CVDR/S6/21/6/1

COVID-19 Recovery Committee

6th Meeting, 2021 (Session 6), Thursday 30 September 2021

Vaccination certification

Introduction

1. At this meeting, the Committee will take evidence on the Scottish Government's proposals to introduce a mandatory COVID vaccination certification scheme in Scotland from the following—

- Professor Christopher Dye FRS, Professor of Epidemiology, University of Oxford;
- Professor Stephen Reicher, Bishop Wardlaw Professor of Social Psychology, University of St Andrews;
- Professor John Drury, Professor of Social Psychology, University of Sussex.

Background

2. On 1 September 2021, the Scottish Government set out its position in relation to vaccination certification schemes during the First Minister's (FM) statement to Parliament. The FM said—

> *"We propose that, subject to Parliament's agreement, vaccination certification should be introduced later this month—once all adults have had the opportunity to be fully vaccinated—for the following events and venues: first, nightclubs and adult entertainment venues; secondly, unseated indoor live events with more than 500 people in the audience; thirdly, unseated outdoor live events with more than 4,000 people in the audience; and lastly, any event of any nature that has more than 10,000 people in attendance. We do not currently consider that it would be appropriate to introduce certification for the hospitality industry as a whole, and we hope that it will not be necessary to do so. However, we will keep that position under review."*

3. On 9 September 2021, the Scottish Government published further details of its proposals and information on how the scheme would operate. The Parliament then debated this issue in the Chamber on Thursday 9 September 2021 and, following debate, agreed the following motion, S6M-01123—

"That the Parliament commends the extraordinary effort of vaccination teams throughout Scotland, which means that, as of 6 September 2021, 84% of eligible over 18-year-olds were double-vaccinated against COVID-19; recognises that case numbers remain stubbornly high and that action is needed from all sectors to ensure that baseline COVID measures are rigorously implemented; acknowledges that a number of other countries have introduced COVID certification schemes and that the UK Government has plans to introduce a vaccine certification scheme in England; believes that, in line with the Scottish Government's strategic intent, a COVID Vaccine Certification scheme can provide a targeted means to maximise Scotland's ability to keep certain higher risk settings open, while reducing the impact of transmission and encouraging the remaining sections of the population to get vaccinated; supports the implementation of a COVID Vaccine Certification scheme; agrees that the scheme will apply to nightclubs, sexual entertainment venues, indoor unseated live events with 500 or more attendees, outdoor unseated live events with 4,000 or more attendees and all events with 10,000 or more attendees; notes that measures are being taken to ensure digital inclusivity and to ensure that disabled people are not disproportionately impacted, and agrees that this scheme will be kept under regular review."

4. The Scottish Government published a further update on its the plans for introducing a COVID-19 vaccine certification scheme on 23 September 2021.

5. In order to give effect to this policy and introduce a mandatory COVID vaccination certification scheme, the Scottish Government must bring forward regulations, which the Committee and Parliament will be asked to approve.

Evidence

6. The Committee took evidence from stakeholders at its meetings on 16 and 23 September 2021. The meeting papers, written submissions and transcripts from those meetings can be found on the website.

7. The Committee has received submissions from Professor John Drury, Professor Stephen Reicher and Professor Christopher Dye FRS, which are attached in the Annexe to this cover note.

Next steps

8. The Committee will consider the regulations giving effect to this policy when these are made.

Committee Clerks
September 2021

Annexe

Implications of introducing a vaccine certification scheme

Written views for Scottish Parliament's Covid-19 Recovery Committee, 2021

Professor John Drury

University of Sussex

Rationale and benefits

1. For those venues and events covered by the proposed scheme[1] -- nightclubs and adult entertainment venues, unseated indoor live events of more than 500 people, unseated outdoor live events of more than 4,000 people, and any event of more than 10,000 people – the scheme would reduce infections at these venues and events (though the precise amount of reduction is not known for Delta variant).

2. Such a scheme could increase the number of venues, events and activities enabled to open (though I note that in the present case these venues and events are already open).

3. Such a scheme could provide greater safety to those who work in such venues and at such events, who are otherwise disadvantaged by greater exposure to Covid due to their working conditions.

4. Such a certification scheme might operate to incentivize some of those who are not already vaccinated to get vaccinated.

Evidence – behaviour and society

5. Much of the psychological evidence gathered in relation to vaccine certification (and similar) schemes relates to public opinion.[2] Do the public support such schemes or not? This can be important for understanding whether such schemes will work well or will divide society or and lead to active opposition. The overall picture suggested by the research on public opinion on vaccine certification schemes[3] shows that public support varies considerably by the purpose for such a scheme. Support is strongest for certification for international travel and weakest for access to work. Some surveys of sports fans find support for such schemes, though it is worth noting that some of these surveys ask people about covid certification more broadly rather than vaccine certification specifically.[4] There is also variation across time, with some surveys in 2021 showing more public support than surveys carried out in 2020.

6. By their nature, COVID-status certification schemes exclude some people just as they increase the freedoms of others. In the UK, given that uptake of vaccination is lower in ethnic minorities[5] and deprived[6] groups, certification will disproportionately exclude these groups from those venues and events that require a certificate. In

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[1] https://www.parliament.scot/chamber-and-committees/what-was-said-and-official-reports/what-was-said-in-parliament/meeting-of-parliament-09-09-2021?meeting=13282&iob=120511
[2] https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-021-11166-0
[3] https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-021-11166-0
[4] https://twitter.com/1IndustryVoice/status/1378289511172542464
[5] https://twitter.com/Dr_D_Robertson/status/1435967596071829510
[6] https://twitter.com/Dr_D_Robertson/status/1437438532725972995

short, inequality in access is likely to be a result of such as vaccination certification scheme. Greater efforts should be made to engage marginalised groups in vaccination. But there is a real possibility of a minority never getting vaccinated, who will then be excluded until the certification scheme ends.

7. Possible effects of such a scheme on people's willingness to get vaccinated are complex. The systematic review[7] published last year found that people's willingness to get vaccinated if a certification scheme was introduced varied with the type of activity enabled, with travel and visit to a nursing home being the activities that most people said they would get vaccinated for. By contrast, one (Polish) study found that of those who did not plan to get vaccinated, 51% were not swayed by any reasons. Other studies looked at possible effects of mandatory vaccination. Some found that compulsion made people less willing to take subsequent vaccines.

8. While certification might incentivize those who are moderately positively disposed towards vaccination (e.g. those who simply haven't got round to getting vaccinated yet), for other groups the opposite could occur. In particular, for those with low levels of trust in authority, such a scheme could confirm views that public health measures are about social control. Thus the *meaning* of the scheme – how members of the public perceive it (e.g., as a way of forcing people to get vaccinated) – matters. Evidence in support of the suggestion that vaccination certification drives vaccination in some but has the opposite effect in others comes from a survey carried out in Israel and the UK[8] and a modelling study in the UK, which found larger effects for domestic (vs international travel) schemes.[9]

9. There is some evidence that after vaccination some people reduce required precautionary behaviours ('risk compensation').[10] Vaccination certification and schemes based on test status could give false reassurance. This would be relevant to those venues and events where those attending are still required to observe covid-safe behaviours such as handwashing, distancing and masks. The framing of the level and nature of protection the vaccine provides can impact on the behaviours of members of the public after vaccination.

Alternatives

10. Other Covid certification schemes are based on testing negative for the SARS-CoV-2 virus or testing positive for antibodies. Evidence from testing programmes last year suggested that these were subject to the same demographic differences as the vaccination programme.[11] However, testing does not seem to lead to the same levels of distrust and hostility as vaccination and therefore might be considered a less controversial alternative to vaccination certification (if the practicalities and problems can be overcome – i.e., reliance on self-reporting results where people have a motive to falsify).

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[7] https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-021-11166-0
[8] https://www.mdpi.com/2076-393X/9/8/902
[9] https://www.thelancet.com/journals/eclinm/article/PIIS2589-5370(21)00389-8/fulltext
[10] https://www.independentsage.org/wp-content/uploads/2021/01/Adverse-behavioural-effects-of-vaccines-7.1.pdf
[11] https://www.gov.uk/government/publications/liverpool-covid-19-community-testing-pilot-interim-evaluation-report-summary

11. Another alternative is to focus on the certification of venues and events as Covid-secure rather than the certification of individuals.[12]

12. Arguably, vaccination certification is a scheme that is premised on heavy reliance on the vaccination programme. Most experts suggest that other public health measures are still needed (such as distancing, masks, working from home).

International comparisons

13. As well as examining research evidence from surveys and experiments, it's important to look at existing schemes. The country with the most well-established and well-documented Covid-certification scheme is Israel. That country's 'green pass' scheme allows access to gyms, hotels, theatres and concerts. It is not clear, however, to what extent Covid-certification was been responsible for Israel's success in uptake figures. Some reports suggest green passes are not always checked at restaurants and other venues. And the country's programme of community engagement (including taking mobile vaccination units into communities and bars and working with trusted local leaders) was taking place at the same time and was judged to be effective.[13]

14. Denmark has recently announced it was finishing its Covid certification scheme.[14] Denmark's scheme was originally based on testing status, and at that time had a higher rate of testing per capita than any other country worldwide. Reports suggest there is public support for the scheme. Denmark has traditionally had higher levels of public trust in the government than countries like the UK, which seems to explain the high levels of public engagement with all aspects of the Covid response.

15. France's vaccination certification scheme was associated with a rise in the numbers coming forward for vaccination. What is notable about this is the fact that that France had high levels of vaccine hesitancy. Therefore the scheme seems to have driven vaccination numbers.[15] I am not aware of evidence on the size of the minority who are refusing vaccination (including how many people whose attitudes have hardened).

16. In the USA there are a large variety of mandate and certification schemes in different states and organizations.[16] It is worth noting in this context that the USA has a history of mandating vaccination.[17]

Limits of the existing evidence

17. The only systematic review on behavioural effects of vaccine (and other Covid) certification[18] was carried out last year, so most of the research studies was conducted before actual certification took place. Public opinion changes over time,

[12] https://www.independentsage.org/how-can-we-safely-re-open-live-events/
[13] https://covidandsociety.com/health-certificates-covid-19-global-review-research-evidence-implies-for-uk-vaccine-passport-policies/
[14] https://twitter.com/M_B_Petersen/status/1436193837744107523
[15] https://www.wired.co.uk/article/france-vaccine-passport-health-pass
[16] https://theconversation.com/whos-covered-by-a-vaccine-mandate-heres-a-quick-guide-to-americas-patchwork-of-covid-19-shot-requirements-167765
[17] https://www.nytimes.com/2021/09/09/us/politics/vaccine-mandates-history.html
[18] https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-021-11166-0

and sometimes opposition to a public health measure reduces when that measure is implemented. The review authors also noted that most of the existing research was of moderate quality (often self-report only) and that it was difficult to draw firm conclusions

18. Nevertheless, there are some clear patterns across the evidence (survey, experimental, and real-world/ behavioural) summarized above; and the evidence on demographic differences in vaccination rates, which is important for understanding who will be excluded, is hard data.

Concluding comments

19. The two key issues that make me reluctant to advocate Covid vaccination certification are inequalities and possible backfire effects (which are related, as the backfire effects are more likely in the same populations that are excluded). The inequalities issue is quite broad, and also takes in digital exclusion (which correlates with age as well as deprivation). It might be argued that elite sports events, for example, are already exclusive in that many people cannot afford to go to them. In this case, there may be no effect in terms of deprivation. But there will still be an effect for minoritized ethnic groups, with audiences becoming whiter. Of course many in the live events industry are aware of these dangers and would seek to implement exceptions to mitigate effects of such schemes on social exclusion.[19] I would be interested to see how these mitigations operate and whether they can counteract the backfire effect mentioned earlier (I am not optimistic).

20. Covid certification schemes are more likely to be supported by the public if there is a clearly-stated end-date. If the end-date is determined by a calculation about when herd immunity is achieved, but then the required vaccine coverage is not achieved (due to residual hesitancy and the backfire effects mentioned above), this could have broader implications for the public's trust in and whole relationship with the government.

23rd September 2021

[19] https://covidandsociety.com/health-certificates-covid-19-global-review-research-evidence-implies-for-uk-vaccine-passport-policies/

Annexe

Submission from Professor Stephen Reicher

Vaccine Passports: Key summary points

- The problem with vaccination uptake is not primarily a problem of vaccine hesitancy. Overall, according to ONS figures, only about 4% of population are vaccine hesitant (in the sense of having concerns about the vaccine). Even in younger age groups, where some 30% remain to be jabbed, hesitancy is under 10%. The main issue is not getting round to go and get a jab or not thinking it is important enough.

- There do, however, exist certain communities, where vaccination rates are considerably lower and hesitancy much higher. These are generally minority groups which have a troubled relationship to authority (including medical authority): the deprived, the unemployed, ethnic minorities.

- It is important not to conflate vaccine hesitancy wirth being an anti-vaxxer. Many of the hesitant have genuine questions (such as the effect of the vaccine on fertility) and would be prepared to accept a vaccine if reassured – although, especially in high hesitancy communities, trust is an issue

- Given the factors outlined above, vaccine roll out will be helped by (a) maintaining a clear and consistent message that the pandemic is still a problem, that infections matter and that getting vaccinated remains critical; (b) removing practical barriers to vaccination by, for instance, siting vaccination stations in schools, colleges, workplaces, communities and also ensuring paid time off from work to go and get a jab; (c) respecting people's concerns about the vaccine, answering those concerns and doing so through trusted sources. This concurs with the WHO advice that community engagement should be at the core of vaccine roll-out.

- Vaccine passports can play a role in vaccine roll-out, but their impact is complex and they can backfire and actually put people off.

- Critically, if passports are seen as making vaccination compulsory and as a form of social control, they generate anger and resistance. More generally, they lead to an alienation from authority and a sense that vaccines are something done 'to us' rather than 'for us'.

- Whether vaccine passports are seen as compulsion is a function of trust. In different countries – and in different communities within countries – that have different levels of trust vaccines can have different (indeed opposed) impacts.

- Where there is high trust, passports are less likely to be seen as a form of compulsion but rather as something aimed at protecting the community. This can have positive effects such as under-pinning pro-vaccination norms and giving people a reason to get round to being vaccinated. Hence is several countries, introduction of passports has led to a surge in take-up.

- However where there is low trust, passports are more likely to be seen as compulsion, they are more likely to consolidate a sense of ‘them’ and ‘us’ with authority, and they can lead to greater resistance to vaccination.

- Overall, then, vaccine passports can often lead to a polarization in society. An initial surge in the trusting is offset by increased opposition amongst the untrusting. Or, to put it slightly differently, they may accelerate the rate at which a society gets to the ceiling of those willing to be vaccinated (an important gain) while decreasing the level of that ceiling (an important loss). The danger is of creating social division and also pockets where the virus can still reproduce.

- There may be ways of introducing vaccine passports in a way that offsets the perception that they are about control rather than about health (a central claim of the anti-vaxxers). One is simply to have a clear end-date or else a clear criterion for removing them. This offsets the worry that they are a trojan horse for introducing ID cards. Another would be to have an opt-out procedure akin to ‘conscientious objection’.

- Vaccine passports may also be more viable at a community level rather than a national level, where they are decided upon from within rather than imposed from without. However, the process by which they are introduced – and the importance of community members having a sense of voice – then becomes critical.

- In sum, vaccine passports raise a number of issues (including matters of practicality and criminality which have not been raised here) and are highly controversial. This controversy in itself may be corrosive at a time where a sense of common cause and of trust in authority is important in controlling the pandemic. They can play a positive part in an overall vaccine strategy under conditions of high trust, but they should not be relied upon as the centrepiece of that strategy.

Annexe

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Research Paper

The potential impact of vaccine passports on inclination to accept COVID-19 vaccinations in the United Kingdom: Evidence from a large cross-sectional survey and modeling study

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ABSTRACT

Background: The UK Government is considering the introduction of vaccine passports for domestic use and to facilitate international travel for UK residents. Although vaccine incentivisation has been cited as a motivating factor for vaccine passports, it is unclear whether vaccine passports are likely to increase inclination to accept a COVID-19 vaccine.

Methods: We conducted a large-scale national survey in the UK of 17,611 adults between 9 and 27 April 2021. Bayesian multilevel regression and poststratification is used to provide unbiased national-level estimates of the impact of the introduction of vaccine passports on inclination to accept COVID-19 vaccines and identify the differential impact of passports on uptake inclination across socio-demographic groups.

Findings: We find that a large minority of respondents report that vaccination passports for domestic use (46·5%) or international travel (42·0%) would make them no more or less inclined to accept a COVID-19 vaccine and a sizeable minority of respondents also state that they would 'definitely' accept a COVID-19 vaccine and that vaccine passports would make them more inclined to vaccinate (48·8% for domestic use and 42·9% for international travel). However, we find that the introduction of vaccine passports will likely lower inclination to accept a COVID-19 vaccine once baseline vaccination intent has been adjusted for. This decrease is larger if passports were required for domestic use rather than for facilitating international travel. Being male (OR 0·87, 0·76 to 0·99) and having degree qualifications (OR 0·84, 0·72 to 0·94) is associated with a decreased inclination to vaccinate if passports were required for domestic use (while accounting for baseline vaccination intent), while Christians (OR 1·23, 1·08 to 1·41) have an increased inclination over atheists or agnostics. Change in inclination is strongly connected to stated vaccination intent and will therefore unlikely shift attitudes among Black or Black British respondents, younger age groups, and non-English speakers.

Interpretation: Our findings should be interpreted in light of sub-national trends in uptake rates across the UK, as our results suggest that passports may be viewed less positively among socio-demographic groups that cluster in large urban areas. We call for further evidence on the impact of vaccine certification and the potential fallout for routine immunization programmes in both the UK and in wider global settings, especially those with low overall trust in vaccinations.

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1. Introduction

Proof of vaccination status via an electronic or physical vaccine passport or certificate has been proposed as a means to aid in the reopening of society after the implementation of non-pharmaceutical interventions to curb the spread of SARS-CoV-2 [1–3]. The discussion around the use of vaccine passports for domestic use in the United Kingdom (UK) has largely centered on their use in non-medical social settings where physical distancing may be challenging, such as public houses, restaurants, nightclubs, and large sporting events. Vaccine passports have also been proposed as a means to speed up the reopening of international travel for freedom of movement or tourism [2], which has largely halted over the past year due to various restrictions on international travel.

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Annexe

Research in context

Evidence before this study

Proof of vaccination has, to date, had limited use in public and private settings for the UK public, such as proof of yellow fever vaccination for international travel to limited destinations, or requirements of Hepatitis B vaccination in some medical roles. Although recent surveys have suggested that the majority of the British public support vaccine passports, we are not aware of any studies assessing the impact that proof of vaccination status for domestic use or for international travel may have on vaccination inclination and thus—perhaps more importantly—on epidemic spread.

Added value of this study

We conducted a large-scale survey of more than 17,000 members of the UK public between 9 and 27 April 2021 to explore attitudes to vaccine passports for domestic and international use. Bayesian methods are used to compute nationally representative estimates of the impact of vaccine passports on change in inclination to accept COVID-19 vaccines and to establish the socio-demographic determinants of vaccination inclination. This study is, as far as we are aware, the first to assess the impact of vaccine passports on vaccination inclination in the UK.

Implication of all the available evidence

We find that vaccine passports receive popular support in the UK, but there exists large variations in their appeal that stratify along socio-demographic lines: most notably, younger age groups, Black and Black British ethnicities (compared to whites), and non-English speakers are more likely to express a lower inclination to vaccinate if passports were introduced. Although these groups comprise a relatively small proportion of the UK population, there are crucial issues that these perceptions among these groups cause: notably, that these groups tend to have lower baseline vaccination intent and they cluster geographically. Therefore, since geographic clusters of low vaccination uptake can result in disproportionate increases in required vaccination levels for herd immunity in adjacent settings, we need to exercise extreme caution in public health interventions that may push these areas further away from vaccination.

There has been much debate about the relative merits of vaccine passports, with incentivising vaccination [4], public health principles of least infringement [5] (though arguments have also been made that passports could be more restrictive [6]), and minimizing SARS-CoV-2 risk when reopening society [3] cited as arguments in favor of vaccine passports. Major ethical concerns remain, however [5]. It has been argued that requiring proof of vaccination to re-enter society may violate freedom of choice [7] and further suggested that a requirement to vaccinate to fully re-enter society may stigmatize those who opt not to vaccinate [5,7] (who may stratify along socio-demographic characteristics leading, ultimately, to barriers or unequal treatment between socio-demographic groups [5,8,9]) or penalizing those who opt not to receive vaccination healthcare through financial and logistical costs to prove disease or immunological status via SARS-CoV-2 tests or antibody tests (the results of will likely be recorded on any vaccine passport or certificate that is introduced). As vaccinated individuals may still be infected with SARS-CoV-2—and the current level of sterilizing immunity from COVID-19 vaccines is unclear[10]—vaccine passports may lead to excluding healthy non-infected or immune individuals from societal events while infectious vaccinated individuals fully return.

These ethical concerns and potential additional costs must be considered in a contextual basis for policy in the UK, where confidence in, and uptake of, routine immunisations strongly depend on socio-demographic status [10–12]. With regards to COVID-19 vaccines in particular, females, younger age groups, Black / Black British ethnicities, Muslims, and Polish speakers have been less likely to state intent to vaccinate compared to males, older age groups, whites, atheists or agnostics, and English or Welsh speakers (respectively) [13]. Early evidence from observed uptake in the UK suggests that gender and ethnicity are associated with lower uptake among healthcare workers [14], and non-whites have lower uptake than whites among the general population too, with Black African and Black Caribbean people with the lowest uptake across the UK [15,16]. Although specific reasons for hesitancy will vary both within and between these groups, trust in authorities and the Government, as well as historic marginalization [17], play a key role [18] and it is currently unclear how the introduction of health status passports or certificates will affect intent to vaccinate as well as a breakdown of trust in authorities recommending vaccinations.

Recent polling in the UK has suggested that vaccine passports receive majority support in the UK, with increased support for use in international travel [19,20]. In this study, we quantitively assess the likely impact of the introduction of vaccine passports for domestic and international use on inclination to accept COVID-19 vaccines using a large nationally representative cross-sectional survey of about 17,000 UK adults conducted in April 2021. In particular, we seek to establish whether vaccine passports are likely to encourage or discourage uptake of COVID-19 vaccines among people who have not yet had two doses of a COVID-19 vaccine. We compute the overall impact of the introduction of vaccine passports on intent to vaccinate and identify the differential impact of passports on vaccination intent across socio-demographic and across UK region.

2. Methods

Data collection and processing A total of 17,611 adults were surveyed between 9 April 2021 and 27 April 2021. Respondent quotas were set to match UK national demographic counts by sex, age, and sub-national region. During data collection, quality control procedures resulted in the removal of 1,084 responses (see appendix). All respondents were recruited via online panels by ORB (Gallup) International (www.orb-international.com). Informed consent was obtained by all respondents before respondents participated in the survey (see appendix for the full survey questionnaire which includes the informed consent statement presented to participants).

Respondents were asked '*If a coronavirus (COVID-19) certificate or passport was required* ***to attend social events in the UK*** *(such as sports events, theatres, pubs, or restaurants), would you be more or less inclined to accept a coronavirus (COVID-19) vaccine?*' and '*If a coronavirus (COVID-19) certificate or passport was required* ***for international travel,*** *would you be more or less inclined to accept a coronavirus (COVID-19) vaccine?*' (emphasis added). As many respondents may not be aware of vaccine passports or certificates, a brief definition was first given (see below). Responses are given on a five-point scale: '*much less inclined*', '*somewhat less inclined*', '*neither more nor less inclined*', '*somewhat more inclined*', or '*much more inclined*' and assigned a numeric value from 1 to 5, respectively. Before being asked to report change in vaccine inclination, respondents were primed with a brief definition of vaccine passports: '*We would now like to ask you some questions about a vaccine or immunity certificate (commonly referred to as a "vaccine passport"). A vaccine or immunity certificate is a physical or electronic document that confirms your status against a particular disease. For example, the certificate could confirm that you have been vaccinated against a disease or that you have some pre-existing immunity*'.

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In exploring change in vaccination intent if vaccine passports were required for domestic or international use, it is important to control for individuals' baseline level of vaccination intent, as survey questions that investigate how an information or event changes their attitudes may illicit the same response as the underlying attitude being measured itself [21]. Thus, to control for existing vaccination intent, respondents are first asked whether they have been offered a COVID-19 vaccine and, if so, whether they have taken the vaccine (and how many doses). Respondents who reported taking one dose only were asked whether they intended on receiving a second dose ('*Do you intend on receiving your second dose?*'), while respondents who reported not having received the vaccine were asked if they intended on accepting the vaccine ('*Do you intend on accepting a coronavirus (COVID-19) vaccine?*'). All respondents who have not been invited to vaccinate were asked whether they would take the vaccine ('*When you are invited to take a coronavirus (COVID-19) vaccine, will you accept the vaccine for yourself?*') (Fig. 1). Responses to all preceding questions in parentheses could answer on the four-point scale, '*yes, definitely*', '*unsure, but leaning towards yes*', '*unsure, but leaning towards no*', or '*no, definitely not*' and were collated into a single variable. These responses are assigned the values 1 to 4, respectively. As we wish to explore the impact of vaccine passports on future vaccination inclination, all respondents who have already received both doses (1984, Fig. 1) were removed from entirely from all analyses.

Individuals' outer postcode, sex, age, highest level of education, employment status, religious affiliation, ethnicity, and primary language are also recorded. Outer postcode (the first half of a UK postcode) was re-coded to administrative region (the NUTS1 unit, see https://www.ons.gov.uk/methodology/geography/ukgeographies/eurostat). These socio-demographic variables serve two purposes: i) they allow a meaningful exploration of the factors associated with vaccination intent and ii) they align with socio-demographic data collected in the latest census. This latter point allows individual-level reweighting according to millions of UK census records. All summary of socio-demographic variables used and details on variable recoding are provided in Table 1. A breakdown of individuals' change in vaccination inclination by baseline vaccination intent and socio-demographic group is provided in appendix, Table 1 for all individuals who have not had two COVID-19 doses.

In addition to the questions on baseline vaccination intent and change in vaccination inclination explained above, all respondents (n = 16,527) are presented with a seven-item questionnaire to explore their attitudes towards vaccination and vaccine passports or certificates. These statements—which are answered on a scale from '*strongly agree*' to '*strongly disagree*' (with '*prefer not to say*' a further option) and in which 'social events' are defined as above—are:

- Proof of vaccination via a vaccine certificate or passport for social events infringes on personal liberties
- I wish to be free to reject a vaccine without consequences on my ability to attend public or social events
- Individuals who reject a vaccine should not be allowed to attend social events
- Private companies should have the right to reject individuals if they have not received a vaccine
- Private companies should have the right not to employ unvaccinated staff
- Overall, I think vaccine passports are a good idea
- Requiring vaccine certificates or passports for social events is the same as requiring me to get vaccinated.

The order in which statements were presented to respondents was randomised.

2.1. Estimating the impact of passports on vaccination inclination across the UK

To estimate the overall impact of the introduction of vaccine passports on intent to accept a COVID-19 vaccine nationally across the UK, we would like to estimate the distribution $P_{Y,Z}(Y,Z)$, where Y and Z denote the change in vaccination inclination if vaccine passports were introduced domestically (or internationally) and each individual's baseline intent to accept a COVID-19 vaccine, respectively. This quantity gives the probability of each pair of responses (both modelled as ordinal random variables) and can be used to investigate how vaccine passports may shift vaccination intent. To estimate this quantity, we use multilevel regression and poststratification [22–24] (MRP) to compute the posterior predictive distribution $P_{Y',Z'|Y,Z}(Y', Z' | Y,Z) = \sum_{s=1}^{N_S} P_{Y'|Y,Z,S}(Y'|Y,Z,\ S=s)P_{Z'|S}(Z'|S=s)P_S(S=s)$, where S is an index variable that represents one of the N_S =370,440 unique census strata (12 regions × 2 sexes × 7 age groups × 3 education

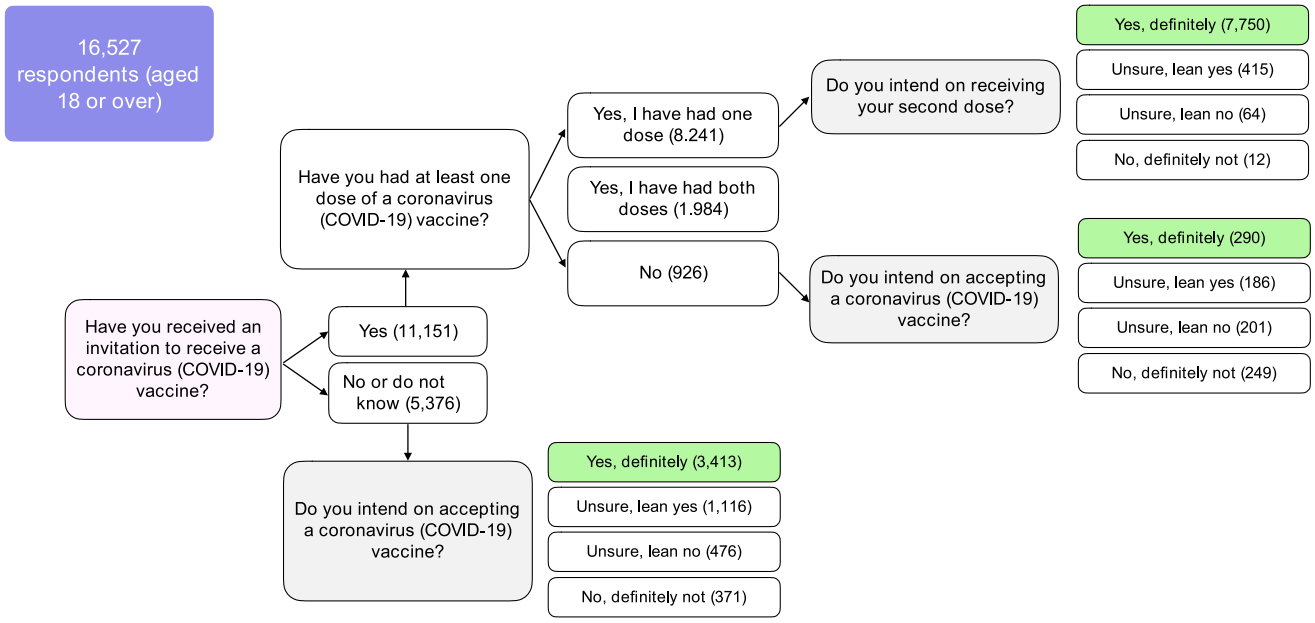

Fig. 1. Baseline intent to accept a COVID-19 vaccine, Z.

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Annexe

Table 1
Study data Survey items are shown with possible responses (including recodes, if any), and baselines used in the ordinal logistic regressions.

	Survey question	Values (recodes in parenthesis)	baseline
Change in COVID-19 vaccination intent	If a coronavirus (COVID-19) certificate or passport was required to attend social events in the UK (such as sports events, theatres, pubs, or restaurants), would you be more or less inclined to accept a coronavirus (COVID-19) vaccine? (*Y*) If a coronavirus (COVID-19) certificate or passport was required for international travel, would you be more or less inclined to accept a coronavirus (COVID-19) vaccine? (*Y*)	much less inclined (1); somewhat less inclined (2), neither more nor less inclined (3); somewhat more inclined (4); much more inclined (5); do not know / prefer not to say (3)	n/a [ordinal response variable]
COVID-19 vaccination intent	Do you intend on receiving your second dose? [if respondent has had the first dose] OR Do you intend on accepting a coronavirus (COVID-19) vaccine? [if respondent has been invited but not reported at least one dose] OR When you are invited to take a coronavirus (COVID-19) vaccine, will you accept the vaccine for yourself? [If respondent not yet invited to vaccinate] (*Z*)	Yes, definitely (4); Unsure, but leaning towards yes (3); Unsure, but leaning towards no (2); No, definitely not (1)	n/a [ordinal covariate]
Covariates	sex	male and female	female
	age	integer value mapped to 18−24, 25−34, 35−44, 45−54, 55−64, 65−79, 80+	18−24
	highest educational attainment	No academic qualifications (none/other) 0−4 GCSE, O-levels, or equivalents (level 1−3) 5+ GCSE, O-levels, 1 A level, or equivalents (level 1−3) 2 + *A* levels or equivalents (level 1−3) Undergraduate or postgraduate degree or other professional qualification (level 4) Apprenticeship (none/other) Other (e.g., vocational, foreign qualifications) (none/other) Do not know (none/other) Do not wish to answer (none/other)	level 1−3
	religious affiliation	atheist/agnostic Christian Buddhist (other religion) Hindu Muslim other religion do not wish to answer (not given)	atheist or agnostic
	work status	working full-time (including self-employed) part-time (including self-employed) unemployed student looking after the home retired (retired / disabled) unable to work (e.g., short- or long-term disability) (retired / disabled) do not wish to answer (other work status)	full-time
	ethnicity	White: English/Welsh/Scottish/Northern Irish/British (White) White: Irish (White) White: Other white background (White) White and Black Caribbean (mixed) White and Black African (mixed) White and Asian or White and Asian British (mixed) Black, African, Caribbean or Black British (Black/Black British) Asian or Asian British: Indian (Asian/Asian British) Asian or Asian British: Pakistani (Asian/Asian British) Asian or Asian British: Chinese (Asian/Asian British) Asian or Asian British: Other (Asian/Asian British) other ethnicity (other ethnicity) do not wish to answer (other ethnicity)	White
	language	English or Welsh Polish Punjabi (other language) Urdu (other language) Bengali (other language) Other (other language) do not wish to answer (other language)	English or Welsh

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levels × 7 work statuses × 7 religious affiliations × 5 ethnicities × 3 primary languages). The first two terms in this equation are posterior predictive distributions obtained from ordinal multilevel logistic regressions which model the association between change in vaccination intention (Y) given existing vaccination intent (Z) and socio-demographic status and vaccination intent (Z) given socio-demographic status. The final term is a post-stratification step that re-weights these distributions according to the number of times a particular stratum appears in the UK census records.

