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A comparative analysis of COVID-19 vaccination certificates in 12 countries/regions around the world: Rationalising health policies for international travel and domestic social activities during the pandemic

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ABSTRACT

As the unprecedented pandemic of COVID-19 became a major barrier during the past two years, many countries were using the "COVID pass" or COVID-19 vaccination certificates in attempts to facilitate effective international travel and domestic social activities. The difficulty remained in how the "COVID pass" from different countries and regions could be mutually recognised. This study surveys the current practice of COVID-19 vaccination certificates in 12 representative countries/regions around the world and provides a comprehensive mapping of the vaccination certificates in these countries/regions. The study compares and contrasts the vaccination certificates in both format and content, including their primary purposes, international accreditation, naming conventions, recipients' personal information, and the details on vaccines and vaccination. The findings are interpreted in light of implementation practices in each country/region and discussed in relation to their various functions, as well as legal, technical, and ethical considerations. Based on the analysis and discussion recommendations are made on the practice of vaccination certificates in attempts to facilitate effective international travel and domestic social activities.

1. Introduction

Since the outbreak of COVID-19 pandemic, countries had adopted varying approaches and regulations to deal with it [1]: some pursued a stringent "Zero COVID" policy that involves large-scale testing, wide-scale lockdowns, and compulsory quarantining; others were less stringent, relying on vaccination as the main means to control. Despite such differences, many countries around the world were using "COVID pass" or COVID-19 vaccination certificates in attempts to facilitate effective international travel and domestic social activities during the pandemic. In some countries/regions like China, Canada, South Africa, the United Kingdom (UK), the United States (US) and the European Union (EU), people were required to display their digital or paper version of COVID passport or vaccination certificate before entering restaurants, malls and attending large gatherings and indoor activities. For some countries like Australia, India, New Zealand, Singapore and South Korea, outbound and inbound international travellers were requested to present proof of COVID vaccination certificates issued by their own countries or destinations with the exemptions from quarantine or testing. To obtain these certificates, people had to be fully or partially vaccinated or had a negative test recently. These COVID passports or vaccination certificates often carried the health information about the holder and the vaccine/vaccination that the holder received.

Identified as one of the few means facilitating international travel across borders, vaccination certificates have become a hot topic both in the media and academia [2–4]. Recent discussions have highlighted the necessity of COVID vaccination certificates and revealed various issues in the practice of vaccination certificates [5–11]. Previous studies mostly focus on the necessity and possible issues to consider in COVID passes or vaccination certificates, or the perceptions of vaccine certificates among the general public [12–14]. As Mithani et al.'s [15] preliminary study found out, most online articles on COVID-19 vaccine certificates centred around six themes, i.e., legality, technology, ethics, travel, policy and science. Most studies in the field of vaccination certificates have dealt with the functions and mechanisms of vaccination certificates in different countries/regions [16–19]. To date, few studies have investigated the association between the interface of vaccination certificates and their functions and mechanisms. This study attempts to

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address this gap by providing a useful account of how vaccination certificates are implemented in different countries/regions around the world.

It needs to be clarified that several terms are used to refer to the same type of COVID vaccination proof document intended to facilitate international travel and attending large gatherings [18,20], including vaccine passport/certificate, immunity passport and immunisation certificate. These terms are often used interchangeably. The generic term "vaccination certificate" is used in this paper in its broadest sense to refer to all digital and paper documents recording an individual's COVID vaccine and vaccination history.

The objective of this study is to examine the current practice of implementation and provide a comprehensive mapping of the COVID passes or vaccination certificates in different countries of the world. It aims to compare and contrast the practices by examining the common function of COVID vaccination certificates in the context of the global pandemic.

2. Data and methods

In collecting the data about vaccination certificates, 12 countries and regions were selected as representing different parts of the world, including Australia, Canada, the Chinese mainland and Hong Kong Special Administrative Region (SAR), the EU, India, New Zealand, Singapore, South Africa, South Korea, the UK and the US. These countries/regions are also representative in different continents, with different population sizes and including both developed and developing countries/regions. The sample of countries/regions is mainly made up of the World Bank classified high-income and middle-income countries/regions and does not contain any low-income countries. This is because there was a general lack of vaccination certificates in most low-income countries.

The data in this study, which consists of images of vaccination certificates and policy files on these certificates, were collected through internet searches on Google and Google Images between November 2021 and May 2022. Each country/region name was searched for in Google and Google Images together with several keywords, including "COVID" and "vaccine" or "vaccination" or "immunity" or "immunisation" and "pass" or "passport" or "certificate". A total of 27 images of certificates and 33 policy documents were collected and analysed from the search results generated on the internet as shown in Table 1. Images of vaccination certificates were downloaded from the websites of each country/region's government agencies or national health services. The collected screenshots and/or scanned copies of vaccination certificates from these countries/regions are presented in the Appendix A. The images of vaccination certificates were interpreted in relation to the official information in policy documents provided on the internet. Relevant grey literature, national guidelines and policies on the websites were also consulted to understand the context of these vaccination certificates in more detail.

After the vaccination certificates were collected, the next step of this study used qualitative descriptive content analysis to gain insights to the functions and mechanisms of the vaccination certificates. Qualitative comparative methods are useful for identifying the nuances and characterizing the similarities and differences between these vaccination certificates. To compare the different practices and uses of vaccination certificates across the countries/regions in the study, we examined whether the certificates document different types of information and how these were collected and listed, including: the official name of the vaccination certificate, its primary purpose and international accreditation, personal details of the holder, information about the vaccine and vaccination status, inclusion of a quick response (QR) code, COVID test result, expiration date of the vaccination certificate. The vaccination certificate from each country/region was checked against these criteria and marked with a tick if it has this type of information or a cross if it does not. A second researcher verified this coding process to ensure that all relevant information was captured correctly.

Table 1
Number of certificate images and policy documents and their sources of information.

Country/ Region	Number of certificate images	Number of policy documents	Source of information
Australia	2	2	Australian Government, Department of Health, Australian Passport Office, Services Australia
Canada	1	3	Government of Canada, Gouvernement du Québec, Government of British Columbia
Chinese Mainland	9	3	Embassy of the People's Republic of China, Baidu Baike, Wikipedia, Alipay, WeChat
EU	1	2	European Commission, European Medicines Agency
Hong Kong SAR	3	1	Office of the Government Chief Information Officer, Government of the Hong Kong SAR of the PRC
India	1	2	Ministry of External Affairs, Government of India, CoWIN
New Zealand	3	4	New Zealand Government, Ministry of Health,
Singapore	2	2	Government Digital Services, Government Technology Agency
South Africa	1	2	South African Government, Health Professions Council of South Africa
South Korea	2	2	Korea Disease Control and Prevention Agency
UK	1	7	UK Government, National Health Service, Department of Health and Social Care, Northern Ireland Government, States of Guernsey Government, Scottish Government, Welsh Government, Isle of Man Government, Government of Jersey
US	1	3	Smart Health IT, Boston Children's Hospital
Total	27	33	

3. Analysis and results

This section describes the vaccination certificates in the 12 countries/regions from aspects of their primary purpose, international accreditation, naming conventions, personal details of the holder, vaccine and vaccination details. Table 2 compares the results obtained from the content analysis of vaccination certificates in these countries/regions. The primary purpose of the vaccination certificates varied across the countries included in the study. For some countries/regions like the EU, the certificates were mostly for international travel, whereas for others like the US, the Chinese mainland and Hong Kong, they were for daily domestic activities and less focused on international travel. The vaccination certificates of Canada, India, South Africa, South Korea and the UK were used both for international travel and domestic activities. Australia, New Zealand and Singapore issued different vaccination certificates for different purposes. The information collected for a vaccination certificate varied across countries if the countries were using the vaccination certificates for different primary purposes. We chose to include all vaccination certificates with different primary purposes rather than just focusing on ones for domestic use or international travel because we would like to provide a comprehensive account

Table 2
A comparison of the vaccination certificates among the 12 countries/regions.

