Comparing card-based vaccine credential systems with app-based vaccine credential systems

Aryan Mahindra\textsuperscript{1}, Chandan CV\textsuperscript{1}, Priyanshi Katiyar\textsuperscript{1}, Anshuman Sharma\textsuperscript{1}, Sheshank Shankar\textsuperscript{1}, Rohan Sukumaran\textsuperscript{1}, Saurish Srivastava\textsuperscript{1}, Armaan Bhojwani\textsuperscript{1}, Rohan Iyer\textsuperscript{1}, Ishaan Singh\textsuperscript{1}, Ramesh Raskar\textsuperscript{1,2}

\textsuperscript{1}PathCheck Foundation, 02139 Cambridge, USA.
\textsuperscript{2}MIT Media Lab, 02139 Cambridge, USA.

raskar@media.mit.edu

ABSTRACT

In this early draft, we compare and contrast the technicalities present in the implementation of a card-based vaccine credentials system and an app-based vaccine credential system. We have chosen the domains of symptom reporting, fraud and impersonation, feasibility, scalability, equity, future data aggregation, importability of health data, and operability to explore each system’s features and drawbacks.

1 INTRODUCTION

The lack of preventive measures taken to tackle the coronavirus disease 2019 (COVID-19) