

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 suggests 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.

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.

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 standards, 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

1. Introduction	5
2. Infectiousness, immunity and vaccine passports	5
3. Vaccine certificate and credential initiatives	7
3.1 Precedents: The yellow card	7
3.2 Overarching international initiatives	7
3.3 Country-based initiatives	7
4. Technical considerations	9
4.1 Systems for verifiable credentials and standards for interoperability	9
4.2 Verifiable credentials and standards for interoperability	9
4.3 Technical challenges to certification	10
5. Legal, ethical and behavioural considerations	10
5.1 UK relevant legal frameworks	10
5.2 Data protection and privacy requirements	11
5.3 Protection of rights and freedoms	11
5.4 Equality and non-discrimination	12
5.5 Labour and health and occupational safety laws	12
5.6 Ethical concerns	13
5.7 Behavioural responses and historical lessons	13
6. Recommendations: 12 essential criteria of vaccine passports	14
7. Appendix 1. International and industry-based certificate initiatives	16
8. Appendix 2. Current international initiatives for COVID-19 vaccine passports	17
9. Appendix 3. Preparation of report	19
10. References	20

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 required¹.

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. Secondly, 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.

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 RNA². 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%)³. 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^{4–6}. 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 responses⁷. 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 dose⁸. Vaccines are likely to be less effective in preventing infectiousness and transmission, but there are presently limited data to determine how much less⁹. 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^{10–13}. 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.

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 outcome	Primary goal: predictive value (+ or -)	Secondary goal: Sensitivity (+) or Specificity (-)
1a RNA test	Infectiousness	Negative	High	Medium
1b Antigen test	Infectiousness	Negative	Medium	High
2a Antibody test	Illness	Positive	Medium	Low
	Infectiousness	Positive	Medium	Low
2b Vaccination	Illness	Positive	High	N/A
	Infectiousness	Positive	Medium	N/A

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)¹⁴, where the WHO works as trusted intermediary enforcing vaccine protocols¹⁵. In many countries globally, individuals are required to provide a ICVP certificate before entry¹⁴. 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 entry¹⁶. 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 holder¹⁷.

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 apps¹⁸.

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!’ 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 immunity¹⁹. However, they piloted ‘e-vaccination certificates’ with Estonia in 2020²⁰, and in late 2020 issued a call for experts to contribute to the Smart Vaccination Certificate, with first meetings in January 2021²¹. 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 elsewhere¹⁸, 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 plan¹⁸. 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)²². 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 assess the feasibility of linking COVID-19 vaccinations to international vaccination certificates and to generate electronic certificates²³. 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 (Denmark²⁴). Others have confirmed that vaccine passports can be used via a vaccine QR code on an App that is valid at travel borders (Iceland²⁵) but also linked to dropping the need to quarantine (Estonia²⁴) and even easing restrictions related to socialisation and movement (Poland²⁶). Israel issued a ‘green passport’²⁷ and Poland a QR Code or printed document²⁶, 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 credentials²⁸.

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 travel²⁹. 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 Union³⁰.

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 virus³¹. 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 possibility³². 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 hiring³³. 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 politicians³⁴. 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 Health²⁷. Others, such as China have introduced Apps that also link QR codes to travel history, which has been critiqued in relation to human rights³⁵.

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-verifiable³⁶.

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 organisation³⁷. 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 York³⁸. 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)³⁹.

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 projects⁴⁰.

Other initiatives detailed in Appendix 1 include a variety of industry initiatives including Microsoft's Smart Health Cards Framework⁴¹, IBM's Digital Health Pass⁴², specifically aimed at employers to provide individuals a privacy-preserving way to share their vaccination and health status⁴³, Apple and Google⁴⁴, IATA (International Air Transport Association) Travel Pass Initiative⁴⁵, CLEAR (<https://www.clearme.com/healthpass>), AOK (<https://www.aokpass.com/>) or WISeKey⁴⁶. 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 identification⁴⁷.

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 Africa⁴⁸. Others have noted that over one billion people do not have a foundational ID, with half of these being children who without a registered birth⁴⁹.

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. 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.

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 diseases⁵⁰.

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 UK⁵¹, 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 Ireland⁵²
- **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 accountability⁵¹. In the UK, this is monitored by the Information Compliance Office (ICO) and data protection must be built into the technologies. This requires technical and organisational measures to proactively deal with privacy situations where the processing of data may transfer data to third countries for commercial purposes. Since vaccine passports would be considered a high risk to the rights and freedoms of individuals under GDPR (Article 35-1), a detailed DPIA (Data Protection Impact Assessment) is required.

