers connecting/transiting onward. This increases the likelihood that, at the time a new variant of concern is detected anywhere in the world, there will already be cases in the UK (weak evidence, moderate confidence). This risk will be higher when the variant occurs in countries with high volumes of direct international travel.

2. No single intervention, other than a complete, pre-emptive closure of borders, or the mandatory quarantine of all visitors upon arrival in designated facilities, irrespective of testing history, can fully prevent the importation of cases or new variants (moderate confidence, moderate evidence).

3. Evidence from the continued spread of the South African and UK variants suggests that reactive, geographically targeted travel bans cannot be relied upon to stop importation of new variants once identified, due to the time lag between the emergence and identification of variants of concern, and the potential for indirect travel via a third country (moderate confidence, moderate evidence). Travel bans will have the most impact if action is taken quickly, there are low volumes of direct or indirect travel, and if the variants have not already spread widely (weak evidence, moderate confidence).

   Travel bans applied pre-emptively (i.e. longer lasting/blanket travel bans, before specific issues of concern are identified) can have substantial social and economic implications for both the UK and other countries. These may only be appropriate in limited circumstances, e.g. when domestic incidence is very low, restrictions have been eased, and importations could lead to R>1; or if there is a significant variant of concern, which could seriously undermine the effectiveness of existing control measures (Low-moderate confidence). WHO analysis suggests that partial travel bans only have the potential to delay spread and peak by a few weeks or months. Extensive travel restrictions (over 90% of journeys stopped) would be required in order to meaningfully affect the magnitude of an epidemic[18].

4. The effectiveness of pre-departure screening, based upon symptoms, is dependent upon the extent to which symptomatic people seek to travel. The use of pre-departure syndromic screening may detect around a third (est. 34%) of infected individuals who are symptomatic and have still chosen to travel to the airport (Quilty) (moderate confidence, moderate evidence) and have a sizeable but still limited preventive effect (moderate confidence, weak evidence).

5. Estimates of the effectiveness of pre-departure testing, are dependent upon the extent to which symptomatic people seek to travel; how close testing is conducted, prior to travel, as well as the sensitivity of the test used. (weak evidence, moderate confidence). Irrespective of the test used, modelling from PHE and LSHTM suggests that pre-departure testing can make a limited contribution to reducing the proportion of people travelling whilst infectious. A residual proportion of infections would still arrive in the UK.

[18] https://www.who.int/bulletin/volumes/92/12/14-135590/en/

6. The timing of when pre-departure testing can be conducted is an important consideration. Using the sensitivity estimates from the Liverpool Mass Testing, pre-departure LFT testing on the day of travel is estimated to detect an additional 11% (10%, 11%) of infectious travellers, if 70% of symptomatic individuals refrain from travelling (Quilty). The more that symptomatic individuals attempt to travel, the more effective this additional measure becomes. This value is similar to the percentage detected by PCR 3 days before departure (weak evidence, moderate confidence). LFTs with higher sensitivity would increase the proportion of infected travellers identified.

7. Test on arrival, with quarantine for those testing positive, could lower the volume of infectious travellers entering the UK. Effectiveness will be reliant on the sensitivity of the test used, adherence to isolation for those who test positive (weak evidence, moderate confidence). PCR testing on arrival could also give a potential opportunity to sequence positive tests from infectious arrivals on entry, with the findings being used to identify the importation of new/high-risk variants. Whilst this raises the theoretical potential for focussed interventions directed towards individuals with these variants, the practicalities associated with this may be significant.

8. Post-entry repeated testing which involves multiple tests on travellers on arrival into the UK, with no quarantine, is likely to be insufficiently sensitive to detect a significant proportion of infectious individuals (Moderate confidence). Daily testing scenarios, where travellers are released into the community upon arrival, and subsequently tested every day with lateral flow tests, will lead to a significant proportion of infected individuals not being detected. For example, LSHTM modelling suggests that, using 10 daily LFA tests, following syndromic screening and pre-flight LFA test, a quarter (26% (18%, 28%)) of infected individuals would not be detected.

9. Post-entry quarantine, with a required negative PCR test to exit quarantine, has the most substantial potential effect on reducing the risk of infected arrivals. (Moderate evidence, Low-moderate confidence). Effectiveness is dependent on the duration of quarantine period, usage of test during/at exit of quarantine, and adherence/behaviours (Moderate confidence). Most models suggest the maximum 14-day quarantine period may be reduced to 10 days (moderate confidence, moderate evidence) and a duration of at least 5 days or longer with PCR test on exit may be considerably effective (low-tomoderate confidence, moderate evidence)

10. Combination of options. Modelling demonstrates a combination of specific policy options (Pre-departure testing, isolation and TTR), are effective at reducing the public health risk, even with relatively low public compliance.

a. The 10-day isolation has similar protective value to the 5-day TTR system, when combined with any combination of testing. PCR testing (72-24hr pre-departure, 90% testing sensitivity) has only slightly more effective than protective value than the LFT testing (0hr pre-departure, 80% testing sensitivity).
b. Figure 1 below compares the percentage of infected people detected by a combination of isolation and testing regimes, considering infection windows of 7 and 14 days. These figures don't demonstrate the asymptomatic people who are correctly isolating but not 'detected' and are not at risk of infecting the community. Infectious hours, shown in Figure 2, present the implied risk of this community infection more clearly.
c. Whilst the modelling demonstrates reduced public health risks from specific policy options is effective at the same level of public compliance. If compliance reduces, because a threshold for policy tolerance is breached, the additional policy may be counterproductive, as shown in figure 2.

Figure 1 Comparison of options: percentage of infected travellers detected (DfT modelling – not published yet)

		Percentage of infected travellers detected												
		Short length of stay (0-7 day infection window)							Long length of stay (0-14 day infection window)					
Pre-departure test	PCR (90% sensitivity, 72-24hrs pre-departure)	23%	47%	62%	81%	36%	45%	55%	51%	67%	77%	90%	59%	64%	71%
	LFT (80% sensitivity, 0hr pre-departure)	32%	52%	66%	82%	44%	52%	62%	56%	69%	78%	90%	63%	68%	73%
	None	14%	41%	59%	80%	27%	36%	47%	27%	51%	67%	87%	35%	41%	48%
UK-side isolation or testing		None	Low (40%)	Current (67%)	High (100%)	Low (40%)	Current (67%)	High (100%)	None	Low (40%)	Current (67%)	High (100%)	Low (40%)	Current (67%)	High (100%)
			5-day TTR, (compliance)			10 day isolation, (compliance)				5-day TTR, (compliance)			10 day isolation, (compliance)		

Figure 1 Comparison of options: Infectious hours undetected (DfT modelling – not published yet)

		Infectious hours undetected per infected traveller													
		Short length of stay (0-7 day infection window)							Long length of stay (0-14 day infection window)						
Pre-departure test	PCR (90% sensitivity, 72-24hrs pre-departure)	206	142	99	46	145	103	52	127	86	58	25	87	61	28
	LFT (80% sensitivity, 0hr pre-departure)	183	128	91	46	130	94	51	112	77	53	24	79	56	28
	None	225	153	105	47	156	110	53	157	104	68	25	105	71	29
UK-side isolation or testing		None	Low (40%)	Current (67 %)	High (100 %)	Low (40%)	Current (67 %)	High (100 %)	None	Low (40%)	Current (67 %)	High (100 %)	Low (40%)	Current (67 %)	High (100 %)
			5-day TTR, (compliance)			10 day isolation, (compliance)				5-day TTR, (compliance)			10 day isolation, (compliance)		

All strategies are highly dependent on the rate of adherence to quarantine, self-isolation, and testing protocols. Analyses by SPI-B suggest that:

i. Self-reported surveys of travellers suggest that the majority were compliant. On-line polls suggest that many people would not comply with quarantine requirements. Social desirability bias means that reported intentions are likely to over-state levels of compliance

ii. Interventions that occur while the traveller is under direct observation of travel bodies have the highest likelihood of adherence. However, these control measures also incur significant time, costs, and effort which should be appropriately weighed against the added benefit of such a strategy. iii. Enforcing quarantine adherence (e.g. through the use of hotels or followup compliance adherence calls), would reduce the number of infectious hours undetected travellers would be expected to be in the community by ~50%, compared to current at home isolation which is estimated to have ~67% compliance (ONS survey) (Moderate confidence, weak evidence).

iv. Beyond this, there is an absence of evidence regarding the effectiveness of measures to enforce quarantine, other than the presumed high effectiveness of mandated methods. The relative balance between providing support for self-isolation and enforcement is also unknown.

v. Any intervention imposed at the pre-departure stage is also subject to a wide variety of performance challenges, and there may be limited access for quality assurance and performance evaluation.

Full paper

1. Countries can expect travellers infected with SARS-CoV-2 to arrive through air, land and sea borders. Countries have therefore deployed a range of different approaches to minimise the risk of importing new infections into the community. This paper considers the science behind different approaches, including remaining unknowns.

2. Infected travellers may be detected at different points: before flying, testing on arrival, testing at the end of quarantine, daily testing at the end of quarantine, or through becoming symptomatic at any point prior to travel up to the end of any period of quarantine on arrival in UK

3. **This provides for a 'menu' of interventions** that can be used alone or in combination to prevent infected travellers to the UK from seeding new chains of transmission. This list does not include interventions to mitigate risks to other travellers during travel such as environmental controls and public health and social measures at points of entry and on planes (e.g. minimising contacts, crowd control and physical distancing including through engineering modification, mask use, hand hygiene, ventilation, cleaning and disinfection etc.):
    a. Pre-departure syndromic screening
    b. Pre-departure testing (0, 1, 2, or 3 days prior to departure)
    c. Post-entry test-on-arrival *without quarantine*
    d. Post-entry repeated testing with lateral flow tests *without quarantine*
    e. Post-entry quarantine, with or without a negative test to exit quarantine

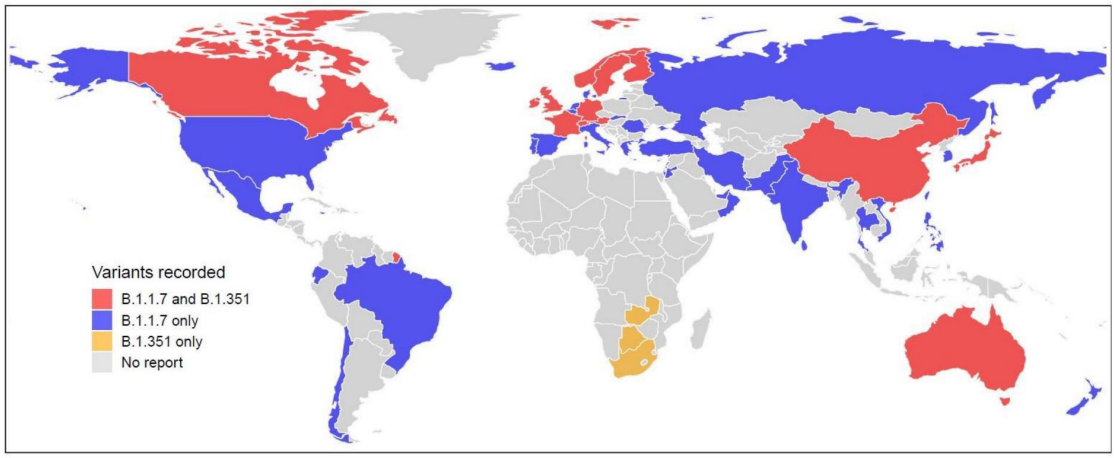
4. **There is no 'zero risk' combination of approaches when considering the potential importation of cases in the context of international travel in the real world**.

5. **The risk of infectious arrivals into the UK should be considered relative to domestic incidence and the domestic effective reproduction number, Rt.** Restrictions on travel have a much higher relative impact in countries where the expected number of infectious arrivals exceeds domestic incidence.
   They will also have a higher relative impact in countries where Rt <1.
    a. When the country of departure and the UK share similar levels of transmission, there is no substantial risk of adversely impacting domestic transmission (though this should take into account subnational variations in both countries).
    b. When the country of departure is experiencing more intense transmission than the UK, the risk of potential impact on domestic transmission is higher.

c. When the country of departure is experiencing less intense transmission than the UK, the risk of potential impact on domestic transmission is lower.
d. Based on figures from December 2020, under no restrictions there would be an estimated 831 (412, 1618) infected entries per day compared to an estimated 58,623 (50755, 71800) new domestic infections per day (Quilty). Percentage reductions through the use of different interventions should be viewed in this context.

6. **The emergence of new variants of concern has given rise to a rationale for attempting to reduce importation of even small numbers of infectious cases.** This rationale will strengthen if new variants emerge capable of immune escape.
    a. Since the new variants of concern from lineage B.1.1.7 and B.1.351 were first detected by the UK and South Africa respectively, they have spread rapidly and have now been detected in a large number of countries. To date, the variant of concern from lineage P.1 has only been detected in Brazil and Japan (during airport screening of travellers from Brazil).
    b. Due to limited genomic sequencing capacity globally, these variants are likely circulating undetected in many more countries. This means that targeted travel measures that apply only to countries that have detected specific variants of concern (and their neighbours) are unlikely to be completely successful in stopping new introductions of these variants into the UK.

Figure 2: Reports of new SARS-CoV-2 variants, lineage B.1.1.7 & B.1.351 in different countries as of 14 January 2021 (does not show the variant from lineage P.1) (Lai)



7. **By the time a case of a new variant is detected for the second time through sequencing approaches, there will already be a significant number of infections in the community**. Not everyone infected with SARSCoV-2 is tested, not all positive tests are sequenced, and delays occur at each stage.

a. Assuming a local R of 1.5 for the B.1.351 variant first detected in South Africa, the first imported infection was estimated to have occurred between 7.6 and 10 days before the second case was reported in the UK (which was before the variant was reported by South Africa).
(Pearson)
b. At the time the second case of this variant was reported in the UK, there were already an estimated 78 (17, 230) people infected with this variant in the UK. (Pearson)
c. The UK has a high level of international connectivity. This makes it more likely that at the time a new variant of concern is detected anywhere in the world, there will already be cases in the UK. This risk of this will be higher for countries with high volumes of direct international travel.
d. Timely, high-volume testing and genomic sequencing are critical to detect cases and clusters of new variants. The UK has significantly increased both of these capabilities since the beginning of the pandemic. However, all interventions outlined are highly dependent on the capacity to deliver these basic functions to maximise effectiveness.

8. **All strategies are highly dependent on the rate of adherence to quarantine, self-isolation, and testing protocols**. Adherence is not binary, and different approaches to non-adherence will vary in terms of risk. For example, leaving quarantine to see friends and family indoors is a much higher risk than leaving quarantine to go for a walk outdoors alone. Additionally, even with quarantine there remains a residual risk of onward transmission associated with travel from their point of entry to their place of quarantine and also with the household members who may share the designated quarantine location. The attached paper by SPI-B considers drivers of adherence and how this may be improved. Relevant evidence includes:
    a. A previous ONS international arrivals compliance survey indicated that 67% of arrivals were compliant with the previous 14-day (now 10-day) self-isolation policy, with 12% saying that they were not compliant and remaining proportion unsure/unlikely to be. [10]
    b. An Ipsos Mori online poll found that only 55% would be 'certain' to comply with quarantine requirements. Estimated non-compliance ranges between 10% (stated would be unlikely to comply) and 36% (stated would be unlikely to comply, or only 'likely' to comply. [9][11] Social desirability bias means that respondents are likely to underreport behaviours that go against the rules or social norms and therefore these estimates of non-compliance could be underreported (and compliance estimates overstated).
    c. Without enforcement, some objective measures of mobility showed small increases over time during lockdown in the UK and elsewhere, self-reports of staying at home decreased, and self-

reports of complete compliance with Government guidelines also decreased. Methods of enforcement include fines for violation – with and without electronic monitoring, denying entry to public spaces without electronically validated proof of being virus-free, and mandating self-isolation and

[10] ONS, 30 September - 8 October 2020, n=1,191

[11] ONS, 23-25 September, n=1060 GB adults

quarantining in supervised facilities. The acceptability of these different methods varies across countries – with harsher measures more likely to be applied in authoritarian regimes, and harsher measures more acceptable as a condition upon entry or re-entry to a country than for those living in the country. There is an absence of evidence regarding the effectiveness of any of these methods of other than presumed high effectiveness of mandated methods described above. The relative balance between providing support for self-isolation and enforcement is also unknown[19].

d. Mandated interventions that occur while the traveller is under direct observation of travel bodies might be expected to have the highest adherence. However, these control measures also incur significant time, costs, and effort which should be appropriately weighed against the added benefit of such a strategy.
e. Hotel quarantine has been used by some countries; one well known example is New Zealand. Evaluation of these case studies is limited, and studies that do mention it have not isolated it from the range of other measures in place. We would expect that compliance levels when mandatory hotel quarantine is imposed would go up significantly, and likely deter travelling in the first place. A small risk of onward transmission to the local community could exist via staff in those hotels, for example, but measures (such as PPE) could minimise these. There is low evidence in this area.
f. Any intervention imposed at the pre-departure stage is also subject to a wide variety of performance challenges and consistency, moreover there may be limited access for quality assurance and performance evaluation.

9. **A number of broad assumptions made across many or all available models.** This is generally necessary given the existing state of knowledge, but modelled estimates need to be understood in this context and may therefore differ from real-world performance. These include:

[19] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/916896/tfms-mass-testing-behavioural-considerations-s0724-200827.pdf

a. **Individuals are not infected during travel**. Models using reported incidence to estimate the volume of potential imported infections only include those who have been infected before the point of travel. This underestimates both the number of possible imported infections and the subsequent timeline for infectiousness and detection.
b. **A significant proportion of symptomatic individuals will not travel.** Most models assumed between 70-100% of infected people already showing symptoms would either choose not to travel or be prevented from flying by pre-departure syndromic screening. SPI-B are looking at the question of what proportion of people are likely to try to travel
despite knowing they are infected, but, particularly at the higher end of this range, this may be an overestimate. Accordingly, the true volume of imported infections under each intervention scenario is likely to be higher.
c. **There are people who are infectious but not yet symptomatic and people who are infectious and asymptomatic who will travel.** Some people who are infectious will travel that are not captured by some modelling and estimates
d. **Global parameters of distribution in SARS-CoV-2 infection are generalisable.** Known heterogeneity in certain parameters will likely affect the modelled estimates of risk. For example, higher proportions of asymptomatic cases in countries from certain regions will decrease the overall effectiveness of many interventions.

10. **This paper does not fully consider wider implementation issues relevant to each intervention**. These include factors such as the availability of testing supplies; the operationalisation of COVID-safe environments for high-volume testing within airports in the UK and at points of departure; the ability to effectively enforce quarantine and / or self-isolation of travellers, whether in homes or hotels / facilities; and the full range of legal, political, and practical considerations relating to travel bans.

Interventions

11. **Pre-departure syndromic screening may detect a proportion of symptomatic individuals who have chosen to still travel to the airport**. However, evidence remains limited on effective screening protocols that can be delivered in practice, and the sensitivity of these protocols in detecting cases.
    a. **WHO's assessment is that the evidence supports visual screening for symptoms such as cough and difficulty breathing as an effective measure for COVID-19, but not exit / entry screening via temperature measurement.** This is because

people may not exhibit fever early in the course of the disease, or may reduce fever through the use of paracetamol and other anti-pyretic medications. However, visual screening for symptoms will also miss people travelling during the incubation period (between exposure and symptom onset), those who are only mildly symptomatic and not detectable through visual screening, or those who are genuinely asymptomatic.

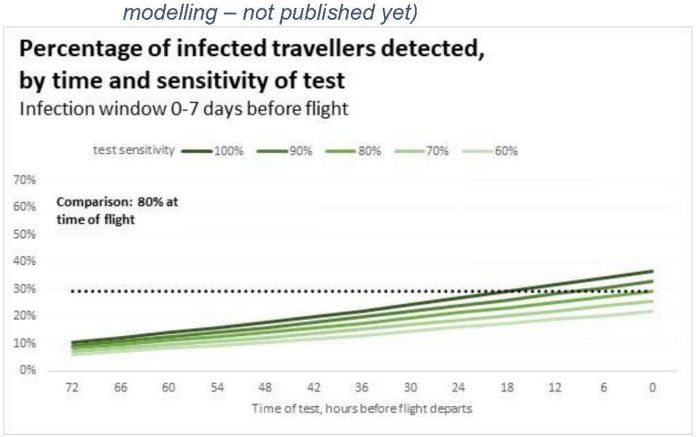
b. **One model suggests 34% (32%, 34%) of infectious travellers would be detected by syndromic screening** (Quilty) but provides limited detail on how this estimate was reached. Effectiveness is likely to be highly dependent on approach to and quality of screening– and this has not been modelled.
c. **There are likely to be behavioural impacts of implementing syndromic screening**. These include positive impacts such as creating a deterrence for symptomatic individuals thinking about travelling, as well as negative impacts such as engendering a false sense of security in those who test negative – resulting in lower adherence to more effective public health measures following the test result. These questions are being considered by SPI-B in parallel.

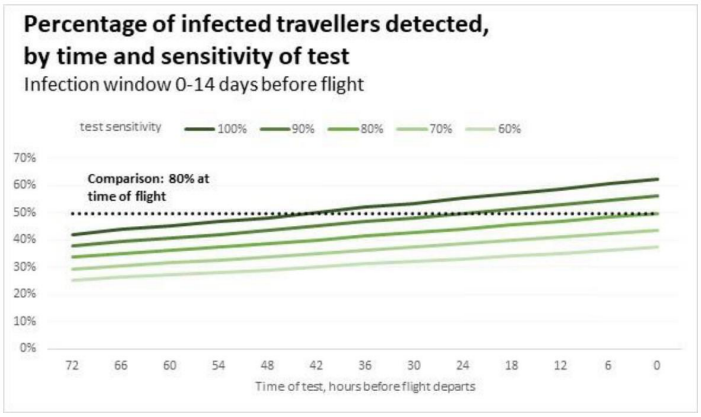
12. **Pre-departure testing can make a limited contribution to reducing the proportion of people travelling whilst infectious**. However, the residual proportion of infections that would still arrive in the UK are so significant that it cannot remove the need for further measures.
    a. **Negative results from pre-departure testing cannot guarantee that travellers are free from infection at the time of travel** since they may have been tested before they became infected or during the period when the viral load is not yet sufficient to be detectable, in addition to false negatives. New variants may also emerge that evade current commercially available PCR and LFT tests until these are retooled.
    b. **Effectiveness is highly dependent on timing**, with the maximum benefit from performing the test as close as possible to the time of travel. Whether undertaken with a PCR or LFT class of device, this provides the most power to detect and deflect travel by an infectious person. (PHE)
        i. The maximum fraction of people detectable if tested at time of travel is ≈ 40% (if assuming a 7-day infection window)/60% (if assuming 14-day infection window)
        ii. The detectable fraction decreases by ≈ 8-10% for every additional 24-hr period the test is done before departure. iii. Using some estimates, the difference in sensitivity of PCR and LFTs are similar at 90% and 80% respectively and both have similar specificity, such that there may be no material difference in detection rates of infectious persons within 3-

days of travel. iv. Inevitably, the logistics of delivery of PCR versus an LFT is such that there is an increased time between test and travel for PCR compared to LFT. Many countries (including some UKOTs) lack the ability to do PCR outside of a clinical setting so there may be some logistical value in administering an LFT close to departure. To optimise the effects of pre-departure testing, an LFT closer to the time of travel may offer better rates of identification of infectious people than a PCR test taken 48-72-hrs before departure.

To understand why having a test closer to departure is better than a more sensitive one further away the figures below show percentage of infected travellers detected by time and sensitivity of test. If we assume an 80% sensitive LFT at the airport at time of departure (represented by the black dashed line) we can see that the detectable fraction decreases by ~8-10% per 24 hour increase in time a test is taken before departure.

Figure 3: % of infected travellers detected by time and sensitivity of 'test' (7 and 14 day infection window) (DfT modelling – not published yet)





c. **However, effectiveness is also highly dependent on test sensitivity**. Using the sensitivity estimates from the Liverpool Mass Testing, pre-departure LFT testing on the day of travel is estimated to detect an additional 11% (10%, 11%) of infectious travellers beyond the proportion already captured by syndromic screening (Quilty) – similar to the 10% detected by PCR 3 days before departure (Gent). LFTs with higher sensitivity are available (with the WHO recommending minimum performance requirements of >80% sensitivity and >97% specificity), and these would therefore pick up a higher proportion of travellers[20].

d. **The value of pre-departure testing is moderated by the effectiveness and/or concurrent implementation of syndromic**

[20] https://www.who.int/publications/i/item/antigen-detection-in-the-diagnosis-of-sars-cov-2infectionusing-rapid-immunoassays

screening. In the absence of syndromic screening (or with lower screening effectiveness than the assumed model parameter of 70100%), many individuals will likely instead be captured through predeparture testing.

e. **Even if more sensitive LFTs are used, test performance may be lower among travellers than the general population**, since a significant proportion of symptomatic individuals and contacts should already have been prevented from travelling. Evaluations of LFT usage at points of entry are limited (WHO) [21].
f. On an absolute basis, pre-departure testing has little to no comparative advantage to post-flight quarantine of any duration (assuming full adherence) (Clifford). However, this neglects to account for potential behavioural effects including acting as a deterrent to symptomatic travellers who might otherwise choose to travel or providing a false confidence in negative results leading to a likely lower adherence to post-entry control measures.
g. Pre-departure testing may also reduce potential transmission between an infectious traveller and others in the process of travel. The impact of this on onward transmission is generally not modelled.

13. **No single intervention, other than a complete, pre-emptive closure of borders, or the mandatory quarantine of all visitors upon arrival in designated facilities, irrespective of testing history, can fully prevent the importation of cases or new variants**. Conversely, even if all other interventions are used in combination, some duration of quarantine is still likely to be necessary to minimise the number of imported cases.

14. **Combined pre-departure syndromic screening and pre-departure testing** may result in a total reduction of 44% (43%, 44%) of infectious travellers prevented from arriving, though limited detail was provided for how this estimate for the 34% of this due to syndromic screening was reached (Quilty).
    a. **This assumes LFT sensitivity** from the Liverpool Mass Testing study. Effectiveness is still dependent on previously outlined issues, and it is unclear whether the joint benefit of both interventions (including any behavioural effects) is justified by the additional financial costs of testing, personnel, and training.

15. **Test-on-arrival without quarantine** could lower the volume of infectious arrivals from entering the community. However, with limited evidence and impractical assumptions about adherence after testing, the true populationlevel benefit may be insufficient to justify the high-effort, potentially high-cost intervention.

[21] https://www.who.int/publications/i/item/WHO-2019-nCoV-Sci_Brief-international_travel_testing2020.1

a. When adherence to isolation (if test returns positive) is maximised, the effectiveness of test-on-arrival policies is driven by test sensitivity: with 100% adherence, use of an LFT reduces the proportion of travellers entering the community from 48% (36%, 56%) to 38% (28%, 43%) or 18% (14%, 26%) assuming Oxford / PHE results for test sensitivity; use of PCR reduces it to 10% (5%, 15%). (Quilty)

16. **Post-entry repeated testing with LFTs and no quarantine** is not likely to avert substantial transmission. Self-administered LFTs have not demonstrated real-world effectiveness at significantly reducing further infections at a population level.
    a. **Maximum stringency LFT testing strategies still allow a significant proportion of infectious travellers into the community**. One modelled scenario using 10 daily LFTs including pre-departure syndromic screening and a pre-departure LFT still suggested 26% (18%, 28%) of infectious travellers are never detected and risk further transmission. (Quilty)
    b. **LFT usage is highly dependent on test sensitivity**. Using the highest accepted sensitivity for the Innova LFT, the proportion of undetected travellers who arrive in the community reduces from 26% to 14% (10%, 20%) (Quilty).
    c. **These strategies also appear to produce more secondary infections than any other quarantine intervention, especially in the first few days.** However, the effect of this approach is highly variable and is dependent on the effectiveness of contact tracing strategies.

17. **Post-entry quarantine** with a required negative PCR test to exit quarantine has the most substantial effect on reducing the risk of infectious arrivals of any other intervention considered in isolation. Compared to a 14-day quarantine period, a 7-day quarantine is likely to achieve comparably high levels of effectiveness in reducing the number of infections entering the community.
    a. **Several approaches to quarantine have been modelled**. These include a simulated model evaluating the optimal timing and duration of self-quarantine and screening/testing strategies (Clifford), another assessing different types of post-exit testing (Quilty), and others looking at quarantine for various exposure situations including travel and contact tracing (Wells).

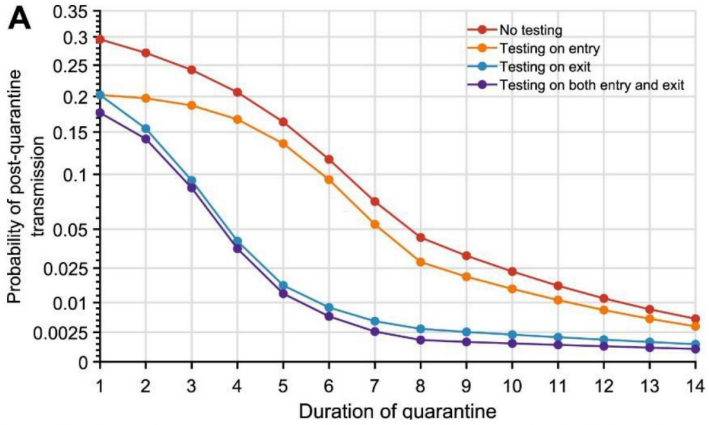


Figure 5: Probability of post-quarantine transmission, by duration of quarantine and testing strategy (Wells)

b. **Most models suggest the maximum 14-day quarantine period may be reduced,** and a duration of at least 5 days or longer with PCR test on exit may be considerably effective. While the full duration is almost completely effective at reducing the number of infections entering the community (>99%) (Clifford, Quilty), one model suggests a 7-day and 5-day quarantine (8 and 6 days with test) would have a ≈95% and 89% reduction, respectively (Clifford). A second model shows that 10 days without a PCR test could be as effective as the 14-day period (Quilty), while a third showed that a 7-day quarantine with test could result in a <1% chance of post-quarantine transmission.
c. **The effectiveness of different approaches depends on the usage and timing of tests during quarantine.** All analyses agreed that testing on exit was the best strategy, while models that evaluated the usage of a second test concluded that the addition of another test either on entry or at different points during quarantine have limited benefit beyond a slight reduction at the longest quarantine durations (Wells, Clifford).
d. **Quarantine strategies are also ultimately driven by the proportion of asymptomatic infections**. (Clifford) As duration of quarantine increases, those who become symptomatic develop symptoms in quarantine instead of the community, and those released from quarantine are more likely to no longer be infectious. One model evaluated a range of asymptomatic population proportions, finding that even isolating 100% of symptomatic individuals immediately upon onset of symptoms would still be insufficient to lower Rt<1 in an epidemic with a basic infectivity profile (Wells).