Country/ Region	Name of vaccination pass	Primary purpose	International accreditation	Personal details					Vaccine details			Vaccination details		QR code	Test result	Expiration date
				Name	**Date of birth**	**Gender**	ID number	**Nationality**	**Vaccine name/type/ brand**	**Dose number**	**Batch number**	**Vaccination date**	**Vaccination location**			
Australia	COVID-19 digital certificate	Domestic activities	×	✓	✓	×	✓	×	✓	×	×	✓	×	✓	×	✓
	International COVID-19 vaccination certificate	International travel	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×
Canada	COVID-19 proof of vaccination[1]	International travel & domestic activities	✓	✓	✓	×	×	×	✓	✓	✓	✓	×	✓	×	×
Chinese Mainland	Health code	Domestic activities	×	✓	×	×	×	×	✓	✓	×	✓	✓	✓	✓	×
EU	COVID certificate	International travel	✓	✓	✓	×	×	×	✓	✓	×	✓	✓	✓	×	×
Hong Kong SAR	COVID-19 electronic vaccination and testing record	Domestic activities	×	✓	✓	✓	✓	×	✓	✓	×	✓	✓	✓	✓	×
India	COVID vaccination certificate	International travel & domestic activities	✓	✓	×	✓	×	×	✓	✓	×	✓	✓	✓	×	×
New Zealand[2]	My Vaccine Record	Domestic activities	×	✓	✓	×	✓	×	✓	✓	✓	✓	✓	×	✓	×
	My Vaccine Pass	Domestic activities	×	✓	✓	×	×	×	×	×	×	×	×	✓	×	✓
	International Travel Vaccination Certificate	International travel	✓	✓	✓	×	×	×	✓	✓	×	✓	×	✓	×	✓
Singapore	Vaccination HealthCert (Notɑrise)	International travel	✓	✓	×	×	✓	✓	✓	✓	×	✓	×	✓	×	×
South Africa	COVID-19 vaccination certificate	International travel & domestic activities	✓	✓	✓	×	✓	×	✓	×	×	✓	×	✓	×	×
South Korea	COVID-19 vaccination verification (COOV)	International travel & domestic activities	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	✓	×	×
UK[3]	NHS COVID Pass	International travel & domestic activities	✓	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×	×
US	SMART Health Card[4]	Domestic activities	×	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	✓	×

[1] Canada implemented both federal COVID-19 proof of vaccination and provincial or territorial proof of vaccination in the provinces of British Columbia, Manitoba, New Brunswick and Quebec [21,22].
[2] New Zealand issued international travel vaccination certificate, My Vaccine Record and My Vaccine Pass.
[3] The UK made use of various vaccination certificates, including the NHS COVID Pass in England and slightly different practices in other parts of the UK, i.e., Northern Ireland, Scotland, Wales, Guernsey, Isle of Man and Jersey [23].
[4] The US did not have a unified COVID vaccination certificate. Some US states had their own vaccination certificates, such as SMART Health Cards which were rolled out in several states, including California, Colorado, Hawaii, Louisiana, New Jersey, New York, Utah, Virginia and Washington [24].

of different categories of vaccination certificates in these countries/regions. We grouped them into those for domestic purposes versus those for international purposes and conduct the comparisons within those sub-groups.

3.1. Naming conventions

It was found that different countries/regions employed various terms to label the vaccination documents, including "certificate", "record", "letter", "pass", "proof", "code" and "card". The term "COVID", "COVID-19" or "vaccination" were included in most vaccination certificates except for the Chinese Mainland and the US, which adopted two distinct names: health code (健康码) and health card. This might be because the vaccination status of the citizens in these two countries was shared domestically with third-party organizations on online mobile apps: namely Alipay, WeChat and QQ in the Chinese Mainland and clinical organization apps in the US respectively. The health code in the Chinese Mainland varied slightly differently in different provinces, but the health codes from different provinces could be incorporated in the same apps and the data were shared with the national government platforms so cross-province travels were facilitated. The US SMART health cards kept a record of vaccination status and also stored personal data and other clinical information such as vaccination history and test results [25]. Several countries adopted alternative alias in naming their domestic vaccination certificates, such as South Korea's COOV for COVID-19 vaccination verification, and New Zealand's My Vaccine Pass and My Vaccine Record for digital vaccination certificates.

3.2. Personal details of the holder

The first part of vaccination certificates was usually the vaccine recipients' personal details, such as name, date of birth, gender, ID number and nationality. Name and date of birth were the two most common personal information items on vaccination certificates for domestic purposes everywhere except for on the Chinese mainland and in India. The Chinese health code did not provide the date of birth but only the person's name, with the option of showing or hiding the person's given name. Other personal information was not displayed because the health code was exclusively intended for domestic use. All inbound travellers to the Chinese mainland without mainland Chinese ID cards, including their compatriots from Hong Kong, Macao and Taiwan, were required to apply for a health code via the travellers' version of health code. The Indian vaccination certificate displayed the person's name, age and gender upon successful verification on the CoWIN platform [26]. The recipient's gender was also shown on vaccination certificates for domestic purposes in Australia, India and Hong Kong SAR. For instance, the Hong Kong SAR's electronic vaccination records via "iAM Smart" mobile app were displayed with name, gender, date of birth and identity document number in full or masked [27]. However, its electronic testing records did not display relevant personal details.

The recipient's identification number was listed on vaccination certificates in five countries/regions, i.e., Australia, Hong Kong SAR, Singapore, South Africa and New Zealand. These identity documents included passports on vaccination certificates for international travel in Australia and Singapore, identity cards on vaccination certificates for domestic purposes in Hong Kong SAR, and identity cards, foreign passports, asylum or refugee numbers in South Africa [28]. In New Zealand, people might be asked to show their Photo ID for the use of My Vaccine Pass domestically, although the ID number was not registered on the vaccination certificates. The vaccination certificates in most countries/regions did not require the vaccine recipient's nationality to be presented for domestic uses, except for the vaccination credentials for international travels, such as the South Korean and the Singaporean vaccination certificates. However, in South Korea, name, date of birth and nationality were additional information that the person could choose not to disclose when verifying their credentials in the COOV verification system [29]. The Singaporean Vaccination HealthCert displayed the nationality and passport number via Notαrise, a mobile app intended for outbound travellers from Singapore to submit their pre-departure COVID-19 testing results for verification and to get their Vaccination HealthCerts issued by the Singaporean Ministry of Health, though the HealthCerts could be viewed via other apps such as Singpass and HealthHub [30]. The person's nationality/citizenship displayed on HealthCert needed to be the same as the one on the person's passport.

3.3. Vaccine details

The second part of the vaccination certificates was the information regarding the vaccine administered, including name, type or brand of the vaccine, number of doses, and batch/lot number. All the selected vaccination certificates contained the name, type or specific brand of vaccines as well as the number of doses the person received except for the New Zealand digital vaccination certificate (My Vaccine Pass) and the South African vaccination certificate in which only the name of vaccine received was provided. The New Zealand domestic vaccination certificate did not list the number of doses because the recipient's COVID-19 vaccination status is recorded in My Covid Record and only those people who received two or more doses of COVID-19 vaccines or with medical exemption could get a My Vaccine Pass issued by the New Zealand Government [31]. The South African COVID-19 vaccination certificate did not display the number of doses directly but it showed information about each vaccination so that the dose number could be inferred.

This information on the vaccine details varied slightly among the vaccination certificates in these countries/regions. The vaccination certificates for domestic purposes provide essential information on the vaccine details. The mainland Chinese domestic vaccination record only displayed the disease targeted and the type of vaccine without the name of the manufacturer, like "COVID-19 vaccine (Vero cell)". The name of the vaccine received was displayed on the Indian and South African vaccination certificates, such as "Covaxin" or "Comirnaty". The Australian, Singaporean and South Korean vaccination certificates displayed vaccine brands or manufacturers, such as "AstraZeneca", "Moderna" or "Pfizer". The names of the vaccine and its manufacturer were listed on the vaccination certificates in Canada, Singapore, the US and Hong Kong SAR, like "Pfizer-BioNTech Comirnaty COVID-19", "Pfizer-BioNTech / Comirnaty COVID-19" or "Comirnaty COVID-19 mRNA vaccine" by BioNTech. The vaccination certificates for international purposes generally provided more information on the vaccine details than the ones for domestic purposes. The EU vaccination certificate displayed disease agent, vaccine type, product and manufacturer, like "SARS-CoV-19, C19-mRNA, Comirnaty, BioNTech". The New Zealand international travel vaccination certificate and the UK NHS COVID Pass provided the most comprehensive information on vaccine details, including disease targeted, vaccine/prophylaxis, medicinal product and vaccine manufacturer.

All the vaccination certificates in the selected countries/regions required people to receive the vaccines approved by the health agencies in their countries/regions. Most countries/regions required people to be vaccinated within their country/region, though increasingly some admitted vaccines received abroad. The BioNTech Comirnaty, Janssen, Moderna and AstraZeneca were the four most popular vaccines approved by the high-income countries, with some additional vaccines such as Novaxovoid authorised by European Medicines Agency [32] and AstraZeneca Covishield approved by Australia [33]. However, these vaccines were not available in some countries/regions which had alternative vaccines, such as Covaxin in India, and Sinovac and Sinopharm vaccines in China.

Most of the selected countries/regions showed vaccine details separately for each dose of vaccine received, except for Australian and New Zealand vaccination certificates which gave vaccine details for different doses together. This might be due to the medical regulations in

these two countries suggesting patients receive two doses of the same type of COVID vaccine to be effective [34,35]. The samples of vaccination certificates provided by the health administrations in each country/region displayed vaccine details for two doses. As more people received a booster dose, the details of booster doses were added to their vaccination certificates. Additional information on the batch or lot numbers of vaccines for different doses received by people was shown on the vaccination certificates mostly for international purposes in some countries/regions, including Australia, Canada, South Korea, the UK, the US, and New Zealand's My Covid Record. However, this information was missing on the vaccination certificates in other selected countries/regions.

3.4. Vaccination details

The third part of the vaccination certificates was details about the acts of vaccination, including the date(s) and location(s) of vaccination. Both the date and location of vaccinations were displayed on the vaccination certificates for domestic and international purposes in Australia, the Chinese mainland, Hong Kong SAR, the EU, India, South Korea, Britain and the US. These countries/regions displayed the information on locations slightly differently. Both the country of vaccination and administering centre were displayed on the vaccination certificates for international travel in Australia, South Korea and the UK. Only the administering centre or clinic site was listed on the vaccination certificates for domestic purposes in the Chinese mainland, India and the US, and the country/region on the Hong Kong SAR and the EU vaccination certificates.

The vaccination date for each dose without information on the vaccination location was indicated in the vaccination certificates involving international purposes, including the Canadian COVID-19 proof of vaccination, New Zealand's international travel vaccination certificate, Singaporean vaccination health certificate and South African COVID-19 vaccination certificate. It was not clear whether the information on the administering centre was recorded but not displayed on the vaccination certificates. The New Zealand digital vaccination certificates (My Vaccine Pass) for domestic purposes presented neither the date nor the location of vaccination as it was presumed that only people who were fully vaccinated could get the certificate but the vaccination record could be viewed in My Covid Record.

Apart from the essential details about the recipient, vaccines and vaccination, all selected vaccination certificates contained this information in QR codes. Most of these QR codes were monochrome except for the Chinese health code which employed a tricolour system of green, yellow and red, representing the different grades in risks of the individual carrying virus: a green code meant that the person was in a normal and healthy condition; whereas a yellow or red code indicated that the person was a close contact of a confirmed, suspected or asymptomatic case, or originated from a high-risk epidemic region who were in mandatory quarantine [36]. A link to the most recent COVID nucleic acid test report, including test result, test date and institution, was shown at the bottom of the Chinese health code. The COVID-19 test results were also demonstrated on the Hong Kong SAR electronic testing record and the US Smart Health Card. The expiration date of the vaccination certificate was recorded on the digital vaccination certificate and international travel vaccination certificate respectively in New Zealand. Most of the vaccination certificates in the selected countries/regions were monolingual in their official language, except for the Canadian proof of vaccination which was bilingual in English and French, and the Chinese mainland and Hong Kong vaccination certificates which were in Chinese and English.

3.5. International accreditation

Additionally, the vaccination certificates for international travel purposes need to gain accreditation as international travel policies in many high-income countries are shifting – often for both vaccinated and non-vaccinated travel. Some governments of these countries/regions joined a mutually recognised scheme to facilitate cross-border travel. For instance, the EU COVID certificates could be used for travel within the EU member states and 37 non-EU countries/territories, including New Zealand, Singapore and the UK [37]. Likewise, the vaccination certificates issued in these countries/territories were accepted in the EU. The UK's NHS COVID pass for international travel could be used in over 60 countries/territories [38]. A total of 35 countries/regions had mutual recognition of COVID-19 vaccination certificates with India, including Australia, New Zealand and Singapore [39]. For international vaccination certificates by other countries like Australia and Canada, which did not have such an international accreditation system with other countries, it depended on the international destinations to decide whether to accept their vaccination certificates since these digital certificates needed to be scanned and verified by foreign authorities [40,41]. Likewise, visitors travelling to these countries needed to apply for their vaccination certificates and undertake tests and quarantine at destinations.