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 health³³. 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 6) to protect privacy of individuals but also consideration of undesirable or unintended outcomes if vaccine status inadvertently compounded already disadvantaged characteristics (age, ethnicity, gender). 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, which is only justifiable under the legitimate conditions of ‘protection of health’ and ‘economic well-being of the country⁵¹.’ We note that there may be many others that are justifiable, but these are likely the most relevant. This also needs to be tested by legality, necessity and proportionality (which are versions of the same test). It is therefore likely that if there is sufficient evidence of the negative health, economic and social impact of COVID-19, vaccination passports would meet this concern. The balance between competing public and private interests must be deemed fair and needs to pay attention to protection afforded to health data, which in this context refers vaccination information or in the case of immunity passports, COVID-19 test results⁵¹.

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 up⁵³. 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 police³⁵. 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 status⁵⁴.

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. Vaccine passports 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-discrimination⁵¹. When considering these aspects, ECHR and HRA are the relevant rights to consider. Freedom of assembly and meeting or assembly of a religious nature are protected under ECHR, with the protection of health (i.e., vaccine passports) potentially viewed as a legitimate aim that may be adopted to restrict these freedoms.

Vaccine passports 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 vaccinated⁵⁵. However, measures such as a vaccine passport would be possible if they were viewed as a response to a pressing social need and considered proportionate to protect public health and rooted in law⁵¹. 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 population⁵⁶.

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 children⁵⁷.

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^{54,55,58,59}. 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 environments⁵⁸. These concerns are also central in the German Ethics Council response³¹.

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 inequities⁵⁵. 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 customers⁶⁰. 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 reasons⁶¹. 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 deportation⁶². 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' rule⁶³. 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 claim⁶⁴.

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 court⁶⁵. 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 allergies⁶⁴. 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 systems¹⁷.

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 certificate¹⁸. 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 required¹⁸. 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 organisations⁶⁶. 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^{67,68};
- 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^{68,69};
- 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’⁶⁹.

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 lines⁷⁰. 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 personal 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 law⁷¹.

Another relevant area of the literature is on vaccine hesitancy, described in detail in a previous Royal Society SET-C report⁶⁸. 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, respectively⁷². South Australia also forbade enrolment of unvaccinated children in kindergartens and day care in the ‘no jab, no play’ policy⁷³. 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.

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^{74,75}. 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 vicinity⁷⁶. 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 phone⁷⁷.

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 breaches⁷⁸. 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.

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.

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 immunity¹⁹, they piloted 'e-vaccination certificates' with Estonia²⁰. 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 call for experts to contribute to the Smart Vaccination Certificate, with first meetings planned in January 2021²¹. 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 York³⁸. 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 information³⁸." 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 Aruba³⁹.

COVID-19 Credentials Initiative. Led by the Linux Foundation, this initiative launched on 14 January 2021 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 (see Box 1). This would allow individuals to obtain an encrypted digital copy of their immunisation credentials to store in a digital wallet that is interoperable. This initiative is a collective of over 300 people representing many organisations and work with IBM and the Common Pass within the Commons Project

to try to develop universal standards for vaccine credential apps to deploy privacy-preserving verifiable credential projects⁴⁰. The initiative includes multiple health and technology companies such as CARIN Alliance, Microsoft, Mayo Clinic, MITRE, Oracle, Safe Health, Salesforce, Epic, Evernorth, Cerner and Salesforce.

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 manner⁴¹."

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.⁴² 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 system⁴³. 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 status⁴³."

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 Apple⁴⁴. 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)⁷⁹.

Additional initiatives. There are also many other initiatives including the IATA (International Air Transport Association) Travel Pass Initiative⁴⁵, CLEAR (<https://www.clearme.com/healthpass>), AOK (<https://www.aokpass.com/>) or WISeKey⁴⁶. 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 identification⁴⁷.

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 year¹⁸. On 7 December 2020, the European Commission Health Security Committee discussed cross-border verifiable COVID-19 vaccine certificates²⁹. 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 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 Union³⁰.
- 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 citizens²⁸.
- In the **United Kingdom**, immunity risk certification was introduced initially in April 2020 as the sixth pillar of the UK Government's contact tracing plan¹⁸. 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 apps²². Some of these include trialling of digital vaccine passports with local public health directors to Mvine, a cybersecurity company and iProov, a biometrics company³¹. 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 assess the feasibility of linking COVID-19 vaccinations to international vaccination certificates and to generate electronic certificates²³.
- 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 history³⁵.
- 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 passport²⁴.
- **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 quarantine²⁴.
- 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 applications³². 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 virus³¹. 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 border²⁵.
- 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 passport²⁷.

- 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 possibility³². 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 vaccine²⁶. It will also free them from restrictions related to socialisation and movement and they will not need to quarantine if they come into contact 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 hiring³³. 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 politicians³⁴.

Appendix 3. Preparation of report

Report prepared for the SET-C Group by

Professor Melinda Mills FBA, MBE, University of Oxford, Leverhulme Centre for Demographic Science

Professor Christopher Dye FMedSci FRS, University of Oxford

Members of The Royal Society SET-C who contributed to and commented on this report

Professor Peter Bruce FRS (Chair), The Royal Society

Professor Sir Roy Anderson FMedSci FRS, Imperial College London

Professor Charles Bangham FMedSci FRS, Imperial College London

Professor Richard Catlow FRS, The Royal Society

Professor Christopher Dye FMedSci FRS, University of Oxford

Professor Sir Marc Feldmann AC FAA FMedSci FRS, University of Oxford

Professor Sir Colin Humphreys FREng FRS, Queen Mary University of London

Professor Frank Kelly FRS, University of Cambridge

Professor Melinda Mills FBA, University of Oxford

Professor Linda Partridge FMedSci FRS, The Royal Society

Professor Sir John Skehel FMedSci FRS, The Francis Crick Institute

Professor Geoffrey Smith FMedSci FRS, University of Cambridge

Professor Alain Townsend FRS, University of Oxford

References

1. Kelleher SR. 2021 Why vaccine passports are 'inevitable,' explained by Tony Blair. *Forbes*. Available from: <https://www.forbes.com/sites/suzannerowankelleher/2021/02/13/why-vaccine-passports-are-inevitable-explained-by-tony-blair/?sh=2b193e8b41d6>
2. Crozier A, Rajan S, Buchan I, McKee M. 2021 Put to the test: use of rapid testing technologies for covid-19. *BMJ*, n208. (doi:10.1136/bmj.n208)
3. *ibid.*
4. Galanti M, Shaman J. 2020 Direct Observation of Repeated Infections With Endemic Coronaviruses. *The Journal of Infectious Diseases* (doi:10.1093/infdis/jiaa392)
5. Callow KA, Parry HF, Sergeant M, Tyrrell DAJ. 1990 The time course of the immune response to experimental coronavirus infection of man. *Epidemiol. Infect.* 105, 435–446. (doi:10.1017/s0950268800048019)
6. The Royal Society. 2020 Herd immunity in the epidemiology and control of COVID-19. Available from: <https://royalsociety.org/-/media/policy/projects/set-c/set-c-herd-immunity.pdf?la=en-GB&hash=2B8F6255CF6FD83CE71FC510596FBCFB>.
7. Dan JM *et al.* 2021 Immunological memory to SARS-CoV-2 assessed for up to 8 months after infection. *Science* 371, eabf4063. (doi:10.1126/science.abf4063)
8. Krammer F *et al.* 2021 Robust spike antibody responses and increased reactogenicity in seropositive individuals after a single dose of SARS-CoV-2 mRNA vaccine. *medRxiv* (doi:10.1101/2021.01.29.21250653)
9. Mahase E. 2020 Covid-19: Oxford vaccine could be 59% effective against asymptomatic infections, analysis shows. *BMJ*, m4777. (doi:10.1136/bmj.m4777)
10. Wibmer C *et al.* 2021 SARS-CoV-2 501Y.V2 escapes neutralization by South African COVID-19 donor plasma. *bioRxiv*. (doi:10.1101/2021.01.18.427166)
11. Collier DA *et al.* 2021 SARS-CoV-2 B.1.1.7 escape from mRNA vaccine-elicited neutralizing antibodies. *medRxiv*. (doi:10.1101/2021.01.19.21249840)
12. Eugia R *et al.* 2020 A human coronavirus evolves antigenically to escape antibody immunity. *bioRxiv*. (doi:10.1101/2020.12.17.423313)
13. Branswell H. 2021 Comparing the Covid-19 vaccines developed by Pfizer, Moderna, and Johnson & Johnson. *Stat.* Available from: <https://www.statnews.com/2021/02/02/comparing-the-covid-19-vaccines-developed-by-pfizer-moderna-and-johnson-johnson/>
14. World Health Organisation (WHO). 2007 International certificate of vaccination or prophylaxis: international health regulations (2005). Available from: https://www.who.int/ihr/ports_airports/icvp/en/
15. Gelb A, Mukherjee A. 2020 Certificate of COVID vaccination: can we do better than the yellow card? *Cent. Glob. Dev.* Available from: <https://www.cgdev.org/blog/certificate-covid-vaccination-can-we-do-better-yellow-card>
16. Wilson K, Atkinson KM, Bell CP. 2016 Travel Vaccines Enter the Digital Age: Creating a Virtual Immunization Record. *The American Journal of Tropical Medicine and Hygiene* 94, 485–488. (doi:10.4269/ajtmh.15-0510)
17. Gelb A, Mukherjee A. 2021 A COVID Vaccine Certificate: Building on Lessons from Digital ID for the Digital Yellow Card. Available from: <https://www.cgdev.org/publication/covid-vaccine-certificate-building-lessons-digital-id-digital-yellow-card>