To estimate the overall impact of vaccine passports/certificates on the UK publics' inclination to accept a COVID-19 vaccine, we assume that respondents who state that they would 'definitely' accept or reject a COVID-19 vaccine will be no more or less inclined to vaccinate *unless* those replying 'yes, definitely' would *lower* their vaccination inclination if passports were introduced *or* if those replying 'no, definitely not' would *increase* their vaccination inclination. Thus, we can form the summary, $U_k = (1-\delta_{k4})\sum_{j>3} 100 * P_{Y',Z'}(Y'=j,\ Z'=k) - (1-\delta_{k1})\sum_{j<3} 100 * P_{Y',Z'}(Y'=j,\ Z'=k)$, which measures the net shift in COVID-19 vaccination inclination induced by the introduction vaccine passports for each baseline intent level k (where δ_{ij} is Kronecker's delta: $\delta_{ij}=1$ if $i=j$ and 0 otherwise). For example, $U_1 = 100 * \left(P_{Y',Z'}(Y'=4,\ Z'=1) + P_{Y',Z'}(Y'=5,\ Z'=1)\right)$ is the change in potential vaccination intention among those who state they would 'definitely not' receive a COVID-19 vaccine. This summary, in discounting individuals who already state a 'definite' intention to accept a COVID-19 vaccination and state that passports will increase their inclination to vote and, likewise, those who state a 'definite' intention not to accept a COVID-19 vaccination cannot be moved to a lower vaccination level, will capture the overall change in vaccination inclination relevant to baseline vaccination intent. The quantity $S = \sum_k U_k$ is a measure of the net population-wide possible change in vaccination intent pertinent to vaccination decisions induced by passports/certificates.

2.2. Socio-demographic determinants of change in inclination to vaccinate

Ordinal multilevel logistic regressions are used to model $Y|Z,S$ and $Z|S$, that is, the probability of changing vaccination inclination if passports were introduced for domestic or international travel (separate models are fit for both domestic and international use – see appendix) and the probability of a given baseline intent. In both cases socio-demographic determinants are obtained. In addition, to assess the determinants of change in vaccination inclination *without* controlling for baseline intent, we also use ordinal multilevel regressions to calculate $Y|S$: this regression is not used in calculating the joint distribution $P_{Y,Z}(Y,Z)$ but illustrates the direct predictors of change in inclination without controlling for pre-existing intent. Fixed- and random-effect regression parameters from these models signify the association between socio-demographic status and change in vaccination intent induced by passports and intent to accept a COVID-19 vaccine at the national (fixed) and sub-national levels (random).

2.3. Attitudes to vaccinations, passports, and societal freedoms

Seven individual MRP models are implemented to simultaneously estimate national (and sub-national) attitudes to the seven-item questionnaire and to explore their socio-demographic determinants. The response variable in each case are ordinal responses from each of the seven statements. Respondents who state that they '*prefer not to say*' are removed from each regression. A sensitivity analysis recoding '*prefer not to say*' to '*neither agree nor disagree*' is also performed to establish stability of estimates under a non-complete-case analysis (see appendix). (Such a sensitivity analysis is not performed for the estimating the impact of passports on vaccination inclination as do not know and prefer not to say were jointly coded in the questionnaire, see appendix).

All multilevel regression models are implemented using JAGS version 4.3.0 (implemented via rjags [25]) and R version 4.0.3. 10,000 posterior samples (not including 2,000 for model burn-in) was sufficient for successful convergence and all posterior draws were well-mixed (see appendix). Post-stratification was implemented in R using UK census microdata (https://census.ukdataservice.ac.uk/get-data/microdata.aspx).

3. Results

3.1. UK-wide intent to accept a COVID-19 vaccine

Across the UK, we estimate that 78·71% (95% highest posterior density interval, HPD, 76·14 to 81·04) of the adult population who have not yet had both doses of a COVID-19 vaccine will 'definitely' accept a future dose (either their first or second having already taken their first), while a further 11·72% (10·54 to 12·83) are 'unsure but leaning towards yes' (see Fig. 1 for sample information on doses received). 4·51% (3·84 to 5·24) say they will 'definitely not' accept a future COVID-19 vaccine, while 5·06% (4·43 to 5·73) are 'unsure but leaning towards no'.

3.2. Impact of vaccine passports on vaccine inclination

A large minority of respondents report that vaccination passports for domestic use (46·5%) or international travel (42·0%) would make them no more or less inclined to accept a COVID-19 vaccine (see Table 2, total change in inclination). Additionally, a sizeable minority of respondents also state that they would 'definitely' accept a COVID-19 vaccine and that vaccine passports would make them more inclined to vaccinate (48·8% for domestic use and 42·9% for international travel), while 2·56% (2·32%) of respondents report that they would 'definitely not' accept a COVID-19 vaccine and that vaccine passports for domestic use (international travel) would make them less inclined to vaccinate (Table 2).

In assessing the impact of vaccine passports on vaccine intention, however, it is essential to consider individuals for whom vaccine passports will likely alter their ultimate decision to vaccinate. The summary metric U_k excludes these individuals and suggests that vaccine passports may result in a *lower* overall inclination to accept COVID-19 vaccines. Overall, while vaccine passports for domestic use may have a very small positive impact on those who report that they will 'definitely not' accept a COVID-19 (U_1=0·20, 95% HPD interval 0·15 to 0·24), they will likely have a negative impact on those who report that they would otherwise have 'definitely' accepted a COVID-19 vaccine (U_1=−4·77, −5·53 to −4·05). The overall net impact $S = \sum_k U_k$ suggests a loss of intent to vaccinate of −3·64, −5·26 to −2·06 (Table 3). Similar results are found for the impact of vaccine passports for international travel; however, the overall net loss of intent is lower, with $S = -1{\cdot}65$ (−2·97 to −0·06), suggesting that vaccine passports for international travel are less disagreeable than for domestic purposes, with $S^{DOM} - S^{INT} = -1{\cdot}99$ (−3·87 to 0·13).

The socio-demographic determinants of self-reported change in vaccination inclination if passports are introduced for domestic use are shown in Fig. 2 while controlling for baseline vaccination intent, $Y|Z,S$ (Fig. 2A) and without this control, $Y|S$ (Fig. 2B). Similarly, these two sets of determinants for international travel are shown in Fig. 3. We interpret odds ratios for which the corresponding 95% highest posterior density interval excludes zero as 'significant'.

Males (odds ratio, OR, 0·87, 95% HPD, 0·78 to 1·00), Black and Black British ethnicities (0·62, 0·44 to 0·82), those unemployed (0·79, 0·65 to 0·98), looking after the home or family (0·77, 0·63 to 0·91), in part-time employment (0·82, 0·71 to 0·94), have another work status

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Table 2
Joint distribution of baseline vaccination intent and change in vaccination inclination. Estimates of the percentage of the UK population who denote a change in inclination to vaccinate if passports were introduced for domestic or international use for each baseline vaccination.

Percentage of population $100 * P_{Y',Z'\|Y,Z}(Y',Z'\|Y,Z)$		**Existing vaccination intent, Z'** No, definitely not (1)	Unsure, but leaning towards no (2)	Unsure, but leaning towards yes (3)	Yes, definitely (4)	**Total change in inclination**
Change in inclination to accept vaccine if passports introduced for domestic use, Y'	Much less inclined (1)	1·88 [1·57, 2·21]	1·03 [0·87, 1·21]	0·87 [0·73, 1·02]	2·62 [2·21, 3·05]	6·41 [5·61, 7·38]
	Somewhat less inclined (2)	0·68 [0·58, 0·80]	0·59 [0·52, 0·68]	0·66 [0·57, 0·76]	2·15 [1·84, 2·47]	4·08 [3·66, 4·54]
	Neither more nor less inclined (3)	1·74 [1·43, 2·05]	2·84 [2·47, 3·22]	6·71 [6·07, 7·36]	35·2 [32·6, 37·8]	46·5 [44·4, 48·7]
	Somewhat more inclined (4)	0·10 [0·08, 0·12]	0·29 [0·23, 0·34]	1·45 [1·27, 1·65]	13·1 [12·6, 13·6]	14·9 [14·4, 15·5]
	Much more inclined (5)	0·10 [0·08, 0·12]	0·31 [0·25, 0·38]	2·03 [1·67, 2·35]	25·7 [23·1, 28·3]	28·1 [25·3, 31·1]
	Total intent	4·51 [3·84, 5·24]	5·06 [4·43, 5·73]	11·7 [10·5, 12·8]	78·7 [76·1, 81·0]	100
Change in inclination to accept vaccine if passports introduced for international use, Y'	Much less inclined (1)	1·62 [1·33, 1·89]	0·77 [0·65, 0·90]	0·73 [0·62, 0·85]	2·49 [2·13, 2·82]	5·61 [4·86, 6·34]
	Somewhat less inclined (2)	0·70 [0·59, 0·80]	0·51 [0·44, 0·59]	0·59 [0·51, 0·68]	2·14 [1·87, 2·42]	3·95 [3·52, 4·35]
	Neither more nor less inclined (3)	1·90 [1·61, 2·23]	2·85 [2·51, 3·24]	6·03 [5·44, 6·68]	31·18 [28·92, 33·24]	42·0 [39·8, 43·9]
	Somewhat more inclined (4)	0·14 [0·12, 0·17]	0·41 [0·35, 0·47]	1·61 [1·43, 1·78]	12·72 [12·27, 13·12]	14·9 [14·6, 15·2]
	Much more inclined (5)	0·16 [0·13, 0·19]	0·52 [0·44, 0·62]	2·76 [2·4, 3·14]	30·17 [27·70, 33·02]	33·6 [30·8, 36·6]
	Total intent	4·51 [3·84, 5·24]	5·06 [4·43, 5·73]	11·7 [10·5, 12·8]	78·7 [76·1, 81·0]	100

(0·50, 0·31 to 0·82), who speak Polish (0·45, 0·29 to 0·71) or another language (0·74, 0·59 to 0·93) report that they would be less inclined to vaccinate if passports were introduced for domestic use (compared to females, whites, those in full-time employment, or who speak English or Welsh, respectively) (Fig. 2B). Age groups above 45−55 and Christians (1·27, 1·10 to 1·43) report that they would me more inclined to vaccinate than 18−24-year-olds and atheists or agnostics, respectively. After controlling for baseline vaccination intent, males (0·87, 0·76 to 0·99) and those with undergraduate/postgraduate degrees or other professional qualifications (level 4) (OR 0·84, 0·72 to 0·94) are less inclined to accept a COVID-19 vaccine if vaccine passports are introduced for domestic use than females or those with level 1−3 education (undergraduate or postgraduate degrees, see table 1), respectively, while Christians (OR 1·23, 1·08 to 1·41) are more inclined than atheists or agnostics (Fig. 2A). There is also a strong association between change in vaccination inclination and baseline vaccination intent (OR 3·11, 2·87 to 3·30, Fig. 2A). There is sub-national variability around these national level (fixed effects) estimates. For instance, respondents identifying as Asian or Asian British state more inclination (than whites) to accept COVID-19 vaccines if passports were introduced for domestic use in the West Midlands and London, while Jewish respondents in London state much more inclination than atheists or agnostics (Table 2, appendix). Those unemployed in Yorkshire and the Humber, individuals working part-time in London, and retired / disabled respondents in South West England are less inclined to vaccinate than those in full-time employment. While students in London are much more inclined to vaccinate if vaccine passports were introduced for domestic use (Table 2, appendix).

Similar trends are observed for determinants of change vaccination inclination if passports were introduced for international use (Fig. 3B). Males, those unemployed, looking after the home or family or with another work status, and Polish speakers still report being less inclined (than females, those in full-time employment, and English or Welsh speakers, respectively) to vaccinate if passports were introduced for international travel. Those retired or disabled (0·83, 0·71 to 0·96) now report being less inclined compared to those in full-time employment, while Black ethnicities are now no more or less likely than whites. Older age groups, Christians, and now Asian or Asian British ethnicities report being more inclined to vaccinate than 18−24-year-olds, atheists or agnostics, and whites (Fig. 3B). After controlling for baseline vaccination intent, males (0·84, 0·74 to 0·95) and those looking after the home or family (OR 0·77, 0·63 to 0·93) are less inclined to accept a COVID-19 vaccine if vaccine passports are introduced for international travel use than males or those in full-time employment, respectively; while 55−64-year-olds (OR 1·21, 1·01 to 1·47), Christians (OR 1·22, 1·07 to 1·39), and Asian or Asian British ethnicities (OR 1·44, 1·13 to 1·84) are more inclined than 18−24-year-olds, atheists or agnostics, or whites, respectively (Fig. 3A). There is again a large association between change in vaccination inclination and baseline vaccination intent (OR 2·90, 2·70 to 3·09, Fig. 3A). Sub-national socio-demographic trends are shown in appendix, Table 3: individuals who report looking after the home or family are considerably less likely than those in full-time employment to be inclined to vaccinate if passports were introduced for international travel in four UK regions, while students in London are again more inclined.

These socio-demographic trends clearly mirror the determinants of baseline vaccination intent, where younger age groups, Black/Black British ethnicities, and Polish speakers are less likely to accept the COVID-19 vaccine than, respectively, older age groups, whites, and English or Welsh speakers. Those with degree qualifications (level 4 education) are more likely to accept a COVID-19 vaccine than those with level 1−3 education (see appendix, Fig. 1).

Table 3
Potential impact of passports on inclination to receive COVID-19 vaccine

	Existing vaccination intent, Z' No, definitely not (1)	Unsure, but leaning towards no (2)	Unsure, but leaning towards yes (3)	Yes, definitely (4)	$S = \sum_k U_k$
Overall impact if passports introduced for domestic use U_k^{DOM}	0·20 [0·15,0·24]	-1·03 [-1·30, -0·77]	1·95 [1·28, 2·54]	-4·77 [-5·53, -4·05]	-3·64 [-5·26, -2·06]
Overall impact if passports introduced for international use, U_k^{INT}	0·30 [0·24, 0·36]	-0·36 [-0·58, -0·11]	3·05 [2·49, 3·66]	-4·64 [-5·27, -4·03]	-1·65 [-2·97, -0·06]
Difference in impact effect size between international and domestic use, $\Delta S = S^{\text{DOM}} - S^{\text{INT}}$	-0·10 [-0·14, -0·05]	-0·67 [-1·02, -0·36]	-1·09 [-1·83, -0·31]	-0·12 [-1·01, 0·82]	-1·99 [-3·87, 0·13]

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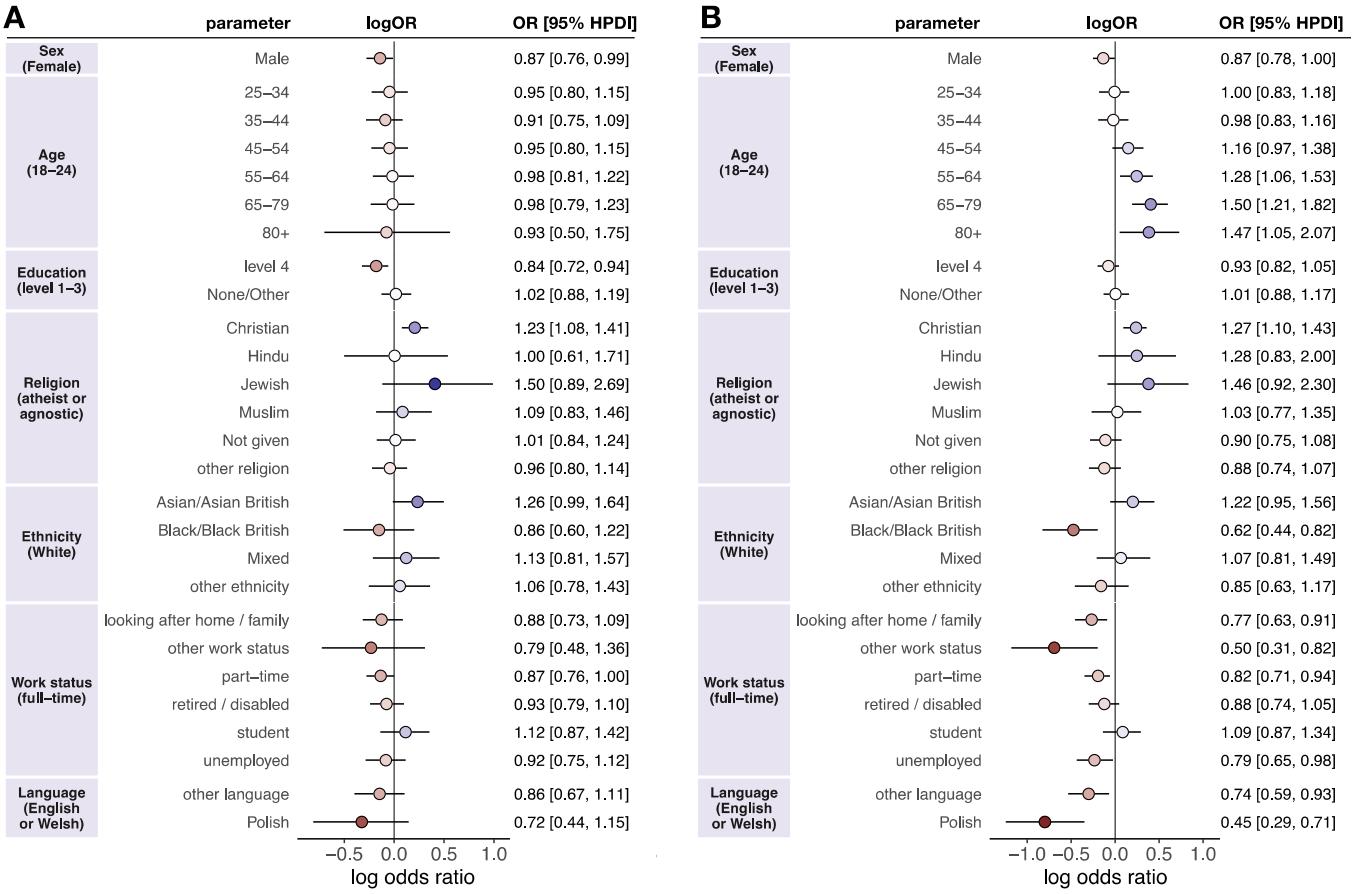

Fig. 2. Socio-demographic determinants of change in vaccination inclination, *Y*, if vaccine passports were required for domestic use with a control for baseline vaccination intent, *Z* (A) or no control (B). Multilevel regression fixed-effect parameter log odds ratios are plotted with corresponding 95% highest posterior density intervals. Baseline intent to accept a vaccine, *Z*, is not shown in A for visual purposes, but the log odds ratio is 3·11 (2·87 to 3·30): this parameter is denoted γ_Z in the model formulation (appendix). Log odds ratios are coloured by effect magnitude and direction, where blues (reds) signify that the group is more (less) inclined than the baseline group to accept a COVID-19 vaccine and the darker the color the stronger the association. For each factor, the baseline group is provided in parentheses on the left. Odds ratios with 95% HPDIs are shown on the right for each parameter.

3.3. Attitudes to vaccinations, passports, and societal freedoms

Overall, a majority of the UK public yet to have both doses believe that vaccination certificates or passports is the same as requiring vaccination (58·4%, 56·8 to 62·6), yet a majority of the public believe that they are a good idea (59·8%, 56·8 to 62·6). More respondents believe that passports do not infringe on personal liberties (41·1%, 38·2 to 43·8) than do (35·5%, 32·9 to 38·83), though this difference is smaller than in the two statements above. More respondents also state that they do not wish to be free to reject a vaccination without consequences on their ability to attend public or social events (39·3%, 36·6 to 42·2 disagree versus 33·2%, 30·7 to 35·8 who agree). A small majority of respondents also believe that individuals who reject a vaccine should not be able to attend social events (50·8%, 47·4 to 54·0). A breakdown of all seven statements, including views on the rights of private companies (not commented on here) can be found in appendix, Fig. 2.

There is a consistency in how socio-demographic groups reply across these statements (appendix, Fig. 3), which also reflects responses to both change in vaccination inclination (Fig. 2B and Fig. 3B) and baseline vaccination intention (appendix, Fig. 1). (The socio-demographic determinants of these statements via the sensitivity analysis are shown in appendix, figure 4.) For example, older age groups—who state a higher intent to vaccinate and also an increased inclination to vaccinate if passports were introduced—are more likely to agree that passports are a good idea; that passports would not infringe their personal liberties; that they do not wish to be free to reject a vaccine; and that individuals who reject a vaccine should not be free to attend social events. However, Black and Black British respondents are more likely than whites to believe that vaccine passports would infringe on their personal liberty; that they wish to be free to reject a vaccine without consequences on their ability to attend social events. Black and Black British respondents are also much less likely than whites to think that individuals who reject a vaccine should be allowed to attend social events and are less likely than whites to think vaccine passports are a good idea. A full set of regression parameters for each statement is provided in appendix, Fig. 3.

4. Discussion

The data from our study suggest a somewhat reassuring picture. In overall terms, vaccine passports have a positive impact on stated intentions to get vaccinated among those who have not received at least one dose of a COVID-19 vaccine. Looking more closely, however, we find a polarizing effect of passports. Passports make those who already intend to get vaccinated (who comprise 80% of our participants) even more positive. This may explain the immediate surge of people coming forward to get vaccinated in places (such as France) where a passport policy has been introduced [26]. But passports have the converse effect upon those who have concerns about the vaccine. Thus, when we remove those participants who express certainty (they either definitely will or definitely will not get a jab) and focus on the remaining doubters, we find *lower* intentions to get vaccinated when vaccine passports are mentioned,

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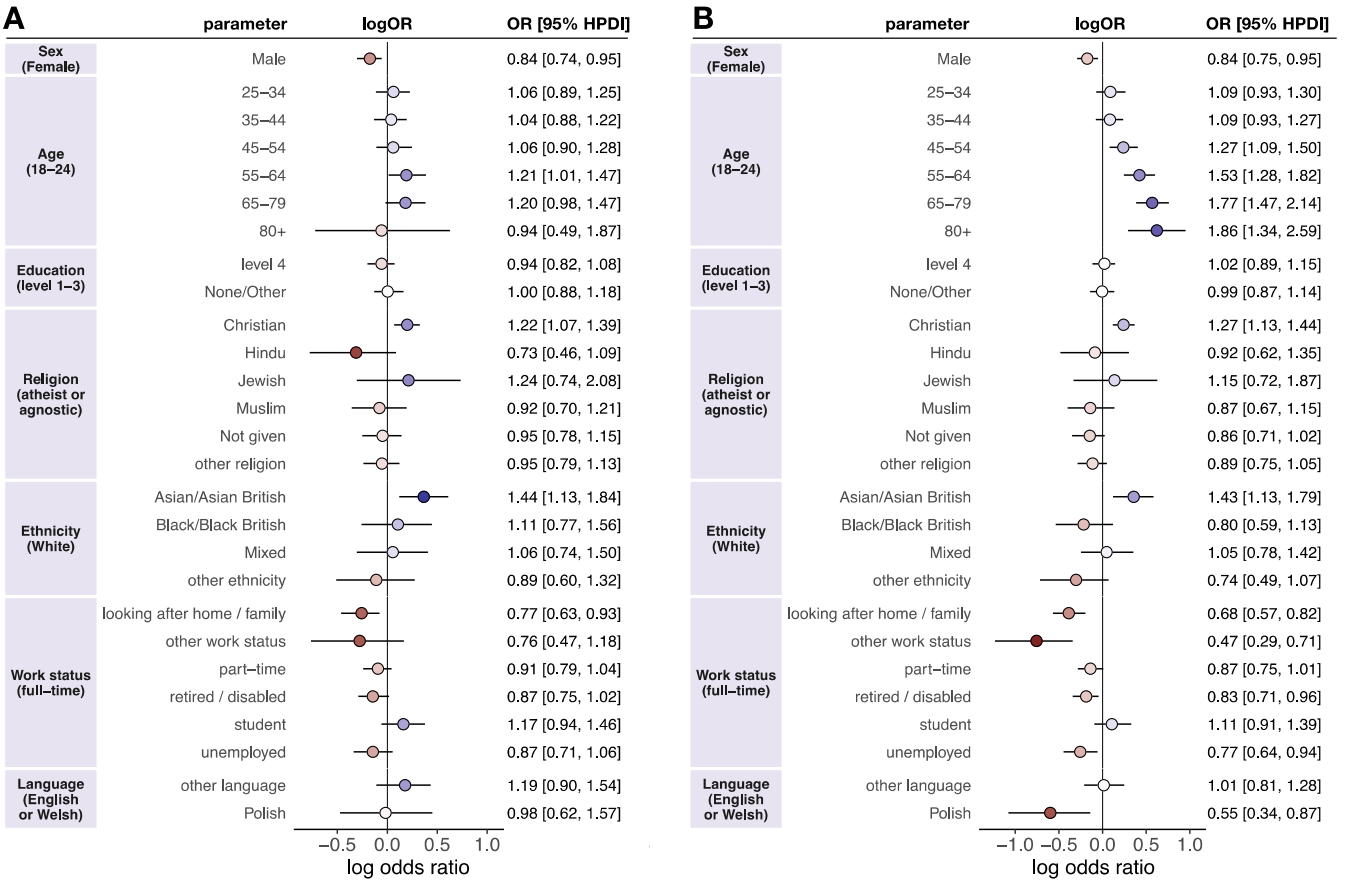

Fig. 3. Socio-demographic determinants of change in vaccination inclination, *Y*, if vaccine passports were required for international travel with a control for baseline vaccination intent, *Z* (A) or no control (B). Multilevel regression fixed-effect parameter log odds ratios are plotted with corresponding 95% highest posterior density intervals. Baseline intent to accept a vaccine, *Z*, is not shown in A for visual purposes, but the log odds ratio is 2·90 (2·70 to 3·09): this parameter is denoted γ_Z in the model formulation (appendix). Log odds ratios are coloured by effect magnitude and direction, where blues (reds) signify that the group is more (less) inclined than the baseline group to accept a COVID-19 vaccine and the darker the colour the stronger the association. For each factor, the baseline group is provided in parentheses on the left. Odds ratios with 95% HPDIs are shown on the right for each parameter.

especially when these passports cover domestic activities as opposed to international travel. These findings are in alignment with recent evidence in the UK that suggests thtat health and social care workers who feel pressured to vaccinate are less likely to vaccinate [27]. In overall terms, then, our findings point to a scenario in which passports may accelerate the rate at which maximum numbers of the population are vaccinated while simultaneously lowering the level of that maximum.

These effects are apparent at a collective as well as an individual level. Levels of uptake in most communities are high; however, there are some regions where uptake is much lower [29]. These areas are typified by larger populations of younger age groups, non-White ethnicities, and non-English speakers [24,29]. Equally, when we break our overall dataset down and look at the effects of vaccine passports on vaccination intentions upon different groups, we find considerable variability. While males have been reported to have a higher intent to accept COVID-19 vaccines in the UK than females [13,30,31] (which is being borne out across most age groups who have been offered COVID-19 vaccines—see appendix, Table 4), we find that, after controlling for baseline vaccination intent, it is males who are more likely to lower their vaccination inclination if vaccine passports are introduced, accounting for baseline vaccination views. Similarly, those with university degrees and other professional qualifications also report a decreased inclination to vaccinate (compared to level 1–3 education, see Fig. 2 and table 1 for variable definition) if vaccine passports are introduced for domestic use. There is notable subnational variation in these trends, for example Jewish respondents in London, passports (both for international and domestic use) increase stated vaccination inclination. It is also notable that, among the groups with lower observed uptake—such as the Black community and those who are economically deprived (unemployed)—the effects of domestic use vaccine passports on stated vaccination inclination (without controlling for baseline intent) are most negative.

As to why we get such different responses in different groups, it is impossible to be certain. However, based on research into the ways that the public make sense of new and unfamiliar scientific phenomena by assimilating them to prior and familiar schemata, one key place to look for an answer is in the shared beliefs (or 'social representations') of the relevant groups [32]. In the case of Jewish groups, of whom many may identify with Israel, the positive view of passports may relate to the publicity given to the 'green pass' system in Israel [33], however, some Israeli medical professors have recently cited segregation of those vaccinated from those unvaccinated by universities and public venues, as well as vaccine rejection by younger Israelis who would "have never considered refusing a vaccine recommended to them" [34]. By contrast, amongst the Black community, the negative impact of passports may relate to a longstanding suspicion, buttressed by historical experience [35], that medical interventions are used as a means of controlling the community [36]. In other words, Black people are more likely to see vaccine passports—especially when they impinge on everyday activities—as something imposed on them rather than something provided for them and therefore are put off vaccination when they are invoked. Our data reveal that Black respondents are more likely than White respondents to believe that vaccine passports are an attack on civil liberties and are in less agreement that

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people who reject vaccines should be disqualified from social events. However, we cannot say from our findings that there is any causal link between historically grounded perceptions of compulsion and control on the one hand and lowered vaccine intentions on the other. Clearly, this is a key site for further investigation.

It is important to note a number of limitations. Most obviously, our data consists of self-reports and, due to social desirability concerns, people may over-state their intention to do what the Government, health professions and media are heavily promoting. However, comparing those who either said they would definitely get vaccinated or were leaning towards it in a nationally representative survey of 16,820 UK adults conducted in October 202,0[14] (two months before the first COVID-19 vaccination in the UK [37]) to the numbers of people who actually took up the offer of a first dose (to 30 April 2021), we find that the former is close to but actually a little lower than the latter (55–64-year-olds: 83·8% vs. 86·9%; 65–79-year-olds: 90·0% vs. 93·2%; Over 80s: 90·1% vs. 94·9%). In sum, without ruling it out, there is little evidence for a strong desirability effect, although previous underestimation could also point to a general increase in intent to vaccinate across the UK since vaccine rollout began.

A second and related issue is that, even if it is accepted that our data reflect genuine intentions, these are still not the same as actual vaccination uptake. While we find that passports result in a net decrease in vaccination inclinations among those who are undecided, we have no way of knowing whether this is enough to tip anybody over into actually refusing the vaccine. Hence, we cannot be definitive about the real-world impact of introducing such passports.

Third, our study provides only a single snapshot in time, and there may be temporal variations in attitudes to passports may not be static and may be influenced by recent media coverage. Moreover, nuances to policy (such as time-limits on passports, or alternatives to presenting proof of vaccination) may allay public concerns and may alter the results in this study.

Finally, it is important to stress that the discussion of COVID passes and passports covers many different possibilities which vary along at least three dimensions: what it depends on (vaccination, negative PCR/lateral flow test results, antibody testing); what it applies to (international travel, attendance at large events, access to pubs/restaurants, shops, employment); and when it applies (immediately, after everyone has been offered vaccination). We suspect that the impact of passport proposals on vaccination intentions will vary as a function of all of these factors (which will impact on possible mediating process such as perceptions of compulsion or else perceptions of legitimacy and equity).

We also acknowledge that the alternatives included in our study (passports for international travel and passports for social events including sports events, bars and restaurants) are not necessarily the alternatives offered in any particular country (for instance, in the UK currently proposals are being mooted to introduce vaccine passports for sports events and nightclubs but not for pubs and restaurants [38,28]). Our precise findings may not be directly applicable, therefore. However, our more general message remains highly relevant across different settings. Moreover, we have not considered whether, for example, *not* introducing passports to facilitate international travel may disincentivise vaccine uptake among those who have stated an intent to vaccinate, especially if financial costs are incurred to prove immunological status to travel.

What we have described is what might be dubbed a 'vaccine passport paradox' whereby the overall positivity of a population towards the introduction of passports may mask processes that alienate critical minorities and may possibly lead to an overall decrease in inclination to vaccinate. This creates a risk of creating a divided society wherein the majority are relatively secure but there remain pockets of lower vaccination where outbreaks can still occur. This latter point is especially important in the context of local vaccination rates required to prevent epidemic spread. The important question here concerns the impact of vaccine passports amongst members of these communities: are they likely to help or hinder efforts to ensure that overall levels of immunity are uniformly high amongst all sections of the population? If we cannot persuade groups in localised clusters to get vaccinated—or worse, enact policies which may lower their confidence in vaccines—then these areas are not only at increased epidemic risk, but may serve to increase required vaccination levels for herd immunity in adjacent settings [39].

This is not an argument against vaccine passports in general. There may be some variants of passport schemes which do not create reactance in these critical minorities. But it is to introduce a note of caution to the debate. Before making decisions on the introduction of any specific vaccine passport policy, it is necessary to address the impact of passports on the decisions of those individuals and communities who are more hesitant about vaccination and hence most need to be persuaded to take them.

This study has implications for the UK's policy on vaccine certification as well as, more broadly, implications for other countries who are planning to introduce vaccine certification. For example, a European Union digital green certificate has been created with the purpose to facilitate free movement inside the EU during the COVID-19 pandemic [2]. However, it is currently unclear whether such a pass could result in lower inclination to vaccinate across European Union member states, notably those who have expressed concerns over the safety and importance of vaccines in recent years [40]. As passports are unpopular with groups with low intent to vaccinate, the introduction of passports could have profound consequences in settings where there are lower levels of baseline confidence in vaccines, such as France and Poland [41].

In conclusion, our study suggests that vaccine passports may induce a lower vaccination inclination in socio-demographic groups that are less confident in COVID-19 vaccines. As these groups tend to cluster geographically in large urban areas, extreme caution should be exercised in any public health intervention that may lead to less positive health-seeking behaviours in areas at high epidemic-risk.

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Data availability

All survey data in this study is publicly available at https://osf.io/xh9p7/. UK census microdata records can be downloaded at https://census.ukdataservice.ac.uk/get-data/microdata.aspx.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Author contributions

AdF designed the study and performed the statistical implementation and inference. AdF wrote the first draft of the manuscript and all authors contributed to interpretation of findings and writing of the manuscript.

Ethical approval

Ethical approval for this study was obtained via the London School of Hygiene and Tropical Medicine's Research Ethics Committee on 7 April 2021 with reference 25,637 and, for October 2020 survey data, the Imperial College Research Ethics Committee on 24 July 2020 with reference 20IC6133.

Annexe

Declaration of Competing Interest

AdF was involved (within the past two years) in Vaccine Confidence Project collaborative grants with GlaxoSmithKline and Janssen Pharmaceutica outside of the submitted work. AdF was awarded a Merck Investigator Studies Program grant that funded data collection in this study. SR is a member of SAGE. HJL is involved in Vaccine Confidence Project collaborative grants with GlaxoSmithKline, Janssen, and Merck. HJL has also received honoraria as a member of the Merck Vaccine Confidence Advisory Board and GlaxoSmithKline roundtables.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2021.101109.

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Annexe

Guardian opinion piece from Professor Stephen Reicher

I never imagined that one day I would be asked to bring my Professorial gravitas to bear on the question of the swollen testicles of the imaginary friend of a cousin of a US rapper, Nicki Minaj (allegedly an effect of the coronavirus vaccine). But these are strange times, in which such laughable matters have very serious consequences – indeed they have become a matter of life and death.

The various vaccines undoubtedly have side-effects and they clearly are not perfect in providing protection. Nonetheless, the overall balance of risk is strongly in favour of being vaccinated. This is most simply illustrated, perhaps, by the fact that some 45 million people have now had two doses of the vaccine, comprising over 80% of the population aged over 16 and yet only just over 1% of Covid deaths in the UK are amongst fully vaccinated people. So far vaccines have saved over 100,000 lives in England alone.

So, when people tweet information that undermines the vaccine roll-out (especially if, like Nicki Minaj, they have 22 million twitter followers), it could well cost lives. Now, I have no idea if Minaj's intent was to stop people getting jabbed or whether it was one of those thoughtless emails we all dash off occasionally. At the very least, though, those with reach need to think very carefully about the stories they spread. When it comes to Covid, great influence entails great responsibility.

But in many ways the focus on the one influencer, and whether or not she should be ashamed of herself, is less interesting than a focus on the 22 million. Why should anyone be influenced by such transparently tall tales? Surely, those who base life-or-death decisions on such flimsy 'evidence' from such an inexpert source must have a less than total grip on reality? So, what does this affair tell us about why people are still not getting vaccinated, about the power of disinformation and about how to improve the vaccine roll-out?

We must start by making some very clear distinctions. There is a tendency to conflate those who are not vaccinated with the vaccine hesitant and those who are vaccine hesitant with anti-vaxxers. This is not only a misunderstanding of the problem but may actually serve to exacerbate the problem.

First, then, some 30% of people under 30 are still unvaccinated, but less than a third of these could be described as vaccine hesitant in the sense of actively refusing a jab. Most haven't got anything against the vaccine, but they haven't got round to it. Or else they believe that infections no longer matter and so can't really see the point. It's just not worth the bother.
Second, even though the vaccine hesitant are a small and shrinking proportion of the population (4% overall, up to around 10% in younger age groups), most are not anti-vaxxers. They have genuine concerns and questions which they want answered: what is the effect of the vaccine on fertility? What if you have sickle cell disease? They want answers. Anti-vaxxers have no questions and want no answers because they consider that they have them already: vaccines are a conspiracy by an oppressive elite who want to control you.

A key issue, then, is whether the vaccine hesitant have their concerns resolved or else increased: whether they go to the side of vaccination or the anti-vaxxers. The

danger is that if you lump them in with anti-vaxxers to start with, deride them as irrational, condemn them as selfish, then this becomes a self-fulfilling prophecy. In treating the hesitant as 'other' to you, you position yourself as 'other' to them. You thereby confirm the anti-vaxxer narrative that the authorities are not on their side – vaccination is something done t rather than for them.

This resolves to an issue of trust. Those with doubts and concerns are assailed on all sides with different voices, some telling them to get vaccinated and some telling them to avoid vaccination. Who do they believe? Who is out to help them and who to deceive them? In the end what is critical is not just the nature of the information provided to us but rather our social relationship to the source of information. And those who are more open to anti-authority sources are not less rational or more venal but rather less trusting of authority – often with very good reasons based in historical experience.

On the one hand, then, populist politics in the Brexit era and a distrust in authority and expertise in general creates a space for misinformation. On the other hand, scepticism about vaccines is particularly high in those groups that have a more troubled relationship to authority: black people, deprived people, the unemployed. And, as our own data shows, this is underpinned by a sense that the vaccine is part of a long pattern of disregard and control.

So what are the implications for how we deal with information and increase vaccination rates. Certainly good clear information is important. Experts should be available at vaccination stations to address concerns about fertility, pregnancy, comorbidities and so on. But information alone won't be enough. We need first to make vaccination as easy as possible, taking the vaccination stations into schools, colleges, universities, workplaces and communities; ensuring people have paid time off to get the jab, and full wage compensation for any absences following on from vaccination. Second, we need clear and consistent messaging that infections do matter, so vaccination matters too in order to keep ourselves and our communities safe. Third, and most critically, we need to rebuild trust, to treat doubters with respect and to take people's concerns seriously.

For if we want to ensure that accurate information prevails over a load of bollocks, we must remember the first rule of effective communication: we will listen to the extent that those who speak are seen as being of us and for us. Influencers need to be seen as ingroup members.

EDITORIAL

COVID-19 vaccination passports

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As countries grow eager to reignite their economies and people increasingly yearn for mobility and normalcy in life, pressure is mounting for some form of COVID-19 health status certificate that would support these desires. There has already been an explosion of COVID-19 passport initiatives for domestic use and international travel. But scientific, legal, and ethical concerns abound with such documentation. Given the high stakes, what is the path forward?

From doctors' examinations to ship inspections, clean bills of health have secured passage through centuries of human plagues. Today's best-known health passport is the International Certificate of Vaccination or Prophylaxis, created by the World Health Organization (WHO). WHO's Yellow Card has certified vaccinations for cholera, plague, and typhoid, among other infections. There is certainly precedent for a COVID-19 vaccination passport certifying that the holder can travel, study, play, and work without compromising personal or public health. Among newly proposed COVID-19 passport schemes are the WHO's Smart Vaccination Certificate, Israel's "green passport," the European Union's proposed Digital Green Pass, and the Africa Centres for Disease Control and Prevention's "My COVID Pass."

> "Many issues surround the fair use of vaccination passports."

Given the momentum, what are the main principles that COVID-19 passports should follow to ensure their appropriate use?

A COVID-19 passport should be scientifically valid. Passport holders must be protected from illness so that they can carry out the activities for which the passport has been issued and to avoid burdening health services. A passport would ideally certify that holders are not, and cannot become, a source of infection for others. Vaccines have high efficacy in preventing symptomatic COVID-19, and there is growing evidence that they can prevent transmission too. No vaccine is perfect, and it remains to be determined whether vaccines meet minimum requirements for preventing infection and illness. The duration of protection conferred by vaccines should be tied to passport expiry dates, perhaps with options to revoke passports if new coronavirus variants compromise efficacy. These passports should also be judged for their comparative advantage. They may be preferable to viral RNA and antigen tests, which aim to certify that individuals are temporarily free of infection, and to antibody tests, which do not guarantee immunity to infection or disease.

The vaccination certificate should be portable, affordable, and linked safely and securely to the identity of the holder. Ideally, it will be internationally standardized with verifiable credentials and based on interoperable technologies. Forgery and personal data security are dominant concerns, but such problems are routinely solved for financial and other sensitive transactions.

Many issues surround the fair use of vaccination passports. The widely held view is that documents must avoid discrimination and inequity. Ideally, a passport would be exclusive only with respect to its primary purpose, which is to protect the health of individuals and others with whom they come into contact. But such exclusions inevitably raise barriers elsewhere. Some, such as restrictions on nonessential leisure activities, should be relatively easy to manage. The greatest risk is that people for whom vaccination is unacceptable, untested, inaccessible, or impossible are denied access to essential goods and services. This could happen where there is vaccine hesitancy or refusal among certain ethnic minorities; where there are no data on vaccine efficacy for people at risk, such as children and pregnant women; where migrants are undocumented and unreachable; where passports are exclusively digital, barring people without smartphones; and where people are not yet eligible for vaccination. These examples signal the need for alternatives and exemptions.

Some decisions about how to use passports will be made by public debate and consent, drawing on social and ethical norms. Others will be determined by domestic and international law. Some employers have already announced "no jab, no job" policies. In such cases, the freedom of choice for individual employees, set against a firm's duty and preference for the care of all staff, might be tested in court.

COVID-19 is a new human disease. The challenges presented by vaccination passports are also new in detail, but mostly familiar in kind. Adding to current, imperfect certification procedures by diagnostic tests, vaccination passports are likely to be widely adopted during the pandemic and its probable sequel, endemic and episodic disease. The choice about how passports are used should be guided by exemplary science, appropriate technologies, and fair use for all.

–Christopher Dye and Melinda C. Mills

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Annexe

Science

COVID-19 vaccination passports

Christopher Dye and Melinda C. Mills

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Annexe

THE ROYAL SOCIETY

14 FEBRUARY 2021

Twelve criteria for the development and use of COVID-19 vaccine passports

This rapid review of vaccine passports is from the Royal Society to assist in the understanding and control of COVID-19.

This paper is a pre-print and has been subject to formal peer-review.

KEY POINTS

- Vaccine passports are certificates to establish proof of vaccination linked to the identity of the holder; the purpose of a passport is to aid the return to pre-COVID-19 activities and allow travel without compromising personal or public health.
- We propose 12 criteria that should be satisfied by a COVID-19 vaccine passport. A passport should:
    1. meet benchmarks for COVID-19 immunity;
    2. accommodate differences between vaccines in their efficacy, and changes in vaccine efficacy against emerging SARS CoV-2 variants. It should be:
    3. internationally standardised with
    4. verifiable credentials for
    5. defined uses, and based on
    6. a platform of interoperable technologies
    7. secure for personal data
    8. portable and
    9. affordable for individuals and governments. It should meet:
    10. legal and
    11. ethical (equity and non-discrimination) standards, and,
    12. the conditions of use should be understood and accepted by passport holders.
- Current evidence suggest that a COVID-19 vaccine passport system is feasible, but that not all criteria have yet been satisfied and consideration should be given to what longer term precedents (e.g., commercial accessibility of registers, expanded state health surveillance) this may create.

Annexe

Executive summary

Vaccine passports are certificates to establish proof of vaccination linked to the identity of the holder; the purpose of a passport is to aid the return to pre-COVID-19 activities and travel without compromising personal or public health.

We propose 12 criteria that should be satisfied by a COVID-19 vaccine passport, namely it should:

1. meet benchmarks for COVID-19 immunity;
2. accommodate differences between vaccines in their efficacy, and changes in vaccine efficacy against emerging SARS CoV-2 variants.

It should be:

3. internationally standardised with
4. verifiable credentials for
5. defined uses, and based on
6. a platform of interoperable technologies.

A passport should be:

7. secure for personal data,
8. portable and
9. affordable for individuals and governments.

It should meet:

10. legal and
11. ethical (equity and non-discrimination) standards, and,
12. the conditions of use should be understood and accepted by passport holders.

Current evidence and precedents suggest that a COVID-19 vaccine passport system is feasible, but that not all criteria have yet been satisfied and consideration should be given to what longer term precedents this may create.

1. Meet benchmarks for COVID-19 immunity

A passport could serve two purposes. To certify that passport holders:

- are protected from illness so they can carry out the activities for which the passport is needed and avoid additional burdens on health services; and,
- cannot become infectious and transmit SARS-CoV-2 to others.

Four different tests of infection and immunity might satisfy these goals:

- viral RNA test-negative (PCR test); and
- viral antigen test-negative (lateral flow test) and that the subject is immune to COVID-19 illness and will not become infectious:
- viral antibody test-positive; and,
- vaccination.

At present, there are only two viable passporting tests, neither of which is entirely satisfactory:

- a recent negative RNA (PCR) test within a particular time-specified interval to certify that subject is unlikely carrying a transmissible infection; and,
- vaccination to signify immunity.

2. Accommodate differences between vaccines in their efficacy, and changes in efficacy against emerging SARS CoV-2 variants:

To place greater confidence in vaccine certification, more information is needed about:

- the efficacy of vaccines in preventing infection and transmission by the currently circulating viruses, including genetic variants; and,
- duration of protective immunity (both to illness and infectiousness) to determine frequency of vaccine passport renewal.

3. Be internationally standardised:

The International Certificate of Vaccination or Prophylaxis (ICVP) or the 'yellow card' is a precedent in this area.

The WHO has initiated a Smart Vaccination Certificate that will establish key specifications, standards, and a trust framework to facilitate implementation of effective and interoperable digital solutions.

Some countries have already introduced vaccine certificates through website portals (Denmark), a QR code valid at travel borders (Iceland) but also link certificates to quarantine (Estonia) or to ease restrictions related to socialisation and movement (Poland, Israel). Expert bodies in some countries note that prior to introduction, more information is still required about vaccination efficacy, transmission and data protection, ethical and legal issues (Germany, Netherlands, Spain).

4. Have verifiable credentials:

International and industry-based initiatives are being developed using international verifiable credentials and standards. The Common Pass and COVID-19 Credentials Initiative are consortiums working toward primarily App-based digital solutions using a QR code that can be displayed without releasing personal sensitive information. Others focus on products that allow individuals to share their vaccination and health status (to employers, authorities) while preserving privacy.

Technical challenges exist such as those related to form (digital, paper), forgery, and attention to privacy and identify proofing.