4. Discussion

This study set out with the aim of examining the current implementation and practices of COVID-19 vaccination certificates in different countries/regions around the world. The results of the study showed that the common practice of COVID-19 vaccination certificates varied considerably from country to country. In terms of format, the naming convention of COVID-19 vaccination certificates itself indicated the diverse public perceptions of the roles of the vaccination certificates. The COVID-19 vaccination certificates also differed in both content and layout, including personal details, vaccine details and vaccination details. The reasons could be attributed to the primary purpose of COVID-19 vaccination certificates and different considerations about ethical, technical and scientific issues regarding vaccination certificates in different countries/regions.

4.1. Primary purpose and function

The differences could be attributed to different considerations about the primary purpose and function of COVID passes/vaccination certificates. COVID-19 vaccination certificates were issued in some countries/regions with the explicit function of facilitating international travel across different nations/regions [9,11], such as Australian international COVID-19 vaccination certificates, the EU COVID vaccination certificate, New Zealand international travel vaccination certificates and Singaporean vaccination HealthCerts. The vaccination certificates in this category functioned like people's "vaccination passports" which contained personal information about nationality, identity number and the vaccination locations. COVID-19 vaccination certificates were utilized in other countries as passes which give access to various public venues and large gatherings within the country/region, such as the Chinese mainland health code and the Singpass. Other types of COVID-19 vaccination certificates operated both as a pass domestically and cross-border travels, such as the Indian COVID vaccination certificates, the UK NHS COVID passes and the Canadian COVID-19 proof of vaccination.

4.2. Issues and possibilities

The different practices of COVID-19 vaccination certificates in different countries/regions around the world imply some issues as well as new possibilities. Firstly, the cross-national accreditation of COVID-19 vaccination certificates relates to legal issues. Each country/region had its COVID-19 vaccination certificates which were not necessarily accredited in another country/region due to different legal systems. This finding broadly supports the work of other studies in this area linking

legal issues with COVID-19 vaccination certificates [5,6]. Secondly, as the COVID-19 vaccination certificates in most countries/regions were issued in both print and digital format, the information on personal details needed to be verified by a mobile app or computer system to generate a digital certificate. The verification of personal information in systems or apps involves concerns about the privacy and security of data. The concern over the protection of data privacy with COVID-19 vaccination certificates is also mentioned by other studies [42]. Thirdly, the verification process also poses technical challenges to the developers of COVID-19 vaccination verification systems and apps. While some countries, such as South Korea, employed the latest technical solutions such as blockchain technology in the verification of the COVID-19 vaccination certificates, many other countries were not doing so or were not able to do so, though the potential in the application of emerging technologies, such as blockchain technology, has been mentioned as a way forward to protect personal privacy implemented in COVID-19 vaccine passports and contact tracing [43–46].

4.3. Factors affecting implementation

While COVID-19 vaccination certificates have been used in attempts to facilitate effective international travel, large gatherings attendance and protection of public health during the pandemic, their implementation has been affected by factors such as vaccine hesitancy, vaccine efficacy and vaccine rollout [47]. As this study indicated, all COVID-19 vaccination certificates from the 12 countries/regions displayed the name of the vaccine received and some COVID-19 vaccination certificates designated certain types of vaccines as recognised types. The use of COVID-19 vaccination certificates and the data collected for them might also have impacts on vaccine hesitancy: for example, Brazal [48] suggests that vaccine hesitancy in EU individuals might be driven, in part, by a lack of access to European Medicines Agency (EMA) approved vaccines which were required for the EU vaccination certificates. The growing health disparities and inaccessibility of certain vaccines between developed and developing countries or between high-income and low-income communities posed extra social equity and ethical issues to COVID-19 vaccination certificates, as discussed in other studies [7,8,10,18,49].

4.4. Recommendations for policy

Based on the analysis and discussion of the present study, the following recommendations are provided on the practice of COVID-19 vaccination certificates as well as vaccination certificates in general as an important aspect of public health policy. As this study is about vaccination certificates or passes that have been used by various countries/regions in coping with the unprecedented pandemic, these recommendations have implications both to COVID-19 vaccination certificates and to vaccination certifications in general.

1 Awareness about vaccination certificates among people of different backgrounds needs to be enhanced in different countries/regions as demonstrated by the workflow and user guide on electronic vaccination and testing record system developed by the Chinese Hong Kong SAR government, the step-by-step COOV user manual by Korea Disease Control and Prevention Agency, the Notœrise portal by the Singapore government and the SMART Health Card portal maintained by the Boston Children's Hospital;
2 Bilateral and multilateral accreditation and mutual recognition of vaccination certificates, such as the EU Digital COVID Certificate system and the mutual recognition of COVID-19 vaccination certificates with India, need to be implemented across countries/regions to facilitate international travel during the pandemic;
3 Suitable technological solutions such as blockchain technology utilised in the South Korean COVID-19 verification system need to be developed in vaccination certificates to protect people's privacy;
4 Cross-border regulations and facilities verifying vaccination certificates to show proof of vaccination status using QR code check-in systems need to be installed for customs.

5. Conclusion

The present study has examined the current practice of COVID-19 vaccination certificates around the world. Though the scope of this study is limited to 12 representative countries/regions examined, it has shown the similarities and differences in the content and format of COVID-19 vaccination certificates among different countries/regions. While the COVID-19 vaccination certificates offered both public health and economic benefits, there were ethical, scientific and legal issues pending solutions [5]. While these might constitute a great challenge faced by scientists in present times [11], possible solutions can be found through interdisciplinary collaboration among scientists from different areas. This paper advocates stronger international guidance and policy on vaccine certificates that are relevant for COVID-19 and future pandemic settings and on how to make them multi-purpose/function, verifiable, simple to understand and difficult to replicate illegally and safe in terms of protecting personal information.

The two distinct approaches to deal with COVID-19, i.e., coexistence with COVID and zero-COVID policy, fundamentally reflected the essence of different social systems between these countries. It is difficult to say which approach is more efficient in dealing with new variants of COVID. COVID-19 vaccination certificates offered an alternative solution, or "a pragmatic approach" as Sharif et al. [49] term it, to both approaches which could be adopted by countries worldwide. The World Health Organization (WHO) issued an "interim guidance for developing a Smart Vaccination Certificate" [50] and is working on the digital documentation of COVID status. Although attempts were being made to the universal COVID vaccination certificate, it still faced many technical, legal and political barriers [51]. It might be feasible to have a mutually recognisable system for vaccine verification for international travel, but relevant technical, legal and political factors must be taken into consideration. An international organisation, such as the WHO, should take responsibility to define and regulate this system and ensure countries/regions abide by these rules. It is hoped that studies of this kind will foster communication between different countries/regions and provide specific recommendations for government officials, policy-makers and stakeholders.

There are inevitably some limitations in this study because it may not be able to represent every country/circumstance and relevant results may have been missed. These countries/regions are selected because of time and resource constraints, language barriers and focus on countries/regions which had vaccination certificates. Given these constraints, we have done as much as we could and included as many different places as possible. An additional limitation in this study is that it does not constitute a very structured review in methodology. Despite its limitations, the study certainly adds to our understanding of the implementation of COVID-19 vaccination certificates in the selected countries/regions. Notwithstanding the relatively limited sample, this study offers valuable insights into recommendations for other vaccinations in general (e.g., vaccination requirements for border crossing) in future pandemic settings.

Declaration of Competing Interest

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Appendix A. Screenshots and/or scanned copies of vaccination certificates from the selected countries/regions

Australia International COVID-19 Vaccination Certificate	Canada COVID-19 Proof of Vaccination	China Mainland COVID Health Code
China Hong Kong Electronic Vaccination and Testing Record	EU Digital COVID Certificate	India Certificate for COVID-19 Vaccination
New Zealand International Travel Vaccination Certificate	Singapore COVID Vaccination Certificate	South Africa COVID-19 Vaccination Certificate
South Korea COVID-19 vaccination credential	UK NHS COVID Pass	US Smart Health Card

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.simpat.2017.03.014.

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