18. Ada Lovelace Institute. 2020 International monitor: vaccine passports and COVID status apps. *Website Arch.* Available from: <https://www.adalovelaceinstitute.org/project/international-monitor-vaccine-passports-covid-status-apps/>
19. World Health Organisation (WHO). 2020 Immunity passports in the context of COVID-19. Available from: <https://www.who.int/news-room/commentaries/detail/immunity-passports-in-the-context-of-covid-19>
20. Miller J, Nebehay S. 2020 WHO looks at possible 'e-vaccination certificates' for travel. *Reuters*. Available from: <https://www.reuters.com/article/us-health-coronavirus-who-passports-idUSKBN28D1J4>
21. World Health Organisation (WHO). 2020 World Health Organization open call for nomination of experts to contribute to the Smart Vaccination Certificate technical specifications and standards. Available from: <https://www.who.int/news-room/articles-detail/world-health-organization-open-call-for-nomination-of-experts-to-contribute-to-the-smart-vaccination-certificate-technical-specifications-and-standards-application-deadline-14-december-2020>
22. Boland H. 2021 Government funds eight vaccine passport schemes despite 'no plans' for rollout. *The Telegraph*. Available from: <https://www.telegraph.co.uk/technology/2021/01/24/government-funds-eight-vaccine-passport-schemes-despite-no-plans/>
23. WhiteHouse.Gov. 2021 National Strategy for the COVID-19 Response and Pandemic Preparedness. Washington, D.C. Available from: <https://www.whitehouse.gov/wp-content/uploads/2021/01/National-Strategy-for-the-COVID-19-Response-and-Pandemic-Preparedness.pdf>
24. Olsen JM. 2021 Denmark to develop digital passport proving vaccinations. *AP*. Available from: <https://apnews.com/article/travel-health-denmark-coronavirus-pandemic-europe-8ffac05453c6f259d5e2cea033ae5ca>
25. Government of Iceland. 2021 Covid-19 screening mandatory for arriving passengers until spring. Available from: <https://www.government.is/news/article/2021/01/15/Covid-19-screening-mandatory-for-arriving-passengers-until-spring/>
26. Brzozowki A, Wolska A. 2021 Vaccinated Poles to receive special 'passports'. *Euraactiv*. Available from: https://www.euractiv.com/section/politics/short_news/vaccinated-poles-to-receive-special-passports/
27. Ministry of Health, Government of Israel. Vaccine administration records ('Green Passport') are valid only if issued by the Ministry of Health. Available from: <https://www.gov.il/en/departments/news/05012021-01>
28. DIVOC. 2021 DIVOC: Digital Infrastructure for Verifiable Open Credentialing. Available from: <https://divoc.egov.org/in/>
29. European Commission Directorate-General for Health & Food Safety. 2020 Health security committee audio meeting on the outbreak of COVID-19 summary report. Available from: https://ec.europa.eu/health/sites/health/files/preparedness_response/docs/ev_20201207_sr_en.pdf
30. Schengenvisainfo News. 2021 EU Commission President: vaccination certificate is a medical requirement. Available from: <https://www.schengenvisainfo.com/news/eu-commission-president-vaccination-certificate-is-a-medical-requirement/>
31. Deutsche Ethikrat. 2021 Besondere Regeln für Geimpfte? [Special rules for vaccinated people?]. Available from: <https://www.ethikrat.org/fileadmin/Publikationen/Ad-hoc-Empfehlungen/deutsch/ad-hoc-empfehlung-besondere-regeln-fuer-geimpfte.pdf>
32. van de Wier M. De vraag naar een vaccinatiebewijs moet vooral heel goed uit te leggen zijn [The question for a vaccination certification must above all be very easy to explain]. *Trouw*.
33. Agencia Espanola Proteccion Datos (AEPD). 2020 Comunicado de la AEPD sobre la información acerca de tener anticuerpos de la COVID-19 para la oferta y búsqueda de empleo [AEPD statement on information about having COVID-19 antibodies for job offers and search]. AEPD Press Release. Available from: <https://www.aepd.es/es/prensa-y-comunicacion/notas-de-prensa/comunicado-AEPD-covid-19-oferta-busqueda-empleo>

