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Nurgalieva, Leysan; Ryan, Seamus; Balaskas, Andreas; Lindqvist, Janne; Doherty, Gavin Public Views on Digital COVID-19 Certificates

Published in:
CHI 2022 - Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems

DOI:
[10.1145/3491102.3502066](https://doi.org/10.1145/3491102.3502066)

Published: 29/04/2022

Document Version
Publisher's PDF, also known as Version of record

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Please cite the original version:
Nurgalieva, L., Ryan, S., Balaskas, A., Lindqvist, J., & Doherty, G. (2022). Public Views on Digital COVID-19 Certificates: a Mixed Methods User Study. In *CHI 2022 - Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* Article 75 ACM. <https://doi.org/10.1145/3491102.3502066>

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Public Views on Digital COVID-19 Certificates: a Mixed Methods User Study

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ABSTRACT

The COVID-19 pandemic has led governments worldwide to introduce various measures restricting human activity and mobility. Along with the administration of COVID-19 vaccinations and rapid testing, socio-technological solutions such as digital COVID-19 certificates have been considered as a strategy to lessen these restrictions and allow the resumption of routine activities. Using a mixed-methods approach – a survey (n=1008) and 27 semi-structured interviews – this study explores the attitudes of residents in the Republic of Ireland towards the idea of introducing digital COVID-19 certificates. We examine the topics of acceptability, fairness, security and privacy of COVID-related personal data, and practical considerations for implementation. Our study reveals the conditional and contextual nature of the acceptability of digital certificates, identifying specific factors that affect it, associated data practices, and related public concerns and expectations of such technologies.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in ubiquitous and mobile computing**; *User studies*; • **Security and privacy** → *Social aspects of security and privacy*.

KEYWORDS

digital health, COVID-19, COVID certificate, privacy, security, fairness

ACM Reference Format:

Leysan Nurgalieva, Seamus Ryan, Andreas Balaskas, Janne Lindqvist, and Gavin Doherty. 2022. Public Views on Digital COVID-19 Certificates: a Mixed Methods User Study. In *CHI Conference on Human Factors in Computing Systems (CHI '22)*, April 29-May 5, 2022, New Orleans, LA, USA. ACM, New York, NY, USA, 28 pages. <https://doi.org/10.1145/3491102.3502066>



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CHI '22, April 29-May 5, 2022, New Orleans, LA, USA
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ACM ISBN 978-1-4503-9157-3/22/04.
<https://doi.org/10.1145/3491102.3502066>

1 INTRODUCTION

In response to the ongoing global pandemic of the coronavirus disease COVID-19 [20], governmental authorities all over the world have implemented restrictive measures to reduce the spread of the virus, ranging from enhanced hygiene recommendations and business closures to lockdowns and travel bans. Several countries, including the Republic of Ireland, have deployed information systems (ISs) as part of their infection control and crisis response strategy. One such IS is digital contact-tracing (DCT), which uses co-location tracking to notify those who have been in close contact with a confirmed COVID-19 case [61]. The Irish COVID tracker app achieved the highest acceptance in Europe [62] and the highest uptake rate among similar voluntary installation apps, close to 40% of the country's population [23].

As COVID-19 vaccinations started to be administered, the further measure of immunisation certification (or “vaccination passports”) was introduced to help ease public health restrictions. These certificates would offer proof of COVID-19 status and permit those who recovered or have been vaccinated for COVID-19 to resume routine activities, such as social interactions and travel. In June 2021, “EU Digital COVID Certificate” (EUDCC) was introduced in the European Union, allowing free human mobility within the territory of the European Member States [21]. Besides COVID-19 recovery or vaccination, the EUDCC also includes a negative test result option [11]. At the time of writing, the certificate is issued for free by the national authorities and recognised by all EU 27 member states. The certificate consists of a QR code displayed on a device, such as a smartphone or a tablet, or printed with a digital signature, verified via an EU Gateway.

With the introduction of the EU COVID certificates, a new feature has been integrated into the COVID tracker Ireland app. It allows for digitizing the paper version of the COVID-19 vaccination or recovery certificate by scanning the QR code and uploading it into the app for digital storage. As the vaccination rate accelerated in Ireland, the introduction of such certificates triggered discussions concerning the implementation of similar dedicated technologies that would allow people to participate in various types of activities more freely. As of today, the government of the Republic of Ireland has launched a separate app called “EU Digital COVID Certificate Checker” [1], which allows organisations to scan COVID-19 vaccination certificates, offer proof of COVID-19 immunity status, and allow access to activities such as indoor sports and social events,

easing public health restrictions. The app can scan an COVID-19 certification QR code using a mobile device, and will state an individual's full name and whether their vaccine certificate is valid.

Definition of such solutions was discussed in previous research, indicating that the term "passport" might be perceived as "all-or-nothing permission" and suggesting the use of other terms such as "license" or "certificate" [47]. The same applies for "immunity" or "vaccination" terms – one can develop antibodies through vaccination or contracting the virus, which nevertheless does not exclude the risk of infection or transmitting the virus [10]. In this study, we use the term "COVID-19 certificate" consistent with the EU initiative (COVID-19 recovery, vaccination certificate, or a negative test result).

The introduction of digital COVID-19 certificates also raises a number of practical challenges, such as the epidemiological and scientific feasibility [9], necessary technical characteristics [60], and legal basis of such technology [19]. Moreover, the privacy of disclosing personal information in digital health systems and crisis-response technologies has its own complexity and implications [42, 57, 58]. From an ethical point of view, such interventions can conflict with civil liberties [10] or increase inequality [47]. An understanding of public views, including associated concerns and perceived benefits of such technology, is needed in order to ensure that such applications can meet their desired healthcare goals, supported by high uptake and continued participation.

External variables often affect individuals' technology acceptance and vary from country to country [16]. For instance, legal informational and cultural norms, social factors, or government support influence the acceptance or resistance to technology adoption [2, 61]. The Republic of Ireland is a country with highly digitized public services, such as healthcare and social welfare, with national legislation on the use of telemedicine and reimbursement of eHealth services [22]. Considering such contextual factors and the high acceptability and uptake rates of the digital contact-tracing app and COVID-19 vaccinations, the deployment of a COVID tracker app as a digital vaccination certificate in Ireland provides an opportunity to study technology acceptability at both the pre-use and initial use acceptance stages [37]. Furthermore, the combination of DCT and COVID-19 vaccination data is an opportunity to study public views on such integration and associated privacy concerns. Hence, homogeneous external factors in the Republic of Ireland, such as a single national strategy regarding COVID-19, high digitization, and a generally high level of public support, provide an opportunity to focus on fundamental factors of technology acceptance.

In this study, we explore the views of residents in the Republic of Ireland, including the topics of acceptability, fairness, data practices, and practical considerations of using digital COVID-19 certificates. Specifically, we aim at answering the following research questions (RQs):

- (1) RQ1. What are the views of potential users on the introduction of digital certificates for COVID-19 and factors that affect their acceptability?

- (2) RQ2. What are the views of potential users on the implementation of such technology, including data handling, interaction design, and potential future evolution of such digital certificates?

Our work contributes to crisis informatics and public health research by informing the design of ongoing and future crisis-response digital public health systems. By exploring user views, our findings can help support the development of acceptable technological interventions for public health, and highlight potential implementation risks. As little work in this field has examined public views in the pre-adoption phase, usage behaviours, and design characteristics of such solutions during times of crisis, we contribute new knowledge on the contextual and conditional nature of public health technology acceptance and outline practical considerations for personal data flows on such systems.

2 BACKGROUND AND RELATED WORK

COVID-19 certificates (also known as "vaccination/immunization passports") are currently being actively considered and implemented in a number of countries around the world to allow the public to resume routine activities, such as social interactions and travel. Such certificates offer proof of the holder's COVID-19 status as posing a lower risk for the transmission of the virus within the community (COVID-19 recovery, vaccination, or negative test) [11]. While considered a means to lift public health restrictions, such a solution has become a topic of debate [34].

Some have argued that there is insufficient evidence relating to COVID-19 immunity resulting in impractical implementations [27]. Other studies indicated related privacy risks [65], fairness issues, risks of fraud and discrimination, and limitations in individual freedoms [8, 35]. Previous research studied ethical considerations of using immunity certificates indicating potential negative outcomes, such as increased risks for corruption and implicit bias [48] or inequality, which are prominent within the scientific community [4]. Inequality can be exacerbated by creating a novel layer of biological inequity [5] and amplifying social or economic exclusion of people without COVID-19 certificates [47]. Another negative aspect is related to the lack of responsibility. While introduced to improve the epidemiological situation, Brown et al. reasoned that COVID-19 certification could instead reward or even incentivize reckless behaviour by releasing certificates to those who failed to follow government guidelines and acquired immunity through irresponsible behaviour [10]. Irresponsible behaviour could also be related to the false sense of security enabled by COVID-19 certificates, as the holders can still endanger the health of their close contacts [15]. Positive ethical arguments included optimizing available state compensatory measures [63] and reviving national economies [55].

As pointed out by de Miguel Beriain and Rueda, COVID-19 certificates will exist, potentially without regulatory governance, a trend observed in many countries including the Republic of Ireland [12]. Hence, the current debate is shifting towards the practical implementation of COVID-19 certificates, in particular, in their digital format. Several studies have been published discussing technical limitations of using such technological solutions, for instance, the absence of guidelines for documentation of vaccination [55] or security and privacy risks of personal data sharing [60].

Established literature on the topic of health technology acceptance suggests challenges in preuse acceptability can be considered distinctly from those that stem from initial use acceptance [37]. There is also a documented distinction of sharing health data for the purpose of general health betterment versus when it is being used as a monitoring tool [13]. These are issues in any digital COVID-19 certification adoption due to the significant level of public discourse in advance of application availability. Considering the controversial nature of digital COVID-19 certificates, both from the ethical and practical points of view, governments and health authorities should be aware of, and account for, public concerns and attitudes towards the requirement to use such technology in daily life.

To date, only a few research studies have explored public attitudes and behavior towards the use of mobile technologies as part of handling infection control. A survey conducted by Doraiswamy et al. among the global physician community (n=1004) indicated the lack of support among them for COVID-19 certificates [14]. A literature review conducted by Drury et al. analysed studies that measured attitudes towards or behavioural consequences of health certificates. Their work indicated that public attitudes are generally favourable towards international travel and protecting the vulnerable, but unfavourable towards their use for access to work, educational or religious activities or settings [15]. The review indicates that user studies conducted to date lack in quality and quantity, and point to the need to explore the potential risks of introducing such certificates, and possible mitigation strategies. Moreover, most of the reviewed studies measured public attitudes in 2020, when certification schemes were not widely discussed or implemented, which makes it particularly important to study them after such schemes are introduced or actively considered as an approach to controlling transmission of the virus.

At the national level, Lewandowsky et al. conducted two large-scale surveys in the United Kingdom (n=1500) exploring public attitudes towards tracking technologies and COVID-19 certificates, which revealed widespread support for both [32]. This finding was in line with the public views in Switzerland [39] but different to the response to the survey conducted by Betsch et al. in Germany where almost half of the respondents were against the introduction of a COVID certificate [7].

With regards to the Republic of Ireland, there have been a few user studies examining public attitudes towards COVID-19 crisis response mobile technologies, which primarily addressed digital contact tracing. A national study on public sentiment towards privacy and the Irish COVID tracker app was conducted by Lohar et al. where they analyzed Twitter data collected from public accounts and feedback data from a national survey on privacy conducted in the Republic of Ireland (n=1012) [33]. While the findings revealed some positive attitudes towards COVID-19 crisis response, there was a significant criticism towards the app that related to privacy, as well as doubts regarding its efficacy. This indicates a need for improved communication regarding both the efficacy of digital contact tracing, and of personal data privacy. Study findings also indicated the trust of Irish residents in public institutions compared to private ones, implying the need for a greater involvement of and reliance on public actors [33]. A few studies focused on improving the design of the application during its implementation [24, 44] and

after it was released. Such studies adopted both qualitative (e.g. focus groups and "think aloud" interviews) and quantitative methods (sentiment analysis of user reviews from the Google/Apple play-stores) to investigate the usability of the COVID tracker app [18] and explore unmet user needs and concerns [52].

Since the end of July 2021, the Irish COVID tracker app has been modified to allow the uploading of COVID-19 vaccination certificates, as a temporary solution towards digital COVID-19 certificates. This makes it an opportune moment to explore attitudes towards the introduction of digital certificates, and their practical implementation.

Addressing user needs – both conceptually and practically – is vital for informing public discourse and the development of such technology. Moreover, as such technological solutions set a unique precedent for digital health systems with their ethical, fairness, and privacy implications, it is important to consider public concerns and future views on such systems. Therefore, in this study, we seek to investigate the acceptability of digital COVID-19 certificates, explore public views on acceptable use cases, as well as perceived risks and benefits for individuals and society.

3 METHODS

To answer the research questions defined for this study, we used a mixed-methods approach combining an online survey with semi-structured interviews. The study was reviewed and accepted by the Research Ethics Committee (REC) of the School of Computer Science and Statistics of Trinity College Dublin, reference number 20210402.

3.1 Online Survey

We conducted a 49-item online national survey among adults residing in the Republic of Ireland between the 7th and 26th of July, 2021. A total of 1036 individuals started the survey and consented to participate. After removing incomplete responses, we had a sample of 1008 complete and unique responses (completion rate = 97.3%).

3.1.1 Survey design. A survey was released via Qualtrics XM survey software [49] and published using the online survey panel, Prolific Academic, which has demonstrated good reliability and validity in prior studies [17, 46]. A complete description of the survey can be found in Appendix A; here, we provide an overview.

After collecting respondents' informed consent, they were introduced to the idea of digital certificates for COVID-19 and asked about their general views and concerns on the topic. The survey then proceeded with questions on the personal acceptability of such certificates, the fairness of introducing them, and the purposes such certificates should be used for, as well as questions on sharing COVID-related personal information. Finally, respondents were asked demographic questions and questions related to their personal experience with COVID-19, such as vaccination views and general pandemic-related concerns. At the end of the survey, participants could provide additional comments, ask questions, and access mental wellbeing resources if necessary.

3.1.2 Survey participants. The majority of survey respondents were younger adults between 18 and 40 years (772/1008 or 76.6%), white (940/1008 or 93.4%), and female (746/1008 or 74.1%). With

regards to residence, they almost equally resided in urban (352/1008 or 35%), suburban (362/1008 or 36%), and rural (294/1008 or 29.2%) settings. Table 1 presents basic demographic information of our study cohort (N=1008), the full information can be seen in the Appendix D.

Table 1: Demographic characteristics of survey respondents (N=1008).

Attribute	Range	Sample size
Gender	Female	746 (74.1%)
	Male	252 (25%)
	Non-binary	6 (0.6%)
	Prefer not to disclose	3 (0.3%)
	Prefer to self-describe	1 (0.1%)
Age	18-30	394 (39.1%)
	31 - 40	378 (37.5%)
	41 - 50	168 (16.7%)
	51 - 60	55 (5.5%)
	61 - 70	10 (1%)
	>71	3 (0.3%)
Race and ethnicity	White - Irish	821 (81.5%)
	Any other White background	119 (11.9%)
	Black or Black Irish - African	19 (1.9%)
	Any other Black background	1 (0.1%)
	Asian or Asian Irish - Chinese	12 (1.2%)
	Any other Asian background	19 (1.9%)
	Other, including mixed background	17 (1.7%)
Residence area	Urban	352 (35%)
	Suburban	362 (36%)
	Rural	294 (29.2%)

With regards to COVID-19 experience, almost half of the participants have been tested for COVID-19 (482/1008 or 47.9%), among which 59/482 or 12.3% ever tested positive (59/1008 or 5.9% of total survey respondents). Following a phased rollout, vaccination for all remaining adults 18+ was open from the 21st of July. The survey results show the majority of survey participants were given the opportunity to avail of a COVID-19 vaccination (874/1008 or 86.8%), and most of them had received it (626/874 or 71.7%) or had the vaccination scheduled (140/874 or 16.1%). Only 108/874 or 12.4% of respondents did not avail of the vaccination offered to them.

3.1.3 Quantitative data analysis. An Ordinal Regression model was created for the identification of the factors that correlate with the intention to install a COVID-19 certification application. This was chosen due to the expected normality of data distribution and the ordinal dependant variable. This approach was registered with the Open Science Foundation in advance of any team member reviewing the data [43]. The analyses were carried out in R v4.0.4 [50].

3.2 Semi-structured Interviews

In addition to the national survey, in July 2021, 27 semi-structured interviews were conducted. To ensure the safety of our participants during the COVID-19 pandemic, the interviews were conducted over the phone or remotely via Zoom call, based on each participant's choice. Each interview lasted for 25-30 minutes and was compensated with a €20 Amazon electronic gift card.

3.2.1 Screening survey. To balance the sample of interview respondents by age, gender, and ethnicity, we conducted a 16-question screening survey (Appendix B) with those interested in participating. The screening survey was advertised through community centres, local organizations, organisations close to the University, as well as through word of mouth and snowball sampling. The decision to take part in the study was completely voluntary. Participants who completed a screening survey entered a random draw of a 20 euro Amazon voucher. Eligibility criteria included level of English from Intermediate and higher and the absence of a severe cognitive impairment (such as dementia or Alzheimer's disease).

3.2.2 Interview participants. The screening survey was completed by 94 respondents, and 27 participants, who were eligible for the study and provided their contact details, were invited for the interviews. Table 2 provides demographic information of interview participants.

Table 2: Demographic characteristics of interview respondents (N=27).

Attribute	Range	Sample size
Gender	Female	15
	Male	10
	Non-binary	1
	Prefer not to disclose	1
Age	18-30	10
	31 - 40	5
	41 - 50	5
	>50	7
Race and ethnicity	White - Irish	10
	Any other White background	12
	Asian or Asian Irish - Chinese	1
	Any other Asian background	1
	Other, including mixed background	3
Highest level of education	Secondary	2
	College	2
	University	10
	Postgraduate	13
Self-described state of health (i.e. mental and physical)	Very good	9
	Moderately good	11
	Neither good nor poor	6
	Moderately poor	1
Did you receive a vaccination for COVID-19?	Yes	17
	No	10
How likely are you to get a COVID-19 vaccine when one becomes available to you (n=10)?	Extremely likely	7
	Somewhat likely	1
	Unsure	1
	Extremely unlikely	1

3.2.3 Qualitative data analysis. The semi-structured interview covered the following primary topics: (1) participants' pandemic experience; (2) general views on the introduction of COVID-19 certificates including their acceptance, potential advantages and drawbacks, and privacy concerns; (3) fairness of such measures; (4) views on the hypothetical scenario and practical implementation of such certificates in a mobile app. The full interview guide is presented in Appendix B. All interviews were recorded and transcribed using commercial language processing tools (Happy Scribe [56]), manually reviewed by the first author, after which interview recordings were destroyed as well as any personally identifiable information.

As the semi-structured interview guides were quite focused (see Appendix C), the qualitative data analysis adopted a hybrid approach: a-priori coding followed by thematic analysis or inductive

coding [31]. Initially, the first three authors discussed and agreed on the high-level categories for the codebook, which included participants' relevant experience and background, general views on the idea of introducing digital certificates for COVID-19, views on privacy and personal data, comments on fairness, as well as views on the digital implementation of such certificates. Next, each of the first three authors independently coded the same three interviews under each of the high-level categories. The next step included a group discussion where the first three authors presented their separate codebooks, resolved disagreements, and agreed on the common codebook. The first three authors then proceeded to code an additional three interviews using the final codebook. As no new codes were added, the coding of the remaining interviews was distributed between the first three authors.

4 STUDY 1: ONLINE SURVEY

In this section, we present the results of the large-scale online survey, which covered such topics as respondents' views on the introduction of certificates for COVID-19 by the Irish government and the acceptability of such certificates in a digital format. The survey shows the prevailing support towards such an initiative in our sample, as well as high acceptability of digital certificates, which was slightly higher in female participants. The results also detail the primary reasons for adoption of such systems, which include travel purposes and attendance of social events, and identifies privacy concerns as the dominant barriers. Finally, the questions on data sharing preferences investigate participants' views on whom their COVID-19 related personal data should be shared with, and for what purposes.

4.1 Descriptive Statistics

4.1.1 Views on the introduction of COVID-19 certificates. Participants were asked *whether they would support the Irish government proposal to introduce "immunity certificates" for COVID-19*. While just 9.6% or 96/1008 indicated that they would not support this at all and 13.2% or 133/1008 would support slightly, 22.6% or 227/1008 of respondents said they would support moderately, 26.3% or 265/1008 – a lot, and 28.5% or 287/1008 – fully.

With regards to more detailed reasoning behind respondents' opinions, they were asked whether such certificates are an appropriate means to handle a global pandemic crisis, good for public health, economy, fair to others who do not have COVID-19 immunity, whether it could increase inequality, and if it is practically feasible. Figure 1 summarises participants' responses, indicating strong support of the certificates for the economy, but also concerns regarding the fairness and practical feasibility of such solutions.

Survey participants were also asked to choose the *purposes COVID-19 certificates should serve*, and the most popular answer option was "Allow international travel" (796/1008) followed by "Allow attendance at social events" (691/1008), "Allow people to return to any job" (588/1008), "Allow domestic travel" (566/1008), and "Allow people to return to high risk jobs" (559/1008). While the most common answer to this question included all choice options (278/1008), the next most popular answer was only "Allow international travel" (70/1008). The open answer field was used by 72/1008 or 7.1% of participants who provided additional comments on the purposes a

COVID-19 certificate should serve. Besides comments that no such purposes should be pursued (31/72 comments), that is, such certificates should not be implemented, respondents mentioned such topics as access to indoor activities (11/72) including hospitality and indoor group activities, and education. Another topic that was mentioned in the comments was related to the wish that COVID-19 certificates would allow life to return to normal or pre-COVID state (9/72 comments).

4.1.2 Acceptability of digital COVID-19 certificates. With regards to personal *acceptability of digital COVID-19 certificates*, the majority of the participants answered that it is extremely (57.7% or 581/1008) or somewhat likely (24.8% or 249/1008) that they would install a digital certificate if it would be provided in the form of a phone application. With regards to gender differences, female participants were more likely to install it compared to males² (Table 3).

When asked about the reasons *in favour of installing it* ("What would be your main reasons for installing a digital immunity certificate?"), "travel purposes" was the most popular answer option (793/1008) followed by attending social (692/1008) and recreational events (634/1008), and "a sense of responsibility to the wider community" (491/1008). One-third of the respondents also mentioned work-related reasons (360/1008) and attendance of cultural activities (341/1008) as reasons to install the digital certificate. The least popular answer option was "to attend religious events" (127/1008). A few additional comments (19/1008) referred to the convenience of the ease of use compared to a paper version of it ("Easier to carry it than a paper version"), using it to avoid being excluded ("To not be left out by not having it"), or rejecting the idea of digital certificates ("I refuse to use a digital immunity cert").

As for the reasoning *against adopting such technology* ("What would be your main reasons against installing a digital immunity certificate?"), "none" was the most popular answer (367/1008). Beyond this, the most popular concerns were related to privacy, such as continued governmental surveillance beyond the pandemic (294/1008) and concerns that public health authorities of Ireland (224/1008) or of countries other than Ireland would have access to their personal data (258/1008). Security concerns ("I worry that my phone will be more likely to get hacked") were relevant for 180/1008 respondents. Few respondents used the comment option (40/1008). Besides comments rejecting the whole idea of COVID-19 certificates ("Morally opposed to the idea"), the answers fall into the following categories: the lack of trust in the government, security concerns due to recent HSE cybersecurity attack ("Would there be a risk of this data also being stolen as the HSE data was stolen earlier this year"), fairness and privacy concerns ("Companies mining data, rather than the government," "Adding to greater inequalities between citizens"), and practical concerns related to the lack of phone storage and compatibility with other countries' certificates.

4.1.3 Sharing their COVID-19 status. Finally, the survey included a series of questions on *sharing COVID-19 status* with various actors and organisations. As can be seen in Figure 4, medical doctors and nurses, public health authorities and current governmental authorities of the country of residence are the top three actors or

²The number of participants of other genders was too low to include in this question analysis (10/1008 or 1%)

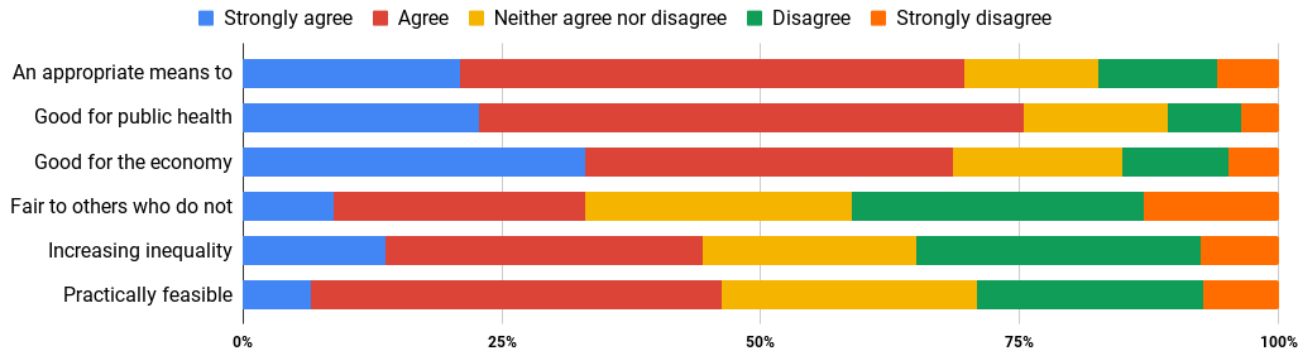


Figure 1: Do you agree with the following statement: “I think that giving immune people immunity certificates for the duration of their immunity is...” , %

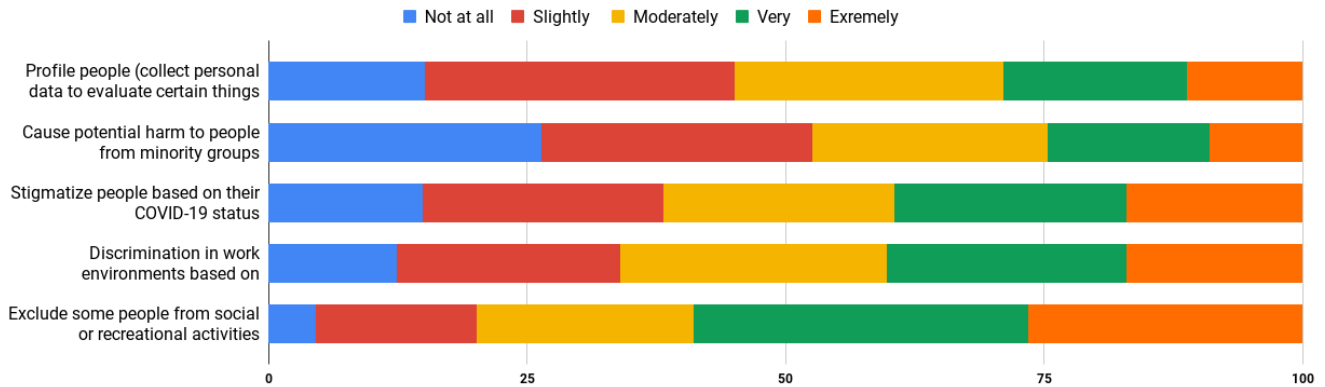


Figure 2: Potential risks that could be caused by introducing immunity certificates, “To what extent there is a risk that immunity certificates will...” , %

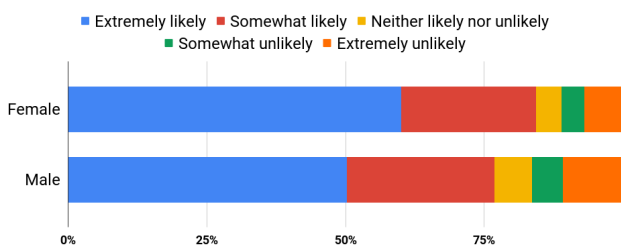


Figure 3: Likelihood of installing a digital certificate if provided in the form of a phone application, by gender, %

institutions participants are willing to disclose their vaccination status – more than 70% of the participants chose them answering this question. Other popular actors were scientists or sharing for research purposes (643/1008), governmental authorities (592/1008) and public health authorities of other EU countries (581/1008), and employers or workplace organisations (576/1008). A small number

of participants (21/1008) commented using the “Other” answer option, which can be grouped into the following categories: friends and family, recreational or educational facilities, private health professionals or anyone. Another category of comments included conditions of the disclosure, for instance, “someone [who] has genuine cause” or “depending on guidelines [...] for return to normality.”

4.2 Statistical Analysis

An ordinal regression model (Model 1) was created to identify what variables increased or decreased the odds that someone would be willing to install a digital COVID-19 certificate. The independent variables selected were questions related to perceived issues of risk, personal COVID-19 experience, and perceptions of fairness. The intention to install a digital COVID-19 certificate was used as the dependent variable. Table 3 provides the details on the statistical analysis related to Model 1.

Three variables were identified as having a positive effect on the odds for application adoption. Strong, statistically significant, correlations with whether a participant would support a government proposal to introduce “immunity certificates” for COVID-19 (OR

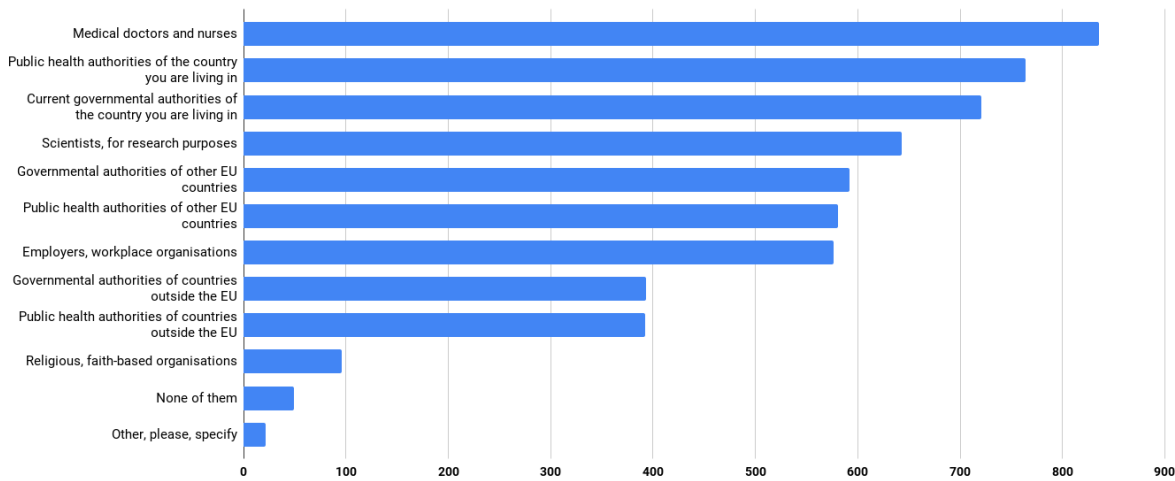


Figure 4: Views on sharing their vaccination status, “With what actors and organisations would you be willing to share your vaccination status?” number of participants who chose these options.

= 2.13, CI = 1.82-2.5, $p < 0.001$) and if they had received, or were scheduled to receive, a vaccination for COVID-19 (OR = 1.95, CI = 1.39-2.71, $p < 0.001$). This suggests that the odds of a participant being willing to install the application increased if they supported the governments’ proposal (as might be expected) and if they were intending to receive, or had already received, the vaccine. Additionally, a strong correlation was identified in the model between adoption intention and the risk of Covid Passports/certs excluding some people from social or recreational activities (OR = 1.4, CI = 1.16-1.7, $p < 0.001$). This suggests that those that anticipated needing the digital COVID-19 certificate to access certain activities were more likely to intend to install it.

A negative correlation was identified with the risk that certificate applications would be used to profile people (collect personal data to evaluate certain things about individuals) (OR = 0.85, CI = 0.73-0.99, $p = 0.0348$). The scale of this effect is small but statistically significant. This suggests that participants who believed that the application would profile people had lower odds of intending installing to it.

In contrast, concerns related to Fairness did not reach the level of statistical significance in this data set.

5 STUDY 2: INTERVIEWS

5.1 Acceptance of Digital COVID-19 Certificates

Views on digital COVID-19 certificates are strongly related to COVID-19 vaccination views [15], which was also indicated by the survey results (Section 4.2). Although we did not ask vaccination-related questions specifically during the interviews, the respondents often mentioned this topic in relation to the certificates.

As can be seen from the pre-interview screening survey (Table 2), most of the interview participants either received or scheduled their COVID-19 vaccinations, and only two of them either rejected or

had strong concerns about them, which is broadly in line with 88.2% 18+ vaccine uptake in Ireland. However, most of the participants still expressed concerns on the concept of COVID-19 certification related to the lack of understanding and clear communication on the implications of COVID-19 vaccination, such as remaining risk to transmit the virus (“*The big concern for mine is that it gives a false sense of security [...] I just think people think, oh, I’m immune, that’s it. I can do whatever I want,*” P11) or limited time span of the immunity (“*It’s a moving target, so whatever treatment people have received in the prophylactic sense is only valid at a certain time at a certain place. If we are sort of four or five mutations, that treatment is completely invalid and irrelevant,*” P3), disinformation campaigns, limited availability of the vaccines and the complications of having vaccinations in different countries (“*I actually called HSE to understand how I could get the green pass if I took one vaccine in Italy and one in Ireland. And I feel like there is no rule for that and I’m pretty sure it’s going to take a while before I get to the actual green pass,*” P24).

5.1.1 Conditional acceptance. While most of the participants had a generally positive attitude towards introducing digital certificates for COVID-19, they often discussed various factors for the conditional acceptance of such measures. These factors can be categorised as the following: improved epidemiological situation, more information on COVID-19 vaccination, temporal condition, accessibility of certificates, activities enabled by the certification, opt-out options, and technical implementation expectations (Table 4).

5.1.2 Contexts and purposes of use. As individuals are embedded in social activities and systems, the context of technology use creates conditions for use and affects technology acceptance decisions. In recent HCI research, user activity often defines the context [25], and indeed, interview participants often described various contexts as acceptable or not for using digital COVID-19 certificates, and reasoning behind these opinions.

Table 3: Ordinal Regression Model 1 - Odds that a participant is more likely to install a Covid Passport Application

Variable	Odds Ratio (95% CI)	σ
To what extent there is a risk that certificates will:		
Profile people (collect personal data to evaluate certain things about individuals)	0.85 (0.73-0.99)	0.0348
Cause potential harm to people from minority groups	0.96 (0.82-1.13)	0.632
Stigmatize people based on their COVID-19 status	0.89 (0.73-1.08)	0.239
Discrimination in work environments based on vaccination status	1 (0.82-1.22)	0.985
Exclude some people from social or recreational activities	1.4 (1.16-1.7)	< 0.001
Would you support a government proposal to introduce "immunity certificates" for COVID-19?*		
Did you receive a vaccination for COVID-19?†	2.13 (1.82-2.5)	< 0.001
To what extent do you believe that it is fair for people with "immunity certificates" for COVID-19 to go back to social activities †		
Very unfair	2.04 (0.83-5.07)	0.122
Somewhat unfair	0.84 (0.41-1.75)	0.642
Somewhat fair	0.87 (0.49-1.55)	0.631
Very fair	1.32 (0.84-2.08)	0.227
Extremely fair	1.03 (0.73-1.44)	0.885
To what extent do you believe that it is fair for people with "immunity certificates" for COVID-19 to travel freely †		
Very unfair	1.46 (0.61-3.57)	0.398
Somewhat unfair	1.53 (0.77-3.1)	0.23
Somewhat fair	1.17 (0.67-2.06)	0.589
Very fair	0.86 (0.54-1.36)	0.514
Extremely fair	0.92 (0.66-1.3)	0.651

* - Dummy Variable is "No" † - Dummy Variable is "Extremely Unfair"

Residual Deviance: 1471.463

AIC: 1513.463

Table 4: Conditional acceptance categories

Category	Definition	Examples
1. Lower spread of the virus, improved epidemiological situation	Concerns related to the risks of getting or transmitting the virus even after being fully vaccinated when the daily cases are still relatively high, which leads to acceptance of certificate use when the epidemiological situation improves, e.g. if there would be a lower number of COVID-19 daily cases	"I don't see myself going inside in a restaurant for another while, at least, not until the infection was reduced in Ireland," P12;
2. More information on COVID-19 vaccination	More clarity, information, and research is needed on COVID-19 vaccination for individuals to accept the certificates	"I just want more study, my concern is the long-term benefits, my concern is, can the vaccine wake up something in my body? For example, I have historic cancer in my family [...] more insurance, that's my only concern," P4;
3. Temporal condition	Acceptance of using the certificates on a fixed-term basis or in the pandemic emergency situation and not after the emergency is over	"I see them as probably a necessary short-term measure [...] I would have more reservations about this long-term use, but in a pandemic emergency, I would generally be supportive of it," P12;
4. Accessibility of certificates	Accepting digital certificates if the accessibility of them is ensured for those in different socio-economic or legal contexts, with limited access to technology or ICT skills, or to individuals who did not yet have a chance to get vaccinated.	"If someone doesn't have a smartphone, a homeless person, how can they get one? [...] Looking at that other side of it, it's like, okay, so you've got the standard person where you live in a house and you have all your documents, and you have your smartphone, that will work that way, and then, but what about the other scenarios? I just want to understand what pathways they are putting in for other people as well," P23;
5. Activities enabled by the certification	Acceptance based on the activities enabled by certification	"I can't really see advantages [of introducing digital certificates] apart from, if you have a system where it'll allow you to access and resume some level of normality, you know, before COVID disappears or before COVID is defeated or whatever then yeah, there is that but the trade-off is big," P23;
6. Opt-out option	Accepting certificates if they are not mandatory, if there is an option to opt-out	"I do see a COVID digital certificate is ultimately a good thing, it's just whoever's involved in the designing of it needs to be careful with regards [...] how they allow people to opt in or opt out," P7;
7. Technical implementation expectations	Acceptance of digital certificates if certain technical implementation expectations are met, for instance, high level of data security or feasibility from the epidemiological point of view	"I have no real concerns as such. More down to how it's implemented technically in relation to the biological reality we live in, it's not [...] So it's a new challenge, which means that most of the implementations I have seen so far are completely inferior," P3.

The most commonly mentioned context of use was international travel, and most of the participants (25/27) considered digital certificates acceptable to be used for that purpose (*"I booked a flight to [home country] to see my dad who I haven't seen in two years, and I can do that, because I have that passport, it's super positive,"* P14). When elaborating their views, participants often provided such reasons as the reduction of both outgoing and incoming COVID-19 cases (*"I definitely think it should be used for travel, I think we have to cut down on the amount of COVID being brought into and out of different countries and particularly Ireland,"* P17), flights being closed spaces with unavoidable close contact (*"I think travel is sensible, because you have unavoidable close contact, especially on aeroplanes,"* P12; *"I think travel is, you know, you're putting you know 300 people in a tin can for a couple of hours, it was bad at the best of times but it's not a great prospect,"* P19), or economic reasons, as constant testing might not be financially sustainable. Moreover, some participants compared COVID-19 certificates with existing health requirements for travel, and considered it as yet another type of such requirements (*"I come from a third world country [...] so when you travel to other countries, say the EU or the US, to get a visa, you need to show that you've had vaccinations against tetanus and other things anyway, so to add one more to that list is okay, it doesn't really make a difference to me,"* P10).

Indoor events and hospitality was the second most accepted use context (14/27), including pubs and restaurants, indoor recreational and cultural activities. With regards to the hospitality industry, interview participants often mentioned their opinions on using COVID-19 certificates both from the customer and business points of view recognising private business challenges as well (*"I don't personally get the argument and the backlash. People like abusing restaurants who have that policy in place, and I don't mind it,"* P25). As P19 describes it, (*"You can't have a system that's going to work without the people who are working in hospitality and the people who are enjoying the services. The contract between them is that they protect each other,"* P19). However, other participants (4/27) did not consider using the certificates for indoor dining as necessary or practical suggesting that protective means can be continued to be used (*"Maybe for a restaurant, you can continue to keep a face mask, but you wouldn't need a certificate,"* P2).

The workplace was often seen as an acceptable use context (7/27). However, participants often referred to certain conditions for digital COVID-19 certificates to be used in the workplace, such as inability to work remotely (*"I suppose for workplaces where people have been perfectly able to do their job offline, perhaps it is reasonable to say, if you want to come back in, you have to have vaccinate. Otherwise, you continue to work from home, no social parts to it,"* P17) or working in specific industries such as healthcare, education (*"No healthcare worker should come inside the premises of any healthcare environment without [COVID-19 certificate]. I think no educator or no education employee should come inside their workplace without one,"* P15); or hospitality. Other participants considered workplaces as definitely unacceptable contexts to share such information, comparing COVID-19 status to other personal data that also shouldn't be shared there: *"You're not allowed to be asked if you're pregnant or not, [...] how old you are, that's the questions they can't ask you anymore and then you shouldn't be putting it out on your CV, so I don't see how this is different,"* P4.

As for social contexts, participants generally agreed that individuals can mediate their communications and find ways to accommodate those with and without COVID-19 immunity without the use of such certificates (*"For social occasions, [...] I think it's hard to see how the government would say 'you can have 100 people at your wedding but they must all be vaccinated'. That seems a little difficult because a wedding isn't a wedding really if you don't have certain key people at it,"* P17). For instance, P23 described it in this way: *"If someone's not comfortable inviting someone that has COVID or isn't vaccinated into their home, that's one's personal decision to protect themselves for whatever reason."*

Finally, several participants did not mention specific contexts but described certain characteristics of them that would require the use of COVID-19 certificates, such as "dangerous areas" or "crowded places" (*"The cinema, sports stadiums, these are places where people would be crowded and become very close to each other,"* P9).

The topics of fairness, personal data and privacy, as well as possible technical implementations of digital certificates were other primary themes of the interviews, which we discuss next.

5.2 Fairness

Fairness is generally defined as the approach to ensuring that no individual or group of individuals are treated any worse than another similar group. It has become a key component in the analysis of ethics within technology and is an important goal in the design of medical technology [36].

Part of the analysis of the qualitative interviews focused on the understanding of perceptions regarding fairness of elective COVID-19 certificate adoption and the impact that choice has on those involved. Participants generally acknowledged the distinction between those that could not and those that choose to not receive vaccinations (*"I think it's for me I just have more leniency if people [...] can't get vaccinated because of a medical condition as opposed to a choice. I think they're very different,"* P23). Several participants shared views that those that choose not to receive the vaccine should be excluded from social activity (*"I think I don't have much sympathy for the for the people who choose not to be vaccinated because they're stupid and short-sighted and blind, and I don't have a lot of sympathy for all that,"* P17; *"For those who choose not to vaccinate, to be honest, I'm of the opinion where they don't seem to care about my public health, my health or, in general, help the nation. Why should I care about their concerns?"* P7).

Those who can not vaccinate due to medical conditions were viewed sympathetically. However, most did not suggest any additional considerations to be proposed for them (*"It is unfair for them, so hopefully, digital immunization certs is kind of a medium term kind of procedure or solution and it's not going to be long term, because it's unfair to, for example, separate families who can travel or can dine indoor just because they have a division of the opinion or some people just can't have the vaccine,"* P27).

There was some concern regarding the fairness of using COVID vaccination status as a method for allowing access to events and locations, considering the act discriminatory (*"I think it's a horrible infringement on privacy, and it's discrimination. I think there was a reason, I think already last year the EU passed a law that you're not allowed to be discriminated against if you didn't get vaccinated and*

this is essentially going this way." P8). However, most participants demonstrated a nuanced view (*"I don't want to let vaccinated people off the hook but of course I do understand, people have rights. I think it's really really hard."* P17; *"I think it always comes down to the trade-off in individual freedom and collective responsibility. I may be more on the collective responsibility side of that balance,"* P12).

5.3 Personal Data and Privacy

Data practices and associated privacy and security of digital COVID-19 certificates were other important topics discussed during the interviews.

5.3.1 Sharing COVID-19 status. Participants were asked about their opinions on sharing their COVID-19 status (being/not being vaccinated or having had the virus previously) with various actors or institutions.

Participants' views were divided on whether COVID-19 status is private or sensitive data or not, which also affected their sharing preferences. For instance, 7/27 participants did not consider COVID-19 status private and were willing to share it widely, for instance, to encourage others to vaccinate (*"I'm quite happy that I have my vaccine, and I'm quite happy to tell other people about it. I do encourage people who are vaccine hesitant, I do encourage them to get vaccinated,"* P5) or because they couldn't imagine any malicious use of this information (*"Can't think of any negative or downside to any and all organizations knowing my vaccine status. It's not like Cambridge Analytica thing where they can use your likes to tell your personality type and then send you ads,"* P21).

For others, the sensitivity of COVID-19 status varied and was often compared to other types of personal information with the application of the same sharing preferences. For instance, some participants related it to sensitive medical information (*"Let's say if a person has some other medical issue or whatever, you don't disclose that widely on social media that, you know, hey, I have attracted chlamydia, right?"* P3) or personal documents (*"I would be comfortable to share it with the same people, as the details of my driving license,"* P1).

Participants also mentioned various conditions for sharing their COVID-19 status by defining certain purposes or the recipients who could or shouldn't have access to it. Such conditions included proactive request-based sharing (*"I don't consider it super private information, we share it with everyone who would ask or request,"* P25), sharing for relevant or legitimate reasons (*"I've already decided the people who have a right to know, as people who either have a public health obligation or are operating some sort of business or social event, something where they reasonably expect strangers to be mixing,"* P10) or sharing in cases of emergency.

5.3.2 Sharing additional personal information. With regards to sharing information beyond COVID-19 status, participants mostly discussed two types of additional data categories: contact-tracing data and additional personal health information.

Ten participants were willing to share additional *contact-tracing data*, such as location or proximity to positive COVID-19 cases, either in general or as a consequence of using a contact-tracing app as a digital COVID-19 certificate. Mentioned purposes for such

sharing were contributing their data for understanding epidemiological trends, for research, or to support contact-tracing (*"Even if you're vaccinated in some cases, you could probably still catch COVID and still spread it, so hanging on to contact data and to location data, I suppose would be helpful much the same way that the current COVID tracker app would do it,"* P7).

Four participants mentioned that additional health data could be integrated into digital COVID-19 certificates, for instance, to be used in emergency situations or provide additional support to more vulnerable groups (*"What else I would expect, that they will ask if you have certain kinds of diseases, like asthma or breathing difficulties and this kind of thing, which is to make you more valuable, and maybe if they do the application to identify, identify certain people to get more help and if they have the coronavirus,"* P9) or to have access to information on other vaccinations (*"If you give a person the option to opt-in rather than having to opt-out [...] I will share that I've had my tetanus injections and if I'm traveling to China, I can say, I've had my vaccination for yellow fever and for all these other things,"* P19).

Another twelve participants rejected the idea of including any other personal data than minimally necessary (*"I think traditional immunity pass should only have the bare minimum information, what's your name, what the vaccine doses you got, when you got them, and pretty much this,"* P12) or preferred the distributed storage of personal data to centralized approach in one app (*"Certainly, there's no need to have other contact information on that type of passport, and there are other means and ways in which that information can be gathered through. Passenger locator forms or through the apps [...] They can be kept separate,"* P12).

5.3.3 Privacy concerns. Privacy concerns were expressed by 19/27 participants, and they were generally related to oversharing personal information and associated risks and consequences of that. For instance, some participants referred to the fact that personal data can be potentially de-anonymized (*"I know how data can be linked up. Even after anonymization, you can be de-anonymized, there are techniques to do this, it's fairly effective,"* P10), especially when additional data is added. Some participants discussed the temporal aspect of sharing their data being concerns that "the sunset clause" (P10) is undefined or that there is no control over sharing (*"I would be open to being convinced [to share] on a one-off basis. But the problem is you have to have to put a lot of trust [that] it would be just a one-off. And I don't think the trust is there with the government,"* P11).

Participants mentioned that breaches could happen through unintentional disclosure (*"With the best of intentions, it could end up in a database somewhere, and the information could be shared unintentionally,"* P18) or deliberate hacking making their data available to unauthorised third parties such as insurance companies or other actors with malicious intentions (*"I would have issues with medical data being shared is that insurance companies whose sole role in life is to not make payments, take money off you, and then not pay you,"* P19) and result in the potential misuse of personal data. Among such risks, they often mentioned monetization of their data, targeted advertisements (*"For example, they will know that I got COVID, so they will promote me some - I don't know - medicines or whatever,"* P25), discrimination and stigma following the disclosure of health data (*"I don't trust the world we live in just yet with health data not to*

discriminate. There are certain diseases that are stigmatized, mental health issues are stigmatized, and that's really sensitive to people, so I just wonder if we're at a point where we trust that information to an app or a certificate and why," P23) or being abused for their views if their COVID-19 and personal data would be available to those with opposing vaccination beliefs ("I guess I wouldn't share it with a mob of anti-vaxxers [...] or people of a certain disposition who may treat my candidness of inoculation as something to be attacked," P5).

The risk of increased surveillance was another category of privacy concerns tapping into a broader issue of civil liberties and governmental control ("I think that would be the worry, where it could be used, in a way, we don't want to get into, [...] as where every move you make is being tracked by somebody, because then, where is the civil liberties?" P19). Along the same lines, three participants expressed their concerns on compromising their privacy by sharing personal data for the common good, as P18 put it, "it was more around civil rights and the blurring of privacy and social responsibility [...] we had to give up our personal freedom in order to keep everything safe as we open up."

5.3.4 Security concerns. Security of personal data shared in digital COVID-19 certificates was another major concern for interview participants, and it was often discussed in relation to the level of trust towards institutions handling that data. Some participants preferred private companies over governmental institutions to implement digital certificates, as they believed they would ensure higher levels of data protection ("I've seen the way public service stuff happens, it's not nearly as secure as any private company stuff. I feel like it's really always behind the times of the sort of thing, so I don't have faith in the government investing properly and having a proper system because they don't showcase in any other area that they are capable of this sort of thing," P23). Several participants mentioned the novelty of such technological solutions ("I'm pretty security conscious. [...] especially for a new app that is built for the first time, maybe it hasn't gone through rigorous security reviews. I wouldn't put too much of my personal stuff," P26) or development of advanced malware technology ("Spyware is only going to get better and better and if you have, for example, this Pegasus software on your phone, which you don't know that you have, you will be able to see everything that is in that app," P8), which can also pose security risks to their data.

Participants also discussed potential consequences of security breaches – both unintentional and malicious ("I wouldn't put it past certain organizations to employ some bad actors to sort of infiltrate through various means employee records in order to actually access whether people have been vaccinated or not," P7) – such as personal data being stolen or falsified ("What if the system was hacked, what if they could change the data and what if it would say, you're not vaccinated, they could limit or could take your details and give it to somebody else," P23).

Still, most of the comments on security concerns were related to a recent HSE cyberattack in Ireland that breached confidential electronic health records [53], 17/27 participants mentioned it during the interviews unprompted. This incident aggravated their concerns on the security of their personal data and undermined participants' trust in the government being able to handle sensitive health data ("I'm not sure the government is able to provide safety of

our data. With the HSE being recently hacked, I have absolutely zero belief that they can protect this data," P4).

5.4 Technical Implementation and Practical Considerations

The final part of the interviews focused on participants' expectations and preferences regarding technical implementations of digital COVID-19 certificates in the form of mobile apps. Participants mainly commented on the data practices of such apps, interaction design, and their views on the future of such technology. In addition, some participants shared their views on future avenues for such certificates.

5.4.1 Data practices. Discussing the potential technical implementation of digital certificates, many participants described their expectations on handling of personal data, which generally referred to the topics of data minimisation and protection, verification of the authenticity of COVID-19 status, transparency of data flows and control over them.

In line with the discussion on data sharing preferences, participants expected a digital COVID-19 certificate app to contain only *minimal necessary information*, which usually included name, ID details, and COVID-19 status details: type of the vaccination and date when it was administered, the details of COVID-19 recovery, or COVID-19 test results. Due to security and privacy concerns described earlier, participants were generally against the app containing other types of information and preferred "one app – one function approach" ("I think it comes with the suggestion of trying to make it as simple as possible, only having the minimum information you need on the app," P27).

Transparency of personal data flows was another major expectation when it comes to the development of digital COVID-19 certificates. Participants often expressed the need to have information on "who administers the app, who has control over the data, how the data managed," P23, and what the information is used for.

Consent and the ability to maintain *control* over their data was another common requirement. Moreover, some participants expected granular access to all the data types shared, being able to opt-out from sharing specific data types over time ("I would not expect it to transfer information without my knowledge, without explicit consent. With consent, it should transfer it on a one-time basis or something like that. I don't think there should be any mechanism of automatically transferring information," P10).

Several participants commented on the risks of fraudulent COVID-19 certificates and expected such apps to implement *verification mechanisms* ("In Italy, they were [...] selling illegal certificates, so there's a new business going on. And of course, that's something that probably will become popular, digital certifications should be able to minimize this kind of scams and illegal things," P24).

Finally, expected *data protection mechanisms* were often mentioned, especially the case for participants with a higher level of familiarity with technology, which included protected databases with restricted access, two-factor authentication on the app, or ensuring the data is encrypted also in transit to prevent interception of private data "over public WiFi or an airport," P26.

5.4.2 Interaction design. The use of QR codes was the most common expectation when it comes to the user interface of the COVID-19 certificates app. Participants often described interaction with such app both from the user point of view and the perspective of the venue or third party that would check it (“*I would expect to see is some sort of QR code that you can get scanned by whoever you’re dealing with, so that they know it’s a valid certificate,*” P7).

In line with accessibility expectations of the certificate, some participants emphasised the importance of inclusive and simple design that would cater for all population groups, for instance, for older adults or for people without access to a mobile phone. Several participants also suggested that such apps should be designed for low engagement (“*You get the QR code and whoever needs to do anything, interacts with it, scans that code and then you put that up in your pocket again, because it’s not something that you kind of go and play around with. I’d imagine it’s a very static app that just kind of acts as a kind of proof that you have been vaccinated,*” P14; “*The app itself doesn’t have to explain anything, it’s like one of those things that’s running in the background,*” P12).

5.4.3 Integration with other pandemic tools. Although it was not asked specifically during the interviews, some participants referred to existing crisis-response technologies and their views on the integration of digital COVID-19 certificates with them, specifically, with contact-tracing apps and the EU green pass [11].

At the time of the interviews, the Irish COVID tracker app allowed the uploading of a COVID-19 vaccination or recovery certificate. Participants often expressed their viewpoints regarding such integration and five of them mentioned that they have already started using a contact-tracing app as their digital COVID-19 certificate.

Few participants viewed features implemented in the COVID tracker app as favourable to be included in digital COVID-19 certificates, such as logging the COVID-19 symptoms or close contact monitoring (“*Maybe an option – what the current COVID tracker app does – where you have an ability to kind of turn on close contact monitoring or there’s [...] different option for you to kind of check-in, to say you feeling okay or do you have any symptoms, just to keep a record with that. I think that would be handy to have in this particular app,*” P7), but there were also considerable concerns regarding the privacy of such functional integration. In addition, P17 predicted lower uptake of such integrated versions of digital COVID-19 certificates and digital contact tracing (DCT) due to privacy and security concerns: “*I know that you can do contact tracing without giving away too much information but it’s very hard for me to understand that. [...] If you muddy this app with that kind of contact tracing, I think you’d only cause difficulties, you’ll have fewer people using it.*”

Six participants mentioned the *EU digital certificate*, describing their experience and expectations regarding it, and suggesting that certain features or interoperability with it could be considered (“*I think eventually they probably should maybe split it out from COVID app, and just make it the vaccine pass, as a green pass, and probably pan European with the same name everywhere,*” P9). For instance, P1 valued the implementation of the EU digital certificate both in terms of design and data practices, and the inclusion regardless of one’s vaccination status, “*It’s a QR code that you can carry in the app or on paper, it has all the necessary data, and it can work offline.*

The data is all there, in the QR code, it’s not stored somewhere. What I also like about it – it has only necessary, the minimum amount of personal data. And then, if we store the data in this way, on the certificate itself in machine-readable form, and digitally signed, so it can verify that this was not altered.”

5.4.4 Future views on digital certificates. Finally, some participants shared their views on the future of such information systems. For instance, such views referred to a unified digital health repository, which could include other vaccinations (“*Whether it’s COVID or any other vaccination, as I said, I think it would be a very good idea to have a central repository of that information,*” P19), other notifiable diseases (“*We’ve always had notifiable diseases. If somebody has TB [Tuberculosis] [...] we need to know about certain things about people but it should be very much limited, so the vaccine certificate or the technology that’s going to use, be used for that, perhaps other vaccines in future.*” P17), or even personal electronic health records in a broader sense.

6 DISCUSSION

This study was designed to answer two research questions defined in Section 1. By conducting a large-scale survey and semi-structured interviews, we explored public views on the introduction and implementation of digital COVID-19 certificates and identified the factors that affect their acceptability. The results have implications beyond the COVID-19 pandemic and outline directions for the design of public health information systems whose efficiency depends on public acceptance.

6.1 Acceptance of Digital Certificates

In line with official statistics on the COVID-19 vaccination uptake in the Republic of Ireland – as of August 30th, 2021, 88.2% of 18+ adults in Ireland were fully vaccinated against COVID-19 [59] – the majority of study participants either received the vaccination or had it scheduled. As expected, both the survey results and the views of interview participants showed a close correlation between vaccination and COVID-19 certificate acceptance, which is also consistent with previous research [28, 38].

Participants showed a high level of support for the introduction of digital COVID-19 certificates by the governmental authorities indicating the public support of the Irish government pandemic response, which was previously reported in other Irish national studies [45, 51]. This finding contrasts with the study of Kowalewski et al. in the German context where participants preferred paper-based certificates [28], which could be related to high digitization and high support of the government response to the pandemic in Ireland. The acceptance of digital certificates was slightly higher for female participants, which was not the case for similar surveys in the UK [32] and the USA [30]. However, this support was not unconditional, and we identified six distinct conditions for user acceptance of COVID-19 certificates (Table 4), which included such factors as a improved epidemiological situation and more clarity on COVID-19 vaccinations, activities enabled by the certificates, opt-out options and time limits for using such systems, as well as their accessibility and technical expectations. Conditional acceptance of crisis-response technologies has also been raised in previous research [54, 64].

The study results reveal the context of use as another important acceptability factor. Both survey and interview participants specified more acceptable or preferred contexts for using such certificates, such as travel or indoor activities, consistent with previous research conducted in Switzerland [39] or the UK [66]. Less acceptable contexts included private occasions or religious events. The interview data allowed us to obtain a more nuanced view of such contexts, unveiling the complexity of using COVID-19 certificates in workplace scenarios, or indicating specific criteria for the context to be considered acceptable, such as crowded places or contexts with a higher risk of getting infected. Such contextual complexity could potentially be generalised to the introduction of other digital public health solutions, which should consider that certain environments can be seen as more or less sensitive and acceptable.

6.2 Fairness

During the interviews fairness was frequently mentioned and discussed. The quantitative analysis did not demonstrate concerns regarding fairness to correlate with adoption. This dichotomy is potentially explained by the participants' expectation (and welcoming) of disparate treatment in the deployment of a digital COVID-19 certificate. Adoption was not found to be influenced by fairness, with differences in the treatment of individuals was perceived as a feature of the process rather than as a fairness concern. This was further reinforced in our quantitative data that showed a more positive attitude to adoption where there was a perceived risk of excluding people because of the process.

Fairness discussions were rooted in the legitimacy of using COVID-19 status as a decision-making variable on whether to allow or restrict someone's access to certain locations or social activities. This concern would exist regardless of if the implementation involves a technical solution or not. Participants also made a clear distinction between how those that choose not to vaccinate versus those that can not receive a vaccination should be considered. Those who could not receive a vaccination were viewed sympathetically, but interview participants proposed no additional firm accommodations.

A recent analysis of the fairness of data-driven decision-making by Kaisinidou et al. has demonstrated that it is possible for those involved to agree with the process used to make a decision, while also believing that the recipient of the decision does not deserve the outcome [26]. This phenomenon is reflected in our qualitative data analysis. Participants largely agreed with the usage of COVID-19 immunity status for decisions of inclusion or exclusion from certain locations or social activities but were generally concerned with the scope and scale of the potential impact on someone's rights.

This concern relates to the concept of "counterfactual fairness" [29], a fairness definition that proposes a decision as fair if individuals are treated the same when a variable about them is swapped. Originally proposed for demographic variables, this can be extended to include COVID-19 status. When participants suggest that it is unfair to exclude someone, this can be seen as use of a "counterfactual fairness" definition. Both the questions of *if* a decision on access should be made and *when* it should be made were the topic of divergent views in the interviews, as detailed in Section 5.2. The disparity between the freedoms permitted to immunity certificate

holders versus non-holders requires a structured framework in order to clearly specify if and when data should be shared, and for what purpose.

Extending this argument, our results correspond with the work of Bennet and Keyes [6] who advocate for the understanding of the sociological and societal implications of health based decision making beyond the perceived fairness of an immediate technical solution.

6.3 Data Practices and Contextual Integrity

Another major theme of this study relates to the disclosure of COVID-19 related personal information and data sharing practices within digital certificates. Based on the Contextual Integrity (CI) Theory by Helen Nissenbaum [41], we can define such views using the following parameters: data subject, sender and recipient of the data, information type, and transmission principles.

6.3.1 Data recipients. While the sender and the subject of sharing personal information were defined by the scope of this study (views on sharing one's own COVID-19 status or related personal data through digital immunity certificates), both the survey and interview responses indicated that particular recipients (actors or institutions) could be seen as more or less acceptable. For instance, even for participants with strong privacy concerns, healthcare professionals and governmental institutions of their country of residence were seen as acceptable recipients. Interestingly, similar institutions in other countries outside the EU were seen as much less acceptable recipients of such data, suggesting a preference towards nationally-kept health data. While internationally-shared health data can be beneficial to tackle a global public health crisis such as COVID-19 pandemic, this finding emphasizes that appropriateness of data recipients is an important privacy factor to consider.

6.3.2 Information types. Whether certain information is appropriate or inappropriate to be shared was widely discussed during the interviews. The sensitivity of COVID-19 data was often compared to other personal information types such as sensitive health information or ID details. We also observed a visible distinction between sharing solely COVID-19 status data (being vaccinated or not, having had the virus, or COVID-19 test results) and combining it with additional personal data types. Even for the participants who did not perceive their COVID-19 status as sensitive, this option raised significant concerns.

However, ID details were often seen as necessary to accompany COVID-19 status data to prove its authenticity and confirm the identity. Instead, contact-tracing related data such as location or contacts with others were rarely accepted in digital certificates, even though some participants could see its value for research or virus containment purposes. Additional health data such as other vaccinations or information on health conditions that pose a risk if infected with COVID-19 were also seen as potentially useful. However, participants still preferred that the minimum necessary information be used in digital COVID-19 certificates.

6.3.3 Transmission principles. Besides accepting certain information to be shared, transmission principles and appropriateness of sharing are other important topics regarding participants' views on data practices. Following CI Theory, appropriate information flow

should conform with legitimate contextual norms, which can be established based on the individual preferences of affected parties, ethical and political principles, and contextual functions, purposes, and values [40].

Referring to the conditional and contextual nature of acceptance of digital COVID-19 certificates, views on sharing personal information also strongly depended on the contextual variables, which was also evident in previous research on pandemic response technologies [61]. In our study, participants required a “genuine cause” or a “legitimate reason” to disclose their data using digital COVID-19 certificates. Depending on their privacy preferences, such causes ranged from sharing to obtain various immunity benefits such as access to hospitality services, to only sharing in limited cases such as for medical reasons. As for the ethical and political principles of sharing personal information, participants generally saw sharing their COVID-19 status as part of the social contract or responsibility for the public good. Finally, on a personal level, participants often referred to the notions of autonomy, transparency, and consent for sharing their personal information. More specifically, they expected granular control of the data types to be shared, dynamic consent that they could withdraw at any time, or defined and limited duration of such sharing. These preferences are important to consider to ensure public trust when designing digital health systems, in particular, when data sharing is required for public health.

6.3.4 Security and privacy concerns. Data protection concerns were an important part of the discussion on sharing. Potential risks and consequences of privacy and security violations were mentioned both in the interviews and the survey. For instance, the survey indicated a negative correlation of acceptability of digital COVID-19 certificates with concerns about profiling, for example, the collection of personal data and its use to infer certain aspects related to the individual. Interviews provided a more profound view on privacy concerns related to the potential misuse of personal data. The perceived risks of such misuse included stigma and discrimination, targeted advertisement or monetization of their data, increased surveillance and violation of civil liberties.

To a large extent, security concerns identified in the study related to the cyberattack on the Irish Health Service Executive (HSE) that happened in May 2021 and breached confidential electronic health records [53]. This incident was mentioned in the survey and discussed during the interviews, and perceived as an important event that aggravated participants’ security concerns. User security behaviours and trust towards digital health systems following a data breach has been discussed in previous research, indicating that users become more aware of the limitations of such systems and are motivated to weigh the risks of a potential privacy breach versus the benefits of using such systems [3]. For our study participants, this data breach affected their trust and confidence in current data protection mechanisms, centralized data storage, and national governmental authorities being capable of protecting personal information, increasing their concerns for systems such as digital COVID-19 certificates.

6.4 Technical Implementation and Feasibility

As for the practical implementation of digital certificates, we observed substantial doubts regarding their feasibility among the

survey participants. However, certain technical expectations were one of the primary conditions for accepting and adopting such systems, which were identified during the interviews. Desirable implementation characteristics included user control and consent over data flows, data protection mechanisms, and user-friendly and accessible interaction design of such systems.

While various pandemic-response systems such as contact-tracing apps and the European vaccination pass have already been implemented at the time of the study, integration with such systems was often mentioned in relation to the implementation of digital COVID-19 certificates. However, while some participants saw the value of expanding them and potentially including additional features, they generally preferred the “one app – one purpose” approach emphasising the need for simplicity and minimalism of such systems.

6.5 Limitations and Future Work

As with all online research, limitations of this study include a selection bias that favours participants with technology literacy and accessibility and might have prevented the participation of those with COVID-19 related research and surveillance scepticism, which could have affected the study results. While the first is difficult to avoid in the current pandemic conditions, we tried to address the latter by using neutral language in the pre-screening survey to allow for the gathering of views from diverse viewpoints. Future studies could look into the views of digital certificates balancing the number of participants with diverse COVID-19 views.

While the implications of contextual and conditional health technology acceptance have significant external validity and applicability across many areas, caution should be used when applying COVID-19 specific learnings to other areas, due to the time and context-specific environment created by the active unfolding of a pandemic.

The causal direction of influence was not tested during statistical analysis, additional future work could include the detection of if those that intend to adopt are doing so in the hope that other, unvaccinated people, would be excluded or fear that they themselves would be excluded. Mindful of these limitations, this work nonetheless provides a starting point for anticipating the potential harms of health certification as a basis for mitigating these to realise the benefits with minimal harms.

7 CONCLUSIONS

Interest in digital certificates for COVID-19 is high, and goes hand in hand with related privacy, fairness, and civil liberties concerns across many countries and specific contexts of use. While such solutions are seen as an opportunity to return life to a normal pre-pandemic state, they pose serious risks of altering social and legal discourse and having implications beyond the pandemic. In this paper, we have demonstrated the need for a clear understanding of the context and conditions of an COVID-19 certification application at both a qualitative and quantitative level. Overall, participants were not against sharing their COVID-19 status and even additional personal data if needed, but they wanted to have control over the data flows and transparency. The perception of fairness of the applications is also conditional on this clarity regarding the

treatment of those that can not vaccinate, tempered by views that unfairness may exist in the goal of public safety. We have shown that when profiling is a concern, then the likelihood to adopt is negatively affected. Without a clear, understandable statement on what exact context and conditions COVID-19 certification application is used, acceptance will remain an ongoing challenge in this type of public-health related technology. With clear opportunities to design mechanisms for the support of transparent, conditional and contextual information sharing, we hope that our results can inform the development of novel technology that can help limit the negative impact of COVID-19 and future diseases while respecting users' privacy and autonomy.

ACKNOWLEDGMENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 754489. It was also supported, in part, by Science Foundation Ireland grants 13/RC/2094 and 18/CRT/6222, and co-funded under the European Regional Development Fund through the Southern & Eastern Regional Operational Programme to Lero – the Irish Software Research Centre (www.lero.ie).

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A SURVEY QUESTIONS

User survey (prolific)

Please, enter your Prolific ID provided to you by the Prolific.co _____

Study introduction

The 2019 coronavirus, otherwise known as COVID-19 or SARS-CoV-2, is an infectious disease that has been reported globally. As vaccinations have begun to be administered around the world and there have been a considerable number of people who obtained antibodies after contracting the disease, immunity certifications ("certificates" or "passports") have been proposed as a means to lift public health restrictions.

In some countries, these certificates would permit those who have been vaccinated or tested positive for COVID-19 antibodies to return to some of their normal behaviours, such as travelling more freely and returning to work. The aim of this study is to learn the opinions of residents in the Republic of Ireland on the potential opportunities and drawbacks of introducing digital immunity certificates or passports.

Definition: Immunity certificates, based on antibody testing, are being considered to offer proof that a person has developed lasting immunity to COVID-19 and hence can return to work or travel freely.

General attitudes

1. Would you support a government proposal to introduce 'immunity certificates' for coronavirus (COVID-19)? [Not at all - Slightly - Moderately - A lot - Fully]
2. How concerned are you about the idea of introducing 'immunity certificates' for coronavirus (COVID-19)? [Not at all - Slightly - Moderately - Very - Extremely]
3. Do you agree with the following statement: "I think that giving immune people immunity certificates for the duration of their immunity is..." [strongly agree - agree - neither agree nor disagree - disagree - strongly disagree, I don't know]
 - An appropriate means to handle a global pandemic crisis
 - Choose "Agree" here
 - Good for public health
 - Good for the economy
 - Fair to others who do not have immunity
 - Increasing inequality
 - Practically feasible

4. What purposes do you think an immunity certificate should serve? (choose ALL that apply):
- Allow people to return to high risk jobs
 - Allow people to return to any job
 - Allow attendance at social events
 - Allow domestic travel
 - Allow international travel
 - Other, please, specify _____
5. To what extent there is a risk that immunity passports will:
[Not at all - Slightly - Moderately - Very - Extremely]
- Profile people (collect personal data to evaluate certain things about individuals)
 - Cause potential harm to people from minority groups
 - Stigmatize people based on their COVID-19 status
 - Discrimination in work environments based on vaccination status
 - Exclude some people from social or recreational activities
6. How much would you like to be allocated an "immunity certificate" for COVID-19 if this will allow you to: [Not at all - Slightly - Moderately - Very - Extremely]
- Return to work
 - Attend social events
 - Attend religious events
 - Attend recreational activities
 - Travel within your country of residence
 - Travel internationally
7. To what extent do you believe that it is fair for people with "immunity passports" for COVID-19 to go back to social activities, while individuals without such an "immunity passport" cannot?
- Extremely unfair
 - Very unfair
 - Somewhat unfair
 - Somewhat fair
 - Very fair
 - Extremely fair
8. To what extent do you believe that it is fair for people with "immunity passports" for COVID-19 to travel freely, while individuals without such an "immunity passport" cannot?
- Extremely unfair
 - Very unfair
 - Somewhat unfair
 - Somewhat fair
 - Very fair

- Extremely fair

Adoption and installation

Definition: Digital immunity certificates or passports, based on antibody testing, are being considered to offer proof (e.g. via an app or QR code) that a person has developed lasting immunity to COVID-19 and hence can return to work or travel freely.

9. If digital certificates were provided in the form of a phone application, how likely would you be to install it?

- Extremely unlikely
- Somewhat unlikely
- Neither likely nor unlikely
- Somewhat likely
- Extremely likely

10. What would be your main reasons **for** installing a digital immunity certificate? (choose ALL that apply)

- A sense of responsibility to the wider community
- Travel purposes
- Work-related reasons
- To attend social events
- To attend religious events
- For recreational activities
- For cultural activities
- None
- Other (please indicate in the field below)

11. What would be your main reasons **against** installing a digital immunity certificate? (choose ALL that apply)

- It would be too much hassle to install
- I would not benefit from the certificate
- I worry that my phone will be more likely to get hacked
- I worry the government would use this as an excuse for greater surveillance after the pandemic
- I don't want to feel more anxious than I already feel
- I don't want the public health authorities of Ireland to have access to my personal data
- I don't want the public health authorities of countries other than Ireland to have access to my personal data
- The certificate could be draining my phone battery
- None
- Other (please indicate in the field below)

12. Please, feel free to provide additional comments on digital immunity certificates below:

Information and sharing

13. With what actors and organisations would you be willing to share your vaccination status? Please, feel free to add the comment if you would like to.

- Current governmental authorities of the country you are living in
- Governmental authorities of other EU countries
- Governmental authorities of countries outside the EU
- Public health authorities of the country you are living in
- Public health authorities of other EU countries
- Public health authorities of countries outside the EU
- Medical doctors and nurses
- Scientists, for research purposes
- Religious, faith-based organisations (to share with the community)
- Employers, workplace organisations
- Other, please, specify
- None of them

14. Where do you get the information about immunity certificates from? [Never - Rarely - Sometimes - Often - Always]

- Online news websites
- Social media websites and apps
- Other online resources
- Print (newspapers, magazines)
- Radio (broadcast, satellite)
- Choose "Rarely" here
- TV (broadcast, cable)
- Family & Friends

Vaccination questions

15. Were you offered or given the opportunity to apply for a COVID-19 vaccine? [Yes, No, Unsure]

If yes

16. Did you receive a vaccination for COVID-19? [Yes, I have a vaccination scheduled, No]

If no

17. How likely are you to get a coronavirus vaccine when one becomes available to you?

- Extremely likely
- Somewhat likely
- Unsure
- Somewhat unlikely

- Extremely unlikely

Demographics

Just before you finish this survey, please provide the following information.

18. How old are you?

- 18-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- Older than 80

19. How would you describe your race and ethnicity?

- White - Irish
- White - Irish Traveller
- Any other White background
- Black or Black Irish - African
- Any other Black background
- Asian or Asian Irish - Chinese
- Any other Asian background
- Other, including mixed background. Please, specify _____

20. Where in the Republic of Ireland do you currently reside?

21. How would you best describe the area you currently reside in?

- Urban
- Suburban
- Rural

22. What is your gender? (please select option that best applies)

- Male
- Female
- Nonbinary
- Prefer to self-describe _____
- Prefer not to say

23. In general, how good or how poor would you say your current state of health is (i.e. mental and physical)?

- Very good
- Moderately good

- Neither good nor poor
- Moderately poor
- Very poor

24. Have you been tested for coronavirus?

- Yes, the result showed I did have coronavirus
- Yes, the result showed I did not have coronavirus
- No, I haven't been tested

25. Your highest level of education:

- Primary
- Secondary
- College
- University
- Postgraduate

26. Is English your first language?

- Yes
- No

27. Which of these are you most concerned about at the moment?

- Childcare
- Homeschooling
- Essential supplies
- Being infected
- Friends/family getting infected
- Keeping job
- Personal finances
- Other, please, specify _____

Debrief

Thank you for taking part in our interview/survey.

The information you have given us will help us to understand the public views on digital immunity certificates in the Republic of Ireland.

If you have any concerns or discomfort regarding the topics covered in this study, you may find it useful to consult the following resources on coronavirus and mental wellbeing,
<https://www2.hse.ie/wellbeing/mental-health/minding-your-mental-health-during-the-coronavirus-outbreak.html>

B PRE-INTERVIEW SCREENING SURVEY QUESTIONS

SCREENING SURVEY

Hello!