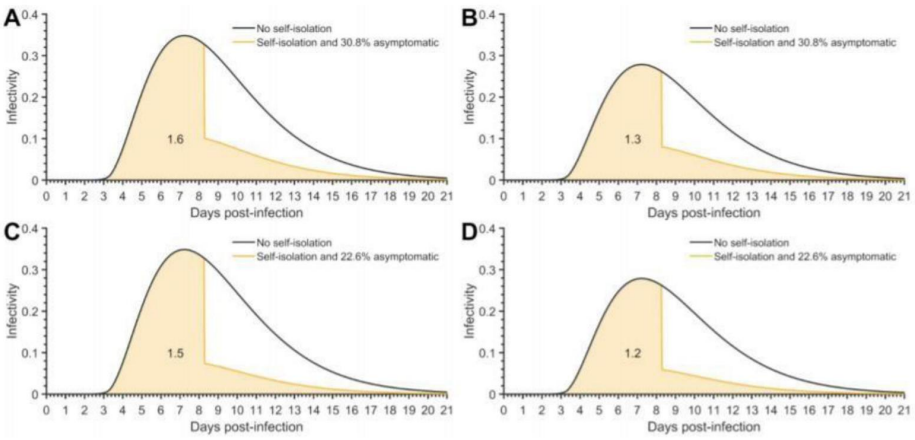


Figure 6: Infectivity curve at days post-infection, by proportion of asymptomatic infection (Wells)

e. **The impact of quarantine should be considered in context of local incidence**. As with most models in this area, the relative risk of onwards infection or number of imported infections demands translation to absolute risk and a comparative interpretation to the domestic situation.
f. **To supplement quarantine strategies, PCR testing on arrival** with quarantine could give the potential opportunity to sequence all positive tests from infectious arrivals on entry to identify new/high-risk variants. A subsequent risk-stratified strategy with increased intensity of interventions on new/high-risk variants may prevent further entry the community, though this brings significant operational challenges (and would require a significant proportion of sequencing capacity to be focussed on travellers).
g. **Overall effectiveness also depends on adherence and the quarantine approach used.** Ideally quarantine should be in a location which removes the risk of within-household transmission, such as in a dedicated hotel. It will be important to explore the evidence, and apply measures that can be taken to maximise effectiveness and adherence to quarantine, and reduce risks of onward transmission. SPI-B are looking into the specific question of drivers of adherence, how these
can be enhanced through interventions, and the maximum level of adherence we can expect in real-world settings after deploying these interventions.

Travel bans

18. **Travel bans are not the most effective tools to reduce the infection rates in all circumstances.** They are likely to be more effective if domestic rates are near a tipping point on exponential virus growth and infection rates domestically are already very low. Travel bans are likely to be less effective (but not ineffective) where tight domestic restrictions are in place (e.g. lockdowns) which minimises local domestic onward

transmission and/or an effective international arrival isolation/quarantine/testing regime (with high compliance) is in place.

a. The closure of borders can only positively affect the epidemic trajectory if combined with a 50% or higher reduction of transmission within the community or where epidemics are close to tipping points for exponential growth (Chinazzi, et al).
b. The risk of international policy is relative to domestic incidence, with countries with low domestic incidence but high travel volume requiring more stringent measures to reduce relative risk. [15]
c. When travel bans targeted at specific countries are put in place, there is also a risk that travellers cross borders and travel to the UK via a third country, which is difficult to track. Therefore, such a policy does not eliminate the importation risk- specific risks are country and connectivity dependant.
d. Travel bans imposed by another country (ie. outbound, in absence of an inbound travel ban) will also reduce inbound travel and therefore risk of importation.

19. **Travel bans should not be relied upon to stop the importation of new variants**. Time lag associated with identification (e.g. sequencing, genomic surveillance etc.) and then policy implementation has been found to allow variant to be exported from the country of origin.
    a. International examples show new strains have spread before being identified.
    b. LSHTM suggest there are many more of the new SA variant infections in the UK than have been reported. They estimate "there were 78 (95% CI: 17–230) infections with the SA 501Y.V2 in the UK at the point the second case tested positive on 12th December".
    c. A new strain that originated in Manaus, Brazil was initially picked up in Japan, following the exportation of cases to Japan (Faria). The higher diversity and the earlier sampling dates of P.1. in Manaus corroborates the travel info of recently detected cases in Japan, suggesting the direction of travel was Manaus to Japan[ref].
    d. If there is an effective policy regime including testing and/or quarantine / isolation for travellers in place with high adherence, or if strict domestic lockdown measures are in place, then the risk of infection spreading is reduced, as noted in other studies. If this is not the case, then the time lag issue may be a more significant issue.
    e. Identifying, tracking and reacting requires high levels sequencing/testing capability/capacity, rapid exchange of information and high levels of coordination

[15] https://www.thelancet.com/cms/10.1016/S2468-2667(20)30263-2/attachment/00496134-9906-48ce-80ab-8e0b61220ff6/mmc1.pdf

between countries, particularly those with high levels of connectivity. There is an important opportunity for coordinated and supporting international action and standard practices to deal with this exchange and minimise future risks and minimise cost associated with pre-emptive travel bans.

20. **We do not know what the impact of travel bans is on the 'critical mass' of traveller importations.** We didn't find any evidence to indicate

if travel bans could reduce the risk of the critical mass of importation being reached.

a. WHO found partial travel bans to only have potential to delay the spread and peak by a few weeks or months, but they found no evidence it could be contained within a defined geographical area. It would take extensive travel restrictions (over 90%) to meaningfully effect the magnitude of the epidemic.

21. **Travel bans have social, economic and political implications.** They could in some circumstance be high-cost policy to keep in place in the absence of a wellknown or credible risk. The potentially large negative impacts of imposing a ban means there needs to be high confidence in the effectiveness of such a tool if used in isolation.

Further questions and considerations

22. Further modelling and investigation to understand the magnitude/difference of whether current or other test and isolation regimes offer enough protection against new variants of SARS-CoV-2 over and above a pre-emptive/ongoing travel ban (i.e. imposed before a risk has been identified)?
23. Further evidence of adherence/compliance rates is crucial to the effectiveness of testing, quarantine, and isolation regimes. What enforcement and measures are most effective? What international traveller non-adherence behaviours represent the largest risk? How can adherence to quarantine be maximised, including behavioural interventions, and use of non-household locations?
24. Trip length is likely to impact on testing effectiveness, particularly PDT. Further modelling should be undertaken to understand the impact of trip length on effectiveness of testing and isolation/quarantine regimes?
25. Further evidence and surveillance needed to understand the size of indirect / third country importation risk (i.e. following a direct travel ban) as well as the importation risk following a travel ban.
26. What is the evidence associated with current available tests ability to detect new variants? How easily can new variants be detected and distinguished from other variants via the current (or alternative) testing regime?
27. Could better surveillance, scientific developments or medical interventions speed up the process of identification of a new variant, so that we can more effectively target a travel ban?

Annex 1: Travel ban case studies

1. **New Zealand**
   a. New Zealand implemented a national lockdown in early 2020, this led to the successful elimination of community transmission there. This eventually eliminated SARs-CoV-2 from NZ for ~120 days, after which

is was reintroduced following importations from international travellers[11]. Travellers were initially allowed to self-quarantine, however after incidences of improper isolation, compulsory lockdown at airport hotels was introduced.

b. Geoghegan, J L, et al (2020) finds the introduction of a New Zealand lockdown in March 2020 resulted in fewer than 20% of introductions into NZ leading to more than one additional case[22].
c. In mid-January, New Zealand had a ~0.002% test prevalence and had only recorded 1,872 total cases.

2. **South Africa**
   a. In late 2020, genomic sequencing identified a new variant of SARS-CoV-2 (501Y.V2) in South Africa. By the time this variant had been identified and a UK travel ban imposed on South Africa and all southern African nations, confirmed cases had already reached the UK.
   b. This suggests that genomic sequencing cannot be relied upon to trigger timely international travel bans. This is especially true when SA where routinely conducting genomic sequencing – the delay in detection would be much longer in other countries without these capabilities.
   c. Modelled estimates of this variant by LSHTM[23] finds the new South Africa variant to be 'roughly 50% (95% CI: 26-79%) more transmissible, under the assumption there is complete cross protection from previous infection with the wild type'.
   d. PHE's current predicted test predicted prevalence in South Africa is 82.4%.

3. **Manaus, Brazil.**
   a. A new strain that originated in Manaus was initially picked up in Japan, following the exportation of cases to Japan. The higher diversity and the earlier sampling dates of P.1. in Manaus corroborates the travel info of recently detected cases in Japan, suggesting the direction of travel was Manaus to Japan[24].
   b. This raises concerns about the ability for short term-travel bans to effectively contain new variants, given exportation of the new strain is likely given the time lag associated with identifying and applying a travel ban.

[22] Figure 3A-B https://www.medrxiv.org/content/10.1101/2020.08.05.20168930v3
[23] LSHTM paper, 24th December
[24] https://virological.org/t/genomic-characterisation-of-an-emergent-sars-cov-2-lineage-in-manauspreliminary-findings/586

Annex 2: Full list of Department for Transport potential policy measures

Proposed Measure	Sub measure
1. Stay off/remove from travel corridor list	
2 Increased surveillance	2a Increase surveillance in post
	2b Genome testing all positive cases
3. Reduce risk – improve hygiene, minimise exposure	3a. Improved cleaning and social distancing standards, and/or separation of crew and pax (e.g. crew with full PPE).
	3b. More stringent travel advice on outbound (e.g. FCDO); could include the risk to passengers in that HMG may not repatriate BNs if borders are closed
	3c. Wider campaign of information e.g. through freight operators
4. Enhanced quarantine	4a Enhanced enforcement for those travelling from affected areas
	Retrospective self-isolation, those who have travelled from the region/country previously voluntary/mandatory selfisolation
	4b. Require all household members to self-isolate
	4c. Remove red+ countries from test and release
5. Compulsory testing at those returning from high risk areas	5a. Testing before return departure. Not allowed on flight, ferry, or international train without negative result.
	5. b Testing at port of arrival
	5.c Those testing positive will need to stay in reception centres
	Quarantine all passengers in reception centres until day X and X negative tests

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