34. Luelmo P, Allen N. 2020 After backlash, Madrid rows back on COVID 'immunity card'. Reuters. Available from: <https://www.reuters.com/article/us-health-coronavirus-spain/after-backlash-madrid-rows-back-on-covid-immunity-card-idUSKCN24U1SX>
35. Mozur P, Zhong R, Krolik A. 2020 In coronavirus fight, China gives citizens a color code, with red flags. The New York Times. Available from: <https://www.nytimes.com/2020/03/01/business/china-coronavirus-surveillance.html>
36. Spring M, Longley D, Chadwick D. 2019 Verifiable Credentials Data Model 1.0: expressing verifiable information on the web. World Wide Web Consortium (W3C) Recommendation. Available from: <https://www.w3.org/TR/vc-data-model/>
37. Health Level Seven International (HL7) Fast Health Interoperability Resources (FHIR). 2019 HL7 FHIR Release 4. Available from: <https://www.hl7.org/fhir/>
38. The Commons Project. 2020 The Commons Project: common pass. Commons Proj. Available from <https://thecommonsproject.org/commonpass>
39. Iyengar R. 2020 If you want to travel next year, you may need a vaccine passport. CNN Bus. Available from: <https://edition.cnn.com/2020/12/27/tech/coronavirus-vaccine-passport-apps/index.html>
40. CCI 2020 COVID-19 Credentials Initiative. Available from: <https://www.covidcreds.org>
41. Microsoft. 2020 SMART Health Cards Framework. GitHub. Available from: <https://smarthealth.cards>
42. IBM. 2021 IBM Digital Health Pass. Available from: <https://www.ibm.com/products/digital-health-pass>
43. IBM Watson Health. 2020 IBM and Salesforce join forces to help deliver verifiable vaccine and health passes. IBM Blog. Available from: <https://www.ibm.com/blogs/watson-health/partnership-with-salesforce-verifiable-health-pass/>
44. Apple. 2021 Download health records in Health on iPhone. Apple iPhone User Guide. Available from: <https://support.apple.com/en-gb/guide/iphone/iphe103f5a3e/ios>
45. IATA. 2020 IATA Travel Pass Initiative. IATA Travel Pass Initiat. Available from: <https://www.iata.org/en/programs/passenger/travel-pass/>
46. WiSeKey. 2021 No TitlWiSeKey upgrades its MyWiSeID app to include vaccination certificates on the blockchain to serve as an official proof for those who receive coronavirus vaccine. Press Release. Available from: <https://www.wisekey.com/press/wisekey-upgrades-its-mywiseid-app-to-include-vaccination-certificates-on-the-blockchain-to-serve-as-an-official-proof-for-those-who-receive-coronavirus-vaccine/>
47. Ryan C, Patel T. 2020 Covid passports keen as key to resuming international travel. Bloomberg. Available from: <https://www.bloomberg.com/news/articles/2020-11-23/airline-lobby-is-building-a-covid-travel-pass-to-spur-flights>
48. Gelb A, Mukherjee A. 2020 Digital Technology in Social Assistance Transfers for COVID-19 Relief: lessons from selected cases. Centre for Global Development. Available from: <https://www.cgdev.org/publication/digital-technology-social-assistance-transfers-covid-19-relief-lessons-selected-cases>
49. The World Bank. 2021 ID4D: Identification for Development. id4d.worldbank.org. Available from: <https://id4d.worldbank.org/>
50. Glasier A, Gülmezoglu AM, Schmid GP, Moreno CG, Van Look PF. 2006 Sexual and reproductive health: a matter of life and death. The Lancet 368, 1595–1607. (doi:10.1016/s0140-6736(06)69478-6)
51. Beduschi A. 2020 Digital health passports for COVID-19: data privacy and human rights law. Available from: https://socialsciences.exeter.ac.uk/media/universityofexeter/collegeofsocialsciencesandinternationalstudies/lawimages/research/Policy_brief_-_Digital_Health_Passports_COVID-19_-_Beduschi.pdf
52. HM Government [Government of the UK]. 2020 Coronavirus Legislation. Available from: <https://www.legislation.gov.uk/coronavirus>
53. World Health Organisation (WHO). 2020 Ethical consideration to guide the use of digital proximity tracking technologies for COVID-19 contact tracing: interim guidance, 28 May 2020. Available from: <https://apps.who.int/iris/handle/10665/332200?locale-attribute=ar&fbclid=IwAR2buRUh7AdKaS2zbdpYhq8Ux194ak5M4sJAA3uG4OvH29Z22A1KqQFeIM>
54. Kofler N, Baylis F. 2020 Ten reasons why immunity passports are a bad idea. Nature 581, 379–381. (doi:10.1038/d41586-020-01451-0)
55. Phelan AL. 2020 COVID-19 immunity passports and vaccination certificates: scientific, equitable, and legal challenges. The Lancet 395, 1595–1598. (doi:10.1016/s0140-6736(20)31034-5)
56. Brown RCH, Savulescu J, Kelly D, Wilkinson D. 2020 A public health ethic should inform policies on COVID-19 immunity passports – Authors' reply. The Lancet Infectious Diseases (doi:10.1016/s1473-3099(20)30922-1)
57. Press Association. 2010 Equality and Human Rights Commission (EHRC): Airport Scanners may breach human rights, watchdog says. The Guardian. Available from: <https://www.theguardian.com/society/2010/jan/17/equality-watchdog-airport-scanners>
58. Nuffield Council on Bioethics. 2020 COVID-19 antibody testing and 'immunity certification'. Available from: <https://www.nuffieldbioethics.org/news/new-briefing-covid-19-antibody-testing-and-immunity-certification>
59. Brown RCH, Kelly D, Wilkinson D, Savulescu J. 2020 The scientific and ethical feasibility of immunity passports. The Lancet Infectious Diseases (doi:10.1016/s1473-3099(20)30766-0)
60. Clark P, Jacobs E. 2021 Should Covid vaccines be mandatory at work? Financial Times. Available from: <https://www.ft.com/content/44964aa6-cb62-4e2b-809a-cafc9e645a7e>
61. New York State COVID-19 Updates. 2020 Governor Cuomo calls into question federal administration's demand for ID numbers of New Yorkers who receive COVID-19 Vaccine. Available from: <https://www.governor.ny.gov/news/governor-cuomo-calls-question-federal-administrations-demand-id-numbers-new-yorkers-who-receive>
62. Jones H. 2021 Up to 1,300,000 illegal immigrants to get vaccine without risk of deportation. Metro. Available from: <https://metro.co.uk/2021/02/08/up-to-1300000-illegal-immigrants-told-to-get-job-without-risk-of-deportation-14041077/>
63. Espiner T. Pimlico Plumbers to make workers get vaccinations. BBC News. 2021; published online Jan 15. <https://www.bbc.co.uk/news/business-55654229>.
64. Bermingham K. 2021 Care worker Maria Glover to pursue unfair dismissal case after she refused mandatory influenza vaccination. news.com.au. Available from: <https://www.news.com.au/lifestyle/health/health-problems/care-worker-maria-glover-to-pursue-unfair-dismissal-case-after-she-refused-mandatory-influenza-vaccination/news-story/a835412b43a85ed114bc0041f9370a8c>
65. Bonyhady N. 2021 Bosses have the power to force employees to take the vaccine: experts. Sydney Morning Her. Available from: <https://www.smh.com.au/politics/federal/bosses-have-the-power-to-force-employees-to-take-the-vaccine-experts-20210101-p56r64.html>
66. Privacy International. 2020 'Anytime and anywhere': Vaccination, immunity certificates, and the permanent pandemic. Available from: <https://privacyinternational.org/long-read/4350/anytime-and-anywhere-vaccination-immunity-certificates-and-permanent-pandemic>
67. Freeman D *et al.* 2020 COVID-19 vaccine hesitancy in the UK: the Oxford coronavirus explanations, attitudes, and narratives survey (Oceans) II. Psychol. Med. , 1–15. (doi:10.1017/s0033291720005188)
68. Mills MC, *et al.* 2020 COVID-19 vaccine deployment: behaviour, ethics, misinformation and policy strategies. R. Soc. Available from: <https://royalsocietypublishing.org/journal/rsos/180101>
69. Voo TC, Clapham H, Tam CC. 2020 Ethical Implementation of Immunity