Annexe

5. Have defined uses:
The uses of vaccine passports need to be clearly defined as they carry the risk that they could be used to discriminate in hiring or access to restaurants, health care centres, sporting or cultural events, insurance companies, or housing applications or other services. Additional concerns are whether vaccination data could be used for other unintended reasons or data linkage, such as by immigration authorities, and precedents (e.g., commercial accessibility of registers, expanded state health surveillance) it may create.

6. Be based on a platform of interoperable technologies:
The technology must meet certain standards for interoperability (HL7 FHIR standards), which is the ability of systems to work together within and across organisational and technical boundaries to enable different information technology systems to communicate and exchange useable data.

7. Be secure for personal data:
A fair balance of data protection and privacy requirements must be considered, in particular to guard against the use of such a passport to track populations, and for unrelated additional scrutiny of already marginalised groups, for example by police, employers or health checks.

Health data – including vaccination records – are protected under the GDPR; these data must therefore be monitored, with technical and organisational measures to proactively deal with data transfers. There are potentially undesirable outcomes if vaccine status were used to compound already disadvantaged characteristics (e.g., age, ethnicity).

8. Be portable:
There needs to be clarity across multiple aspects such as biometric authentication, QR codes, card readers, or paper copies to provide flexibility for individuals and governments.

9. Be affordable for individuals and governments:
There must be sufficient resources to develop and sustain vaccine passports. If there are costs to acquiring a certificate or access issues, affordability needs to be considered.

10. Meet Legal Standards:
Certification needs to be consistent with various legal standard, including:

- international, regional and domestic human rights laws,
- data protection laws,
- equality and discrimination laws,
- COVID-19 legislation; and,
- labour, occupational health and safety laws, but considerations need to be weighed against duty of care and commercial freedom to act.

11. Meet ethical, equity and non-discrimination standards:
Core ethical concerns require further scrutiny including:

- testing whether vaccine passports are inclusive,
- have clearly defined uses and minimum data collection,
- appropriate sharing and who gains access to the information;
- where and how vaccine certification will be linked to other types of data; and,
- avoidance of discrimination and exacerbating existing inequalities (e.g., vaccine hesitancy in certain groups, pregnant women, differential roll-out or access, digital divide).

12. Have conditions of use that are understood and accepted by passport holders:
Ensure that individuals understand the utility of vaccine passports and monitor public acceptance and experiences. Unintended behavioural responses and resistance could arise if uses are not transparent, making it essential to monitor impacts on vaccine hesitancy, trust, incentives and responses and in communication strategies.

Contents

Annexe

1. Introduction

As vaccination coverage increases across the UK and globally, there is considerable focus on the control measures that would allow individuals to move freely, return to work or education, and travel internationally. Currently, the dominant control strategies are behavioural, non-pharmaceutical interventions (NPIs) including testing with isolation and contact tracing with quarantine; plus personal (physical distancing, face coverings, hand hygiene) and social protection (closure of businesses and schools, banning mass gatherings, travel restrictions). Another strategy of a control measure that has been proposed is vaccine certification in the form of vaccine passports. As the number of countries in Europe introducing vaccine passports continues to grow, coupled with pressure to resume international travel and return to pre-COVID conditions, scrutiny of the feasibility of vaccine passports is urgently required[1].

Vaccine passports are a certificate based on established proof of being vaccinated. They are a form of ID with one component consisting of data related to the vaccination (date, vaccine, place of vaccination, and so forth), linked to the identity of the holder. This differs from infection or immunity passports, which refer to tests that demonstrate negative infection status or immunity (e.g., viral RNA PCR (polymerase chain reaction) or viral antigen lateral flow tests). Theoretically, the aim of all such tests of infectiousness, immunity and vaccination, is to allow the return to school or work and for people to travel freely nationally and internationally without compromising public health. Currently negative PCR tests are used as a 'passport' for international travel. Given the continued roll out of vaccinations, it is valuable comparing tests of infection and immunity with vaccination as potential passporting devices and to evaluate whether they satisfy key criteria.

The aim of this rapid review is to evaluate the feasibility of using tests for infection and immunity (including vaccination certificates) as passports, considering biological, logistical, legal and ethical arguments; and with regard to international precedents and comparisons. We propose twelve essential criteria that a vaccine passport would need to satisfy, and consider whether these criteria have been or could be met, based on existing evidence.

2. Infectiousness, immunity and vaccine passports

A COVID-19 passport could serve two purposes, namely to certify that subjects (passport holders):

- are protected from illness so that they can carry out the activities for which the passport is needed, and to guarantee that they would not become an additional burden on health services; and
- cannot transmit SARS-CoV-2 infection to others (they are not or cannot become infectious).

Four different tests of infection and immunity could help to satisfy these goals. Although the four tests might be used in combination, this paper considers the strengths and weaknesses of each test separately. An ideal passporting test will have, above all, high predictive value, i.e. those who test positive or negative will be correctly identified. For instance, if the intention of the test is to certify that a person is immune to COVID-19 (protected from illness), then a positive test result should guarantee that immunity. Secondarily, such a test should also be sensitive, i.e. it would include all subjects who are immune. In other words, some people who are immune, and entitled to a passport, should not test negative.

The four tests and their performance characteristics are summarized as follows, and in Table 1.

In summary, Table 1 shows only two areas for high predictive value, which is the primary goal for a passport. Criterion 1a explains why a negative RNA (PCR) test is already used by some countries as a passport for international travel, certifying that a traveller is unlikely to be carrying a transmissible infection. Criterion 2b indicates that vaccination, rather than antibody testing, is most likely to satisfy the requirements of a passport with regard to protection from illness, but not necessarily protection from infectiousness.

With present knowledge about licensed COVID-19 vaccines, a vaccination certificate is currently an imperfect passporting tool. To place greater confidence in vaccine certification, more information is needed about (1) vaccine efficacy, particularly with regard to preventing infectiousness and SARS-CoV-2 transmission, including protection against genetic variants, and (2) the duration of protective immunity – both to illness and to becoming infectious – to determine how frequently a vaccine passport would have to be renewed. Data on both aspects is rapidly emerging from studies of genomics, immunity, infectiousness and vaccination. We have not explored in this paper the possibility of certification based on a combination of the four tests in Table 1.

Annexe

BOX 1

Desirable characteristics of passporting tests

1. Subject is not infectious

a. Viral RNA test-negative (PCR test). PCR is a highly sensitive method of detecting viral RNA[2]. A negative test result indicates that the subject is unlikely to be carrying the virus and, at the time of testing, is not infectious to others (negative predictive value >90%)[2]. However, a small proportion of subjects who test PCR negative could have acquired infection just before testing or could be infected just after testing; either way they would become infectious within a few days. However, as a passporting test, a negative result signifies that the subject is unlikely to be carrying a transmissible infection (green light in Table 1) but conveys no information about immunity. In addition, while a negative test result has high predictive value, it has lower specificity: PCR does not identify all non-infectious subjects because, in the later stages of an episode of COVID-19, the test can detect fragments of RNA among subjects who no longer carry transmissible virus. A further drawback is that, because PCR tests are carried out in laboratories, they deliver results relatively slowly, with a turnaround time of 1 – 2 days (cf 1b).

b. Viral antigen test-negative (lateral flow test). A negative antigen test (lateral flow test) does not guarantee that the subject is not infectious, especially for subjects with low viral load (low negative predictive value). Nasopharyngeal swab sampling requires skill, and swabbing by untrained individuals, including self-swabbing, can yield false negatives, missing infected and potentially infectious subjects. In partial compensation, a lateral flow test is unlikely to misclassify subjects who are truly non-infectious (it is a highly specific test), or subjects that are most infectious (it is sensitive for subjects with high viral loads). A positive antigen test (followed by isolation) has a role in preventing transmission, but in the context of certifying that a test-negative subject is not infectious, the main virtue of rapid antigen testing is speed, producing results on the spot within 10 – 30 minutes.

2. Subject is immune to Covid-19 illness and will not become infectious

a. Viral antibody test-positive (serological test). Quantitative studies suggest that antibodies generated by natural infection are associated with strong protection against illness (approximately 70 – 90% efficacy) for a least 6 months, but less protective against asymptomatic infection (approximately 20 – 60% efficacy), and may therefore be less effective in reducing infectiousness and transmission. With regard to developing a satisfactory passporting test, no standard antibody assay yet exists and there are no validated antibody concentrations that correlate with or signify protection, either against illness or infectivity. To the extent that antibody is associated with protective immunity, the duration of protection is unknown[3-5]. It may prove difficult to develop a reliable passporting test based on antibody alone because protective immunity depends on a diversity of B-cell and T-cell responses[6]. Moreover, immunity to reinfection with one strain of SARS-CoV-2 may not guarantee protection against other strains, including novel variants that are relatively transmissible and which are able to evade immunity. Antibody testing also demands significant laboratory capacity.

b. Vaccination (certificate). A growing number of clinical trials show that vaccines can provide a high level of protective immunity against COVID-19 illness (approximately 70 – 95% efficacy), even after a single vaccine dose[7]. Vaccines are likely to be less effective in preventing infectiousness and transmission, but there are presently limited data to determine how much less[8]. As for immunity induced by natural infection (2a), the duration of vaccine protection, either against illness or infectiousness, is not yet known. That duration depends on the waning of B-cell and T-cell responses after vaccination, and on the emergence of novel variants of SARS-CoV-2 that may be able to evade vaccine-induced immunity, at least partially[9-12]. The rate at which immunity wanes, and the rate at which SARS-CoV-2 escape mutants emerge, will influence the types of vaccine that can be used and certified in any locality, and the how often vaccination certificates would need to be renewed. An additional question is whether passports could be taken away, potentially at short notice and if so how.

BOX 1 (CONTINUED)

TABLE 1

Four types of passporting test, with desirable test outcomes (negative or positive), for two main attributes of each test (primarily, positive and negative predictive value; secondarily, sensitivity for positive tests or specificity for negative tests). Colours summarize the current performance of each test, ranging from low (red) to high (green).

Type of passport/test	Test to prevent	Test outome	Primary goal: predictive value (+ or -)	Secondary goal: Sensitivity (+) or Specificity (-)
1a RNA test	Infectiousness	Negative		
1b Antigen test	Infectiousness	Negative		
2a Antibody test	Illness	Positive		
	Infectiousness	Positive		
2b Vaccination	Illness	Positive		
	Infectiousness	Positive		

Predictive value (+ or -): test+ is a true+, test- is a true-
Sensitivity (+): test- excludes true+
Specificity (-): test+ excludes true-

KEY
Low Medium High N/A

3. Vaccine certificate and credential initiatives

Vaccine passports are portable documents that would record which vaccines have been provided and when any additional boosters may be required. They would be ideally designed to be held by the individual and updated by primary or secondary care providers of vaccinations.

3.1 Precedents: The Yellow Card

A COVID-19 vaccine certificate or vaccine passport would indicate vaccine status similar to the so-called Yellow Card or International Certificate of Vaccination or Prophylaxis (ICVP)[13], where the WHO works as trusted intermediary enforcing vaccine protocols[14]. In many countries globally, individuals are required to provide a ICVP certificate before entry[13]. Yellow fever is the currently the only disease that is expressly listed in the International Health Regulations that countries can require proof of vaccination from travellers as a condition of entry[15]. This is in addition to any recommendation concerning vaccination or prophylaxis, with additional recommendations possible for specific emergencies. The paper-based Yellow Card, however, has little protection against alteration or forgery, does not incorporate digital technology nor have verifiable link with the holder[16].

Multiple initiatives are currently being developed around the world in the form of digital health passports building on existing digital identity technology, including mobile phone applications (Apps), QR codes or electronic bracelets. Although not exhaustive, a list of some of the most prominent initiatives are listed below. For updated information, readers can refer to a tracker produced by the Ada Lovelace Institute in the UK that monitors international vaccine passports and COVID-19 status apps[17].

3.2 Overarching international initiatives

Although various countries in Europe have started to introduce their own systems, it is essential to support and align with a global vaccine passport program. This requires a set of common rules and common verification systems, to avoid what one former Prime Minister, Tony Blair noted could otherwise be 'chaotic and difficult to manage[1].' There are several international and industry-based initiatives, with details of each provided in Appendix 1. The World Health Organisation has initiated a Smart Vaccination Certificate. This fits with its mandate to coordinate member states to provide a public health response to the international spread of diseases. The WHO does not support 'immunity passports', given the lack of knowledge of the duration of immunity[18]. However, they piloted 'e-vaccination certificates' with Estonia in 2020[19], and in late 2020 issued a call for experts to contribute to the Smart Vaccination Certificate, with first meetings in January 2021[20]. In this call they note that they will focus on "establishing key specifications,

standards, trust framework for a digital vaccination certificate to facilitate implementation of effective and interoperable digital solutions that support COVID-19 vaccine delivery and monitoring, with intended applicability to other vaccines." We discuss the related Common Pass and COVID-19 Credential Initiatives in the next section that addresses technical aspects of this system.

3.3 Country-based initiatives

A regularly updated monitor of vaccine passports and COVID-19 status apps can be found elsewhere[17], with a selective and concise summary in Appendix 2. The majority of initiatives are in relation to travel, with an increased international move to use them to allow people to attend cultural or sporting events, eat at restaurants, not quarantine when coming into contact with a COVID-19 positive person and debates in relation to employment.

In the United Kingdom, immunity risk certification was introduced initially in April 2020 as the sixth pillar of the UK Government's contract tracing plan[17]. As with other nations, the uncertainties and insufficient evidence around antibody test results and use of serological testing resulted in a stepping back from this position. It was reported on 24 January 2021 that Innovate UK had granted eight projects a total of £450,000 to conduct feasibility studies developing vaccine passports and COVID-19 status apps (see Appendix 2 for detail)[21]. At the time of writing no official message regarding their usage is available.

As part of United States President Biden's national pandemic strategy announced on his first full day in office, there is a directive for multiple government agencies to collaborate and asses the feasibility of linking COVID-19 vaccinations to international vaccination certificates and to generate electronic certificates[22]. A variety of countries have already introduced or announced that citizens will be provided with an official confirmation of vaccination via a government eHealth Portal (Denmark[23]). Others have confirmed that vaccine passports can be used via a vaccine QR code on an App that is valid at travel borders (Iceland[24]) but also linked to dropping the need to quarantine (Estonia[23]) and even easing restrictions related to socialisation and movement (Poland[25]). Israel issued a 'green passport'[26] and Poland a QR Code or printed document[25], with both countries allowing those who with proof of vaccination to attend events, eat at restaurants, not be obliged to quarantine and travel abroad. India is developing DIVOC, a system to manage digital vaccination credentials[27].

In December 2020, the European Commission Health Security Committee discussed cross-border verifiable COVID-19 vaccine certificates with mixed opinions over whether they should be provided for medical reasons only or also for travel[28]. In December 2020 and in response to a letter from Greek Prime Minister Kyriakos Mitsotakis, President of the European Union Commission, Ursula von der Leyen provided support to create a common EU vaccination certificate to facilitate travel within the European Union[29].

The German Ethics Council recommended against exceptions for those vaccinated for reasons that it would be unacceptable to wider society, risk further spread until more knowledge is acquired about the transmission of the virus[30]. They further recommended that after lockdown, businesses should be legally entitled to ask customers for proof of vaccination, which should not apply to those offering essential goods and services. In the Netherlands, there has been considerable discussion over potential discrimination, privacy and human rights and the legal and ethical issues discussed in the next section. The Health Council (Gezondheidsraad) has stated that it would be possible for businesses, health care centres and schools to ask for proof of vaccination, but only if there they have clear reasons and there is absolutely no other possibility[31]. The Health Council suggested a spectrum of options for the government from: advice to implement vaccine passports, to 'nudging' the public in that direction, to making it strictly necessary.

In Spain, there has been considerable legal and public controversy over vaccination passports or cards, starting in 2020 with the Spanish Data Protection Agency ruling against employers asking about antibodies of prospective employees and concluding that all information about antibodies must be excluded during hiring[32]. A pilot in Madrid to simulate an international vaccination card that would allow people to enter gyms, bars and museums was abandoned due to critiques from rights groups, health experts and politicians[33]. There was also considerable national debate in Israel as to whether this technology could also be used by the private sector, with current uses now only allowed by the Ministry of Health[26]. Others, such as China have introduced Apps that also link QR codes to travel history, which has been critiqued in relation to human rights[34].