Thanks for your interest in our Academic Research on Digital COVID-19 Immunity Cert

To participate, you need to be aged 18 or over, based in the Republic of Ireland, proficient English language, and not diagnosed with severe cognitive impairment. Please complete **3-minute survey** below to identify your eligibility for the interview.

If you complete the survey in full, you will be entered into a drawing with a 1:90 chance 20 euros Amazon voucher (meaning that one out of 90 respondents will receive a 20 euro Amazon voucher). If you are eligible, we may also invite you to do a 30 mins interview, via videocall or over the phone. We will compensate you with a 20 euros Amazon voucher the interview.

Please provide your valid contact information at the end of the survey so we can contact you to potentially schedule an interview. Please also make sure you read and checked "I consent to participate" before completing the survey.

Please do not name third parties in any open text field of the questionnaire. Any such information will be anonymised. Please, consider that any illegal activities, if disclosed, will have to be reported to the authorities.

If you have any questions, please contact us at:

Phone: _____ (call, text, or leave a voicemail)

Email: _____

INFORMED CONSENT FORM - SCREENING SURVEY

I consent to participate in this study conducted by _____ in the _____. I understand that by ticking the box below, I will have provided my consent to take part in this research and that I can withdraw from the study at any time during the survey without having to give

I understand this study requires completing a questionnaire. This will require approximately 10 minutes of my time in total. I have read or had read to me, information about this research and this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being conducted and provided to me.

I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity. I understand that if I make any illegal activities known, these will be reported to appropriate authorities. I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.

I understand that if my data has been fully anonymised so that it can no longer be attributed to me, then it will no longer be possible to withdraw. I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights. I acknowledge that my consent will be stored electronically in an encrypted folder, separately from data, until my data is destroyed.

I understand what I need to do, and I am ready to start the survey.

- I consent, begin the study
- I do not consent, I do not wish to participate

SCREENING SURVEY

For each question please give ONLY ONE answer unless you are asked to "Choose ALL that apply".

1. How old are you?
 - 18-30
 - 31-40
 - 41-50
 - 51-60
 - 61-70
 - 71-80
 - Older than 80
2. Do you currently reside in the Republic of Ireland?
 - Yes
 - No
3. What is the gender you most identify with?
 - Male
 - Female
 - Nonbinary
 - Prefer to self-describe _____
 - Prefer not to say
4. Please rate your level of English language proficiency.

- No proficiency
- Basic
- Intermediate
- Advanced
- Native or bilingual proficiency

5. Your highest level of education:

- Primary
- Secondary
- College
- University
- Postgraduate

6. How would you describe your race and ethnicity?

- White - Irish
- White - Irish Traveller
- Any other White background
- Black or Black Irish - African
- Any other Black background
- Asian or Asian Irish - Chinese
- Any other Asian background
- Other, including mixed background. Please, specify _____

7. In general, how good or how poor would you say your current state of health is (both mental and physical)?

- Very good
- Moderately good
- Neither good nor poor
- Moderately poor
- Very poor

8. Have you ever been diagnosed with a severe cognitive impairment (such as dementia or Alzheimer's disease)?

- Yes
- No
- Not sure

9. Have you ever tested positive for COVID-19?

- Yes

- No

10. Did you receive a vaccination for COVID-19?

- Yes
- No

If not, how likely are you to get a COVID-19 vaccine when one becomes available to you?

- Extremely likely
- Somewhat likely
- Unsure
- Somewhat unlikely
- Extremely unlikely

11. How do you prefer to be informed should you be eligible for the interview? Check ALL that apply.

- By phone
What is your phone number? _____
- By email
What is your email address? _____

Note: By checking any of the boxes above, you agree to be contacted by us in the future to be invited to the interview or to be informed about winning a 20 euro Amazon voucher in the drawing. We will only use this information for these purposes and will destroy it immediately upon study completion.

(If you do not check any box and/or do not provide any contact information, we will not be able to contact you about an interview and/or about the drawing if you win).

Thank you for completing the survey!

Please answer the survey as soon as possible and not later than 30 July 2021. Make sure you answer all the questions including the consent form.

We will review your answers and will let you know within 2 weeks after receiving your responses if you have won a 20 euros Amazon voucher in the drawing and/or are eligible for the interview. Unfortunately we are unable to contact people who are not eligible for the study. Therefore, if you do not hear from us within 2 weeks after submitting the responses, it means that you did not qualify for the study or the participation quota has been met.

C INTERVIEW QUESTIONS

Semi-structured Interview Script

Hello. Thank you for agreeing to participate in the interview, we greatly appreciate your help with our research. My name is [...] and I will conduct this interview. The interview will last around 30 mins and will be audio recorded.

The recording is to accurately record the information you provide and will be used for transcription purposes only. After the transcription, we will destroy the audio recording. If you don't wish to be recorded you can stop the interview. However, incomplete interviews will not be compensated.

If you feel any discomfort, please, let me know and we could pause or stop the interview. Please, do not name any third parties. I also have to mention that any illegal activities, if disclosed, will have to be reported to the authorities.

Do you have any questions? You can have a break any time during the interview. Are you ready to start?

Let me give you some introduction to our research first. The 2019 coronavirus, otherwise known as COVID-19, is an infectious disease that has been reported globally. Let's start with a few questions about yourself and your COVID-19 pandemic experience.

General questions and COVID-19 and lockdown experience

1. What do you do, what is your current primary occupation?
2. How were the pandemic and, in particular, lockdown experience for you so far?
3. How did your life change?
[Follow-up questions, if needed] Were you able to continue working/studying, did your work/study conditions change? What was the hardest thing?

Immunity certificates questions

As the vaccinations started to be administered around the world and there have been a considerable number of people who obtained antibodies after contracting the disease, immunity certifications (or "passports") have been proposed as a means to lift public health restrictions.

As they are currently discussed, in some countries, these certificates would permit those who have been vaccinated or tested positive for COVID-19 antibodies to return to some of their normal behaviours, such as travelling more freely and returning to work. Today, we would like to

discuss digital immunity certificates with you and learn your opinions on the potential opportunities and drawbacks of such technology.

Digital immunity certificates or passports, based on antibody testing, are being considered to offer proof (e.g. via an app or QR code) that a person has developed lasting immunity to COVID-19 and hence can return to work or travel freely.

4. How concerned are you about the idea of introducing 'immunity certificates' for coronavirus (COVID-19), from 0 to 10?
If more than 1, what are your concerns?
5. Would you support an Irish government proposal to introduce immunity certificates?
Why?

If not mentioned:
6. Is there any scenario where an immunity certificate is a good idea?
What do you think the certificate should be used for? Why?

Acceptance

7. Would you like to be allocated an immunity certificate?
8. [If yes] Under what conditions would you accept a compulsory certificate?
[If no] What options would need to be available to you to accept the immunity certificate?

Drawbacks and advantages of immunity passports

9. What do you think will be the potential advantages and drawbacks of using immunity certificates?

Privacy and personal data

10. Would you share your COVID immunity status (that you have been vaccinated or not or whether you have or do not have antibodies) with others?
11. If yes, with what institutions or actors?
12. Do you think that an immunity passport should be expanded to include other forms of personal data e.g. travel location, location history, contact with others? Should it include other forms of health data in the future?

Fairness

13. Are you concerned about the limitations that the introduction of an immunity passport may impose on those that can not or choose to not receive a vaccination?

14. What about inclusion or exclusion from various social activities based on the COVID-19 status (being vaccinated or not or whether a person has or does not have antibodies)?

15. Are you concerned about other people treating someone differently due to their COVID-19 status?

16. Are you concerned about employers requesting information on an employees COVID-19 status?

App-related questions

Hypothetical scenario: The Irish government may consider using an app to identify those who have immunity to COVID-19. This could help reduce community spread by identifying those not at risk and allowing them to participate in different activities. Potentially anyone with a mobile phone would be included in the project, with no possibility to opt-out. Data would be stored in an encrypted format on a secure server accessible only to the HSE and other relevant government departments. Individual quarantine orders could be made on the basis of this data.

17. What do you think about this scenario? Do you think something should be added or removed?

18. Do you have any concerns about this scenario?

19. What could be the functionality of such an app: what would you expect it to do or not to do? What should and should not an app of this kind include?

Additional: if you open the app, what would you expect to see?

20. What would be your concerns regarding such an app, if any?

Final remarks

21. How concerned are you about the idea of introducing 'immunity certificates' for coronavirus (COVID-19), from 0 to 10?

22. Are there any other questions you expected me to ask, or anything else you want to tell?

D DEMOGRAPHIC INFORMATION

D.1 Online survey participants (n=1008)

Table 5: Full demographic characteristics of survey respondents (N=1008).

Attribute	Range	Sample size
Gender	Female	746 (74.1%)
	Male	252 (25%)
	Non-binary	6 (0.6%)
	Prefer not to disclose	3 (0.3%)
	Prefer to self-describe	1 (0.1%)
Age	18-30	394 (39.1%)
	31 - 40	378 (37.5%)
	41 - 50	168 (16.7%)
	51 - 60	55 (5.5%)
	61 - 70	10 (1%)
	>71	3 (0.3%)
Race and ethnicity	White - Irish	821 (81.5%)
	Any other White background	119 (11.9%)
	Black or Black Irish - African	19 (1.9%)
	Any other Black background	1 (0.1%)
	Asian or Asian Irish - Chinese	12 (1.2%)
	Any other Asian background	19 (1.9%)
English as the first language	Other, including mixed background	17 (1.7%)
	Yes	920 (91.3)
Highest level of education	No	88 (8.8%)
	Primary	1 (0.1%)
	Secondary	162 (16.1%)
	College	259 (25.7%)
	University	319 (31.7%)
Residence area	Postgraduate	267 (26.5%)
	Urban	352 (35%)
	Suburban	362 (36%)
Self-described state of health is (i.e. mental and physical)	Rural	294 (29.2%)
	Very good	355 (35.3%)
	Moderately good	486 (48.3%)
	Neither good nor poor	106 (10.6%)
	Moderately poor	50 (5%)
Tested for coronavirus	Very poor	11 (11.1%)
	Yes, the result showed I did have coronavirus	59 (5.9%)
	Yes, the result showed I did not have coronavirus	423 (42%)
Offered or given the opportunity to apply for a COVID-19 vaccine	No, I haven't been tested	526 (52.2%)
	Yes	874 (86.8%)
	No	124 (12.4%)
Received a vaccination for COVID-19 ³	I'm not sure	10 (1%)
	Yes	626 (71.7%)
	I have a vaccination scheduled	140 (16.1%)
How likely are you to get a coronavirus vaccine when one becomes available to you ⁴ ?	No	108 (12.4%)
	Extremely likely	76 (56.8%)
	Somewhat likely	18 (13.5%)
	Unsure	16 (12%)
	Somewhat unlikely	10 (7.5%)
	Extremely unlikely	14 (10.5%)