- Passports During the COVID-19 Pandemic. *The Journal of Infectious Diseases* 222, 715–718. (doi:10.1093/infdis/jiaa352)
70. Olivarius K. 2019 Immunity, Capital, and Power in Antebellum New Orleans. *The American Historical Review* 124, 425–455. (doi:10.1093/ahr/rhz176)
71. Wolfe RM. 2002 Anti-vaccinationists past and present. *BMJ* 325, 430–432. (doi:10.1136/bmj.325.7361.430)
72. Trentini F, Poletti P, Melegaro A, Merler S. 2019 The introduction of 'No jab, No school' policy and the refinement of measles immunisation strategies in high-income countries. *BMC Med* 17. (doi:10.1186/s12916-019-1318-5)
73. Kirby T. 2017 No jab, no play: Australia and compulsory vaccination. *The Lancet Infectious Diseases* 17, 903. (doi:10.1016/s1473-3099(17)30459-0)
74. Guinchard A. 2020 Our digital footprint under Covid-19: should we fear the UK digital contact tracing app? *International Review of Law, Computers & Technology* 35, 84–97. (doi:10.1080/13600869.2020.1794569)
75. Bradford L, Aboy M, Liddell K. 2020 COVID-19 contact tracing apps: a stress test for privacy, the GDPR, and data protection regimes. *Journal of Law and the Biosciences* 7. (doi:10.1093/jlb/ljaa034)
76. Williams SN, Armitage CJ, Tampe T, Dienes K. 2020 Public attitudes towards COVID-19 contact tracing apps: a UK-based focus group study. *medRxiv*. (doi:10.1101/2020.05.14.20102269)
77. ThirdSector. 2019 Want to get Brexit-ready? Then buy an Android phone. *ThirdSector.co.uk*. Available from: <https://www.thirdsector.co.uk/want-brexit-ready-buy-android-phone/management/article/1596391>.
78. Davis SLM, Maleche A. 2018 "Everyone Said No": key populations and biometrics in Kenya. *Health and Human Rights Journal*. Available from: <https://www.hhrjournal.org/2018/07/everyone-said-no-key-populations-and-biometrics-in-kenya/>
79. Apple. 2021 Institutions that support health records on iPhone and iPod touch. Available from: <https://support.apple.com/en-us/HT208647>
80. African Union & African CDC. 2021 Trusted Travel: My COVID Pass. African CDC. Available from: <https://africacdc.org/trusted-travel/>
81. Cogley M. 2021 Exclusive: Vaccine passports to be trialled by thousands of Britons. *The Telegraph*. Available from: <https://www.telegraph.co.uk/technology/2021/01/12/exclusive-vaccine-passports-trialled-thousands-britons/>
82. Deutsche Ethikrat. 2020 Immunitätsbescheinigungen in der Covid-19-Pandemie [Immunity Certificates in the Covid-19 Pandemic]. Available from: <https://www.ethikrat.org/fileadmin/Publikationen/Stellungnahmen/deutsch/stellungnahme-immunitaetsbescheinigungen.pdf>

DISCLAIMER

This paper has drawn on the most recent evidence as of 14 February 2021 and has been subject to formal peer-review. Further evidence on this topic is constantly published and the Royal Society may return to this topic in the future. This independent overview of the science has been provided in good faith by experts and the Royal Society and paper authors accept no legal liability for decisions made based on this evidence.

THANKS

The Royal Society is grateful to the Leverhulme Trust for its support for the Society's pandemic response work and for support to the Leverhulme Centre for Demographic Science.

The text of this work is licensed under the terms of the Creative Commons Attribution License which permits unrestricted use, provided the original author and source are credited. The license is available at: creativecommons.org/licenses/by/4.0

Issued: February 2021 DES7385 © The Royal Society