Annexe

4. Technical considerations

4.1 Systems for Verifiable Credentials and Standards for Interoperability

There are various options to create a system for identification and monitoring of vaccine passports, with only a brief non-technical overview provided here. For digital vaccine passports, there is the need for digital access to vaccination records. One option is via SMART (Substitutable Medical Applications, Reusable Technologies) Health Cards, which manage the privacy of patient identity and give access to certain groups (e.g., health practitioners, pharmacists, travel officials). One way to verify these credential is through W3C (World Wide Web Consortium) Verifiable Credentials, which is an international community of member organisations and staff that work together to develop Web standards. Credentials and cards are used in many other areas including driver's licenses. The W3C specification provides a mechanism to communicate these credentials on the Web that is cryptographically secure, respects privacy and is machine-verifiable[35].

The technology must also be interoperable and meet certain standards for interoperability, which in this case are the HL7 FHIR standards. Interoperability in this context refers to the ability of systems to work together within and across organisational and technical boundaries to enable different information technology systems to communicate and exchange useable data. HL7 refers to a standard created by the Health Level Seven International (HL7) health-care standards organisation[36]. It has produced the FHIR standards which refers to Fast Healthcare Interoperability Resources (FHIR), which are standards that describe data formats and elements and an API (application programming interface) for exchanging electronic health records. A central goal of these standards is to facilitate interoperation or in other words to provide health care information to providers and individuals on a variety of devices including computers, tablet, apps on phone and to allow third-party application developers (i.e., Apps) to easily integrate into existing systems. For vaccine passports these systems could allow individuals to obtain an encrypted digital copy of their immunisation credentials to store in a digital wallet that is interoperable.

4.2 Verifiable Credentials and Standards for Interoperability

Two inter-related international projects are of note, which is firstly, the Common Pass from the Commons Project, from a Geneva-based non-profit company working with the World Economic Forum to create a digital health pass which has been trialled on flights between Hong Kong, Singapore, London and New York[37]. The 'Common Pass' works via an App that allows the upload of medical data, including COVID-19 test results and vaccination records that can then be displayed as a QR code and shown to authorities without releasing sensitive personal information. The network has now also partnered with large airlines and hundreds of health systems (see Appendix 1)[38].

The second relevant project is the COVID-19 Credentials Initiative, led by the Linux Foundation. This initiative, launched on 14 January 2021, includes multiple health and technology companies with the aim to allow digital access to vaccination records using the SMART Health Cards Specification, based on W3C Verifiable Credential and HL7 FHIR standards. This would allow individuals to obtain an encrypted digital copy of their immunisation credentials to store in a digital wallet that is interoperable with privacy-preserving verifiable credential projects[39].

Other initiatives detailed in Appendix 1 include a variety of industry initiatives including Microsoft's Smart Health Cards Framework[40], IBM's Digital Health Pass[41], specifically aimed at employers to provide individuals a privacy-preserving way to share their vaccination and health status[42], Apple and Google[43], IATA (International Air Transport Association) Travel Pass Initiative[44], CLEAR (www.clearme.com/healthpass), AOK (www.aokpass.com) or WISeKey[45]. IATA is a trade body representing 290 airlines and the bulk of global air traffic and the IATA Travel Pass app would allegedly show COVID-19 test results, proof of vaccination and natural entry rules and link to an electronic copy of the holder's passport for personal identification[46].

4.3 Technical challenges to certification

Although not exhaustive, several core technical challenges emerge in introducing digital vaccine passports, which are:

- **Forms and forgery.** Since paper documentation is vulnerable to forgery, electronic documentation such as an integrated app would be more efficient, also for retesting.
- **Beyond digital versions only.** But, the COVID-19 Credentials Initiative acknowledges that there are many individuals globally that do not have access to smartphones and thus traditional paper vaccine certificates and an online version that can be stored, reproduced in parallel, and are resistant to forgery, need to be developed.

- **Broader use of Apps and attention to privacy.** As discussed in a later section, there is a danger that if QR codes on smartphones are used to enter buildings, restaurants or for other tracking reasons, there are risks to privacy, and to public compliance and acceptability. Apps record multiple aspects such as locations, mobility history, body temperature, and so forth, meaning that privacy has to be at centre in development and communications or these technologies could fail.
- **Identity proofing.** Pre-registration has been shown as very useful if through a combination of websites, Apps, WhatsApp and SMS. This has been used in what has been called a remarkable success of digital application processes for COVID-19 relief programmes in Pakistan, Namibia, Togo and South Africa[47]. Others have noted that over one billion people do not have a foundational ID, with half of these being children who without a registered birth[48].

5. Legal, ethical and behavioural considerations

The introduction of vaccine and any digital health passports raise multiple legal questions across a spectrum of human rights, data privacy, domestic, equality, COVID-19 and labour laws. As noted previously elsewhere, this is due to the fact that vaccine passports use sensitive personal information, create a distinction between individuals based on health status, and could potentially be used to determine the degree of freedom or rights of individuals[51].

The overview provided here is not exhaustive, but rather gives a brief summary of initial and obvious considerations. As with the other sections in this report, these aspects are covered briefly and need detailed expert scrutiny. Although in this section we adopt a largely human rights and data protection perspective, such considerations need to be weighed against duty of care and commercial freedom to act. The rights and freedoms afforded to individuals does not provide them with the freedom to potentially harm others. An analogous comparison is unsafe sex and the need for interventions to prevent sexually transmitted diseases[49].

We also recognise that there are different criteria that can be used for judging legality. Below we briefly present the assessment of legality often using a human rights and data protection criteria lens, but acknowledge that this is not a detailed assessment of legality on these grounds. In some cases, human rights law incorporates data protection laws, but there may be extra safeguards in data protection law that need to be acknowledged.

5.1 UK relevant legal frameworks

Others have explored the legal implications of vaccine passports for data privacy and human rights law in the UK[50], but more detailed peer reviewed evidence is required specifically in relation to COVID-19 passports. In the UK, some of the relevant legal frameworks in the context of which to consider vaccine passports are as follows:

- **International human rights laws,** including in particular the International Covenant on Civil and Political Rights (ICCPR), the International Covenant on Economic and Social and Cultural Rights (ICESCR), as well as the many other international agreements on rights to which the UK is a party.
- **Regional human rights law,** in particular the European Convention on Human Rights and Fundamental Freedoms to which the UK is a signatory and the rulings of whose court (the European Court of Human Rights) it is under an international law duty to implement.
- **Domestic law,** in particular the Human Rights Act 1998, enacted to bring into domestic law the rights to be found in the European Convention on Human Rights.
- **Data protection laws,** guaranteed by the General Data Protection Legislation Regulation (GDPR), implemented in the UK by the 2018 Data Protection Act.
- **Equality and discrimination laws,** which in the UK are now principally to be found in the 2010 Equality Act.
- **COVID-19 legislation** of primary and secondary legislation in England, Scotland, Wales and Northern Ireland[51].
- **Labour laws, occupational health and safety** regulations have also recently entered the discussion in relation to employers.

We also note that there are multiple other factors to consider that we do not consider in this rapid review. For instance, Scotland has a separate legal system and must therefore have its own framework.

5.2 Data protection and privacy requirements

Health data is protected under the GDPR as implemented in the UK 2018 Data Protection Act (Article 9), which includes vaccination records. Given that vaccine passports contain sensitive personal information, they must be compliant with GDPR (Article 5) principles of lawfulness, fairness and transparency, purpose limitation, data minimisation, accuracy, storage limitation, integrity, confidentiality and accountability[50]. In the UK, this is monitored by the Information Compliance Office (ICO) and data protection must be built into the technologies.

Annexe

On 18 June 2020, the Spanish Data Protection Agency issued a warning that immunity passports were a violation of data protection regulations, and that employers could not ask job candidates whether they had COVID-19 antibodies since it is personal data related to health[32]. They also noted that companies needed to delete any information that referred to antibodies in job applications so that it did not influence hiring decisions. The extension of this concern for hiring in relation to vaccine status seems plausible and would need to be tested and debated.

From a human rights perspective, confidentiality of personal health data is a relevant principle of the ECHR (article 8) to protect privacy of individuals but also consideration of undesirable or unintended outcomes if vaccine status inadvertently compounded already disadvantaged characteristics (age, ethnicity, gender)[51]. Legal data protection and privacy requirements need to be considered in relation to respect to private lives, which includes the protection of personal health information and biometric data. With the ECHR, the state cannot arbitrarily interfere with private life[51]. As noted: "restricting the right to privacy must safeguard one of the legitimate aims enumerated in Article 8, paragraph 2 of the ECHR. These include 'the protection of health' and 'the economic well-being of the country'[51] (see page 9). We note that there may be others that are justifiable, but these are likely the most relevant. This also needs to be tested by legality, necessity and proportionality. As has been argued: "a fair balance must be struck between the competing public and private interests at stake[51] (see page 9).

A broader ethical concern is that electronic vaccine passports could be used to monitor individuals' movements or their health status. This is an obvious human rights point of extreme concern that has considerable Strasbourg case law to back it up[52]. In China, for instance, an App is scanned by authorities and indicates health status and travel history, with considerable discussion about privacy concerns given that this App appears to send personal data to police[34]. If vaccine passports were linked to rights or used to track populations, already marginalised groups could potentially be subject to more scrutiny such as by police, employers or health checks on vaccine status[53].

5.3 Protection of rights and freedoms

A prominent concern is that the lack of holding a vaccine passport could limit individual freedom on the basis of biological risk and thus inadvertently increase discrimination or inequality and restrict human rights. The state and law must also guarantee legal rights and freedom of movement, assembly and to manifest one's religion or beliefs and the right to equality and non-discrimination[50]. When considering these aspects, ECHR and HRA are the relevant legal instruments to consider. Freedom of assembly and meeting or assembly of a religious nature are protected under ECHR, with the protection of health potentially viewed as a legitimate aim that may be adopted to restrict these freedoms[51].

The state and law could conceivably restrict or promote the exercise of these freedoms. If for instance, individuals are required to show their vaccine passport to enter into particular public or private spaces (e.g., work, restaurant, museum), unless there are exceptions to the vaccine passport, some individuals may be restricted based on their health status. Similar to immunity passports, vaccine passports could risk undermining the health of individuals since it would also discriminate against the realisation of social and economic rights of some individuals who are not vaccinated[54]. It has been argued that these measures also need to protect the rights and freedoms of those who may not have COVID-19 or have been vaccinated to avoid restricting the movement of the entire population[55].

Where potential issues and problems will arise is if vaccine passports are suggested as 'optional', but individuals are barred or cannot go anywhere without them. A legal challenge to airport full body scanners is a historically analogous comparison. Here the discussion was that they might breach an individual's right to privacy and have a negative impact on privacy, and in particular disabled, elderly, transgender individuals, and children[56].

5.4 Equality and Non-discrimination

ECHR recognises the right to equality and guarantees against discrimination, with the 2019 UK Equality Act outlining protection on equality and the right to non-discrimination on multiple grounds (e.g., age, disability, marriage and civil partnership, race, religion, sex, sexual orientation). Vaccine passports would impact this protection if they structurally exclude a segment of the population.

One of the most prominent arguments against the introduction of vaccine and immunity passports is the risk that they will exacerbate existing structural inequalities[53,54,57,58]. The UK's Nuffield Council on Bioethics focussed on the ethical risks of immunity passports and argued they could exacerbate structural disadvantage and social stigmatisation and had the potential to generate coercive work environments[57]. These concerns are also central in the German Ethics Council response[30].

Further scrutiny is required to clarify a public versus private distinction. Human rights law usually protects only from state and not private action, whereas other laws go much wider. Another concern is that vaccine passports could be used for structural discrimination by employers or for access by insurance companies, employers, restaurants, health care centres, or housing applications. As some have noted in related to immunity passports, this could result in individuals being excluded from social, civic and economic activities or compound existing gender, ethnicity and nationality inequities[54]. As the next section elaborates, there is a concern about the vaccine capital of the workforce. Access issues also need national and international regulations and clarity. Recently, the over 50s holiday and insurance group Saga, which runs Cruise Ship operations, has said vaccines will be mandatory for customers[59]. Here further scrutiny is required of the possibility of consenting to breaches of human rights. The majority of crew on these ships, however, are from the Philippines so it is unclear if they can make it mandatory for passengers, crew or both or whether requiring crew to quarantine for 2 weeks before employment is a plausible solution.

Others have raised concerns about how mandatory proof of vaccination impacts different groups in relation to immigration. New York Governor Andrew Cuomo argued that vaccine records could be at a risk to fall into a federal US database that may be accessible to immigration authorities to use beyond the initial intended reasons[60]. In the UK, there was concern that the estimated 1.3 million illegal immigrants would not come forward to be vaccinated due to fears of deportation[61]. Since in the UK many of these individuals are not registered at doctor's offices, where many of the vaccinations take place, they will potentially remain relatively invisible but also be disproportionality impacted. Another question is under what conditions passports are mandatory. If they are introduced to regulate access to schools, employment, public spaces and travel it is plausible that certain groups may be disadvantaged, though this needs to be considered against the groups who may otherwise not be protected.

5.5 Labour and health and occupational safety laws

There is still considerable debate over the role of labour, health and occupational safety laws in relation to vaccine passports. London's Pimlico Plumbers recently announced a 'no jab – no job' rule[62]. They noted that they would rewrite worker's contracts to require them to have a vaccination and that the company would pay for private vaccinations. Whether there will be legal issues is still under discussion, namely that employees could claim unfair dismissal or a discrimination claim[63].

In Australia, two leading labour law experts stated that businesses would have the power to compel staff to get vaccinated as 'lawful and reasonable' directions to employees. The law, the experts note, however has not been formally tested in court[64]. Another extension is that employers need to fulfil employment health and safety responsibility, which could include vaccinations. Requiring employees to be vaccinated could be required to satisfy obligations for the safety of other employees. Those with allergies could be excluded but other legal tests would likely also arise such as whether holding anti-vaccination beliefs is a legitimate health reason or is discrimination on the grounds of a political belief. This requires a full legal analysis which is outside scope of this report, but we note may arise. Here the discussion will also arise of whether employees could be dismissed from social care or childcare or other vulnerable individual settings if they refused to be vaccinated. Care worker Maria Glover filed an unfair dismissal after she refused to have her mandatory influenza shot due to allergies[63]. Some employers might also offer incentives to their workers to be vaccinated (free TV, paid time off work), which could risk claims under the Equality Act.

5.6 Ethical concerns

Legal and ethical concerns are interrelated, as noted in the previous sections. Before introducing vaccine passports, some core ethical concerns need further scrutiny. Many of these aspects are broader and relate to overarching principles of Sustainable Development including universal access, robustness, trust and data minimisation and recognition of variation across country systems[16].

First, as noted in the draft principles of the WHO consortium, any certification should be inclusive; everyone has the right to obtain and hold a vaccination certificate[17]. There has already been considerable concern over differences in vaccination levels across countries and different communities. If everyone does not have access to an effective vaccine, any situation or system that requires a vaccine passport for entry or service would be unfair. If it takes a longer period of time for vaccinations in certain groups or areas of the world and it is tied to uses such as international travel, freedom of movement could be restricted for some.

Second, there should be clearly defined uses and minimum data collection. As noted in the WHO principles, only data related to vaccinations should be required[17]. In relation to this, clarification and further scrutiny is necessary to determine whether vaccination passports will be used as part of a new system for digital identity schemes or whether it creates any future precedents, such as the commercial accessibility of registers, expanded state health surveillance, which is a concern of some privacy organisations[65]. Third, appropriate sharing and who gains access to the information on vaccine passports and how they will use it must be clearly determined, including clarification for international travel, employers, access to services and public spaces. Finally, clarity is required about where and how vaccine certification will be linked to which types of data.

Although not exhaustive, some examples of ethical concerns of how vaccine passports could result in potential discrimination and exacerbate existing inequalities is if there is:

- higher vaccine hesitancy in certain ethnic minority and lower socioeconomic groups, with certain groups disproportionately less likely to hold a vaccine passport[66,67];
- clinical trials that have not taken place in certain groups (e.g., pregnant women), with the decision to vaccinate shifted to individual risk choices. If a pregnant woman decides to postpone vaccination, for instance, they may face discrimination;
- an individual or group unable to access vaccines and thus not use their vaccine passports, restricting multiple rights such as travel, cross-border employment, attending gatherings or religious meetings; immunocompromised populations including those on immune suppressant drugs who are not vaccinated and subsequent lack of clarity in relation to certification;
- geographic, financial or distribution-related inequalities such as due to a shortage of vaccines or unequal roll out, or vaccines are provided on a commercial or cost basis;
- a group or groups unable to take time off of work, afford or have the ability to travel to reach vaccination locations[67,68];
- access issues if individuals need to apply digitally for the certificate or the process is not accessible to the entire population (e.g., disability issues, technology access);
- vaccine passports that are exclusively digital, exacerbating the digital divide for the elderly or those without digital devices;
- globally, a disparate timing in vaccine roll-out and ability of different nations to secure vaccine supplies, creating a segregated society or world into the 'vaccine-privileged' versus 'vaccine-deprived'[68].

5.7. Behavioural responses and historical lessons

There are various historical studies examining the introduction of vaccine certificates such as in the nineteenth Century, for yellow fever New Orleans, Louisiana. There the population was divided into the 'acclimated' who had survived yellow fever and those who had not and resulted in the stratification of society upon highly unequal ethnic and socioeconomic lines[69]. The Vaccination Act of 1840 introduced in the UK made vaccination compulsory for all infants and parents liable to a fine or imprisonment. Due to public protests and concern over infringement on personality liberty and choice, a Royal Commission concluded in 1896 opted to abolish penalties and need for proof to allow parental vaccine exemptions for their children based on conscience, which was when the concept of 'conscientious objector' was introduced into English law[70].

Another relevant area of the literature is on vaccine hesitancy, described in detail in a previous Royal Society SET-C report[67]. Given increases in parental vaccine hesitancy, for instance, Italy and France introduced mandatory vaccination in a 'no jab, no school' policy in 2017 and 2018, respectively[71]. South Australia also forbade enrolment of unvaccinated children in kindergartens and day care in the 'no jab, no play' policy[72]. Whether these types of measures would be introduced and the public response is essential to consider, also in light of considerations such as the Gillick competence.

Annexe

Attention also needs to be placed on individual's level of trust and acceptance of vaccination certificates, but also concerns of how the vaccine passport data might be linked to access or other types of data and the precedents that it sets. Recent public responses to the test, trace and isolate Apps are obvious areas to learn from. The initial digital contact tracing app built in the UK, for instance, raised concerns about government surveillance and collaborations between NHSx and the private sector in relation to privacy, data collection and sharing[73,74]. A study of public attitudes towards the COVID-19 contact tracing app in the UK found that those who stated they would not use it had concerns over privacy and stigma compared to those stating they would use it holding the view that it would support the 'greater good'. One of the largest misconceptions was that the App could allow users to identify COVID-19 cases amongst their own contacts and their geographic vicinity[75]. Other examples include the public's concern about the track record of such technologies. There has been a lack of interoperability of recent systems, such as Europeans seeking settled status in the UK only able to upload their passport data using an Android phone[76].

Public understanding and trust can have potentially serious backlashes on any public health intervention. In Kenya, a system that was planned to link HIV/AIDS treatment to biometric data in form the thumbprints was halted after a public campaign. The information was planned to be stored and then connected to personal information on key populations in the country. Here the concern was that the data might be used for other purposes and potential data breaches[77]. Learning from this literature and behavioural responses will be key when considering vaccine certificates.

6. Recommendations: 12 Essential Criteria of Vaccine Passports

The aim of this rapid review was to evaluate the feasibility of vaccine passports considering multiple dimensions of infectivity and immunity in addition to logistical, legal and ethical arguments; with regard to international precedents and comparisons.

Bringing these multiple perspectives and bodies of evidence together, we propose 12 essential criteria of vaccine passport.

A passport should:

1. **Meet benchmarks for COVID-19 immunity.** Certification would need to demonstrate that passport holders are: (1) protected from illness; and, (2) cannot become infectious and transmit SARS-CoV-2 to others.
2. **Accommodate differences between vaccines in their efficacy, and changes in efficacy against emerging SARS CoV-2 variants.** As the virus, variants and vaccines may change, the certification system needs to have in-built resilience to allow for multiple vaccines, duration of immunity, different responses to variants and efficacy levels.

It should be:

3. **Internationally standardised.** Certification needs to be linked internationally with the WHO's Smart Vaccination Certificate, based on verifiable credentials and standards and internationally agreed upon key specifications, standards, trust and that is effective and interoperable.

With:

4. **Verifiable credentials.** Verification needs to be possible on and offline, be portable within and across borders, with common global standards, determination of who accesses immunisation records, and be able to confirm that data is accurate and not falsified. Around the world vaccine registries are in different forms and have coped at different levels with digitalisation and technical change. Many countries have had mixed success in developing and implementing their own test, trace and isolate or other Apps and need to learn from these experiences.

For:

5. **Defined uses.** Clarity on how and where the vaccine passport will be used such as travel, work, leisure activities, medical or employment. If businesses require customers to provide proof of vaccination, this should exclude all essential goods and services. Also tests of unintended uses should be considered including for immigration purposes or tracking of populations.

Annexe

And based on:

6. **A platform of interoperable technologies.** Integrated systems are required that can handle data, privacy, and security issues but also offer interoperability. The Common Pass and COVID-19 Credentials Initiative are promising digital solutions that use a QR code without releasing personal sensitive information.

A passport should be:

7. **Secure for personal data.** There is a need to generate a digital manifestation (e.g., QR code), certificate or online system individuals can log in to, that privately links to identification data, but also lists vaccine manufacturer and dosage information, where vaccination occurred and who administered it.
8. **Portable.** There needs to be clarity across multiple aspects such as biometric authentication, QR codes, card readers, or paper copies to provide flexibility for individuals and governments.
9. **Affordable for individuals and governments.** There must be sufficient resources to develop and sustain vaccine passports and clarity of costs to the individual.

It should meet:

10. **Legal standards.** Needs to be consistent with: (1) international, regional and domestic human rights laws, (2) data protection laws, (3) equality and discrimination laws, (4) COVID-19 legislation; and, (5) labour, occupational health and safety laws.
11. **Ethical, equity and non-discrimination standards.** Core ethical concerns require further scrutiny including: (1) testing whether vaccine passports are inclusive, (2) have clearly defined uses and minimum data collection, (3) appropriate sharing and who gains access to the information; (4) where and how vaccine certification will be linked to other types of data; and, (5) avoidance of discrimination and exacerbating existing inequalities (e.g., vaccine hesitancy in certain groups, pregnant women, differential roll-out or access, digital divide).
12. **Conditions of use that are understood and accepted by passport holders.** Ensure that individuals understand the utility of vaccine passports and monitor public acceptance and experiences. Unintended behavioural responses and resistance could arise if uses are not transparent, making it essential to monitor vaccine passport usage on vaccine hesitancy, trust, incentives and responses. Clear and consistent communications are particularly relevant in this domain.

We conclude that vaccine passports are feasible given that the 12 criteria listed above would be satisfied and that current evidence and precedents suggest that they could be satisfied. However, we note that not all criteria have been met to this point and we need to consider what longer term precedents this may create beyond COVID, related to other aspects such as inequality, discrimination, fraud and political implications.

Annexe

Appendix 1. International and Industry-based Certificate Initiatives

World Health Organisation: Smart Vaccination Certificate. The WHO has a mandate to coordinate member states to provide a public health response to the international spread of diseases, so has taken a primary role. Although the WHO has opposed 'immunity passports', given the lack of knowledge of the duration of immunity[18], they piloted 'e-vaccination certificates' with Estonia[19]. In October 2020 Estonia worked with the United Nations to pilot a 'smart yellow card' to test data tracking for the WHO COVAX initiative to focus on vaccinations in the global south. On December 2 2020 the WHO also issued a called for experts to contribute to the Smart Vaccination Certificate, with first meetings planned in January 2021[20]. In this call they note that they will focus on "establishing key specifications, standards, trust framework for a digital vaccination certificate to facilitate implementation of effective and interoperable digital solutions that support COVID-19 vaccine delivery and monitoring, with intended applicability to other vaccines."

Commons Project: Common Pass. The Commons Project is a Geneva-based non-profit company working with the World Economic Forum to create a digital health pass which has been trialled on flights between Hong Kong, Singapore, London and New York[37]. The 'Common Pass' works via an App that allows the upload of medical data, including COVID-19 test results and vaccination records that can then be displayed as a QR code and shown to authorities without releasing sensitive personal information. As they note: "The CommonPass framework will allow individuals to access their lab results and vaccination records, and consent to have that information used to validate their COVID status without revealing any other underlying personal health information[37]." These records can be accessed through existing health data system, national or local registries or personal health records. The network has now also partnered with large airlines such as Lufthansa, United Airlines, Virgin Atlantic and Cathay Pacific and hundreds of health systems across the United States and the government of Aruba[38].

COVID-19 Credentials Initiative. Launched in April 2020 by a group of technologists building on W3C Verifiable Credentials (VCs) prior to COVID-19, CCI is an open global community of over 400+ participants looking to deploy and help deploy privacy-preserving Verifiable Credential projects in order to mitigate the spread of COVID-19 and safely reopen. CCI was adopted in December 2020 by Linux Foundation Public Health (LFPH), a project of the Linux Foundation, working with public health authorities (PHAs), healthcare organizations, technology vendors, academia, industry associations, and the public to ensure that investments into public health technology meet common needs and have maximum impact. LFPH:CCI is working to advocate the use of VCs as the suitable technology for COVID-19 credentials and to facilitate data and technical interoperability of VCs for these use cases. The goal of LFPH:CCI is to build open-standard-based open source codebases (e.g. basic issuer app, basic verifier app, and user wallet with basic functionalities) that provide minimal viable components for PHAs and industries so that they can work with their solution providers to contextualize easily, cost-effectively without interoperability headaches and privacy and security concerns.

Microsoft's Smart Health Cards Framework. Large companies have also started their own initiatives such as Microsoft's 'Smart Health Cards Framework' that would allow individuals "to store and manage their own COVID-19 vaccination or laboratory records, and present these records to another party in a verifiable manner[40]."

IBM Digital Health Pass. IBM has developed a Digital Health Pass which could be used by companies and venues to customize what information they require such as COVID-19 tests, vaccination records or temperature checks. These credentials are sent in the form of a QR code to a chosen mobile wallet.[41] This initiative announced on 25 August 2020 is seen as part of workplace management to share vaccination and health status of employees, customers and visitors to a company their vaccination and health status via a smartphone. On 18 December 2020, IBM also integrated it into their Salesforce's Work.com system[42]. Here the explicit aim is "to help organizations as they strive to safely reopen in the wake of COVID-19 and provide individuals with a privacy-preserving way to share their vaccination and health status[42]."

Apple and Google. Although not on the public domain, other large companies such as Apple and Google will likely join these initiatives. Given that these companies have deep experience with privacy issues surrounding other health apps, there is considerable expertise to draw upon. For instance, Apple allows people to download their immunisation and medical records to their devices in some areas if their providers have agreements with Apple[43]. As of January 25 2021, there are limited healthcare institutions globally that allow this mostly the United States, some in Canada and two in the UK (Oxford and Milton Keynes)[78].

Additional initiatives. There are also many other initiatives including the IATA (International Air Transport Association) Travel Pass Initiative[44], CLEAR (https://www.clearme.com/healthpass), AOK (https://www.aokpass.com/) or WISeKey[45]. IATA is a trade body representing 290 airlines and the bulk of global air traffic. It has been reported that the IATA Travel Pass app would show COVID-19 test results, proof of vaccination and natural entry rules and link to an electronic copy of the holder's passport for personal identification[46].

Annexe

Appendix 2. Current International Initiatives for COVID-19 Vaccine Passports

Currently prominent international initiatives for vaccine passports include:

- The **European Union** has made multiple negative statements about immunity passports since May 2020 of last year[17]. On 7 December 2020, the European Commission Health Security Committee discussed cross-border verifiable COVID-19 vaccine certificates[28]. Opinions were mixed, with some representatives in favour of a vaccine certificate at a European or global level, enabled by the WHO. There is considerable debate over whether interoperable vaccination certificates should be provided for medical reasons only, or also for travel. In December 2020 and in response to a letter from Greek Prime Minister Kyriakos Mistsotakis, President of the European Union Commission, Ursula von der Leyen provided support to create a common EU vaccination certificate to facilitate travel within the European Union[29].
- The **African Union** commission and Africa Centres for Disease Control and Prevention (African CDC), introduced My COVID Pass tool, which will include COVID-19 test results, vaccination certificates for yellow fever and COVID-1980.
- **India** is developing DIVOC, to aid in the rapid rollout of digital credentials for vaccination programs, which manages core registries to support vaccination credentials and collect vaccination feedback from citizens[27].
- In the **United Kingdom**, immunity risk certification was introduced initially in April 2020 as the sixth pillar of the UK Government's contract tracing plan[17]. As with other nations, the uncertainties and insufficient evidence around antibody test results and use of serological testing resulted in a stepping back from this position. It was reported on 24 January 2021 that Innovate UK had granted eight projects a total of £450,000 to conduct feasibility studies developing vaccine passports and COVID-19 status apps[21]. Some of these include trialling of digital vaccine passports with local public health directors to Mvine, a cybersecurity company and iProov, a biometrics company[80]. Other projects include a decentralised digital COVID-19 credentials system (Enduring Net), QR-code-based digital and physical certificates of negative test results, antibody testing and proof of vaccination (The Hub Company), accreditation platform with vaccination certificates and health passports for the global sporting and events industry (EAS Technologies), use of facial biometrics to proof immunity status (Eyn Limited) and Logifect (post-vaccination immunity passports).
- In the **United States**, President Biden's national pandemic strategy announced on his first full day in office in January 2021, there is a directive for multiple government agencies to collaborate and asses the feasibility of linking COVID-19 vaccinations to international vaccination certificates and to generate electronic certificates[22].
- In **China** the Alipay Health Code App provides users a colour-based QR code that can be scanned by authorities and indicates health status and travel history[34].
- In **Denmark**, the government announced that by the end of February 2021, Danish citizens will be able to access a health website that has official confirmation on whether they have been vaccinated and noted that they will later evaluate a digital passport[23].
- **Estonia** has various initiatives including advanced multiple pilots, including one with the WHO. Using a state-issued Estonian ID, individuals can share information using a QR code that expires after an hour. As of 2 February 2021 passengers who arrive in Estonia and can prove vaccination (with when vaccine was made, used, issuer and batch number) do not need to quarantine[23].
- There has been considerable discussion in **Germany**, with negative advice by the German Ethics Council (Deutscher Ethikrat) in September 2020 against immunity certificates due to the uncertainty around establishing immunity, with concern about ethics, reliability and other far-reaching applications[81]. On 4 February 2020, the German Ethics Council recommended against exceptions for those vaccinated for reasons that it would be unacceptable to wider society, risk further spread until more knowledge is acquired about the transmission of the virus[30]. They further recommended that after lockdown, businesses should be legally entitled to ask customers for proof of vaccination, which should not apply to those offering essential goods and services.
- Building on the ICVP (yellow fever) standards, as of 15 January 2021, **Iceland** confirmed that vaccine certificates that meet certain national standards and issued by EEA/EFTA states will be valid at the border[24].
- In **Israel**, as of January 2021 the Ministry of Health issued a 'green passport' that will allow those who are vaccinated to openly attend cultural or other events, eat at restaurants, not be obliged to quarantine and allowed to travel abroad. There was considerable discussion against allowing this technology to be used by the private sector, with it now only allowed by the Ministry of Health, with discussions for this to become a general medical passport[26].

Annexe

- In the **Netherlands**, there has been considerable discussion over potential discrimination, privacy and human rights. For this reason, the Health Council (Gezondheidsraad) has stated that it would be possible for businesses, health care centres and schools to ask for proof of vaccination, but only if there they have clear reasons and there is absolutely no other possibility[31]. They ask whether it is necessary in order to reach a particular goal (care, economic reasons), if it outweigh the violation of rights and freedoms and whether it would result in unjust exclusion and discrimination (e.g., youth who are not yet vaccinated). The Health Council suggested a spectrum of options for the government from: advice to implement vaccine passports, to 'nudging' the public in that direction, to making it strictly enforceable.
- In **Poland** those who are vaccinated will receive a QR code or printed document to serve as a vaccine passport after receiving the second dose of the vaccine[25]. It will also free them from restrictions related to socialisation and movement and they will not need to quarantine if they come into contacted with an infected person.
- In **Spain** there has been considerable legal and public controversy over vaccination cards. The Spanish Data Protection Agency ruled in June 2020 against employers asking about antibodies of prospective employees and that all information about antibodies must be excluded during hiring[32]. A pilot in Madrid to simulate an international vaccination card that would allow people to enter gyms, bars and museums was abandoned due to critiques from rights groups, health experts and politicians[33].

Annexe

Appendix 3. Preparation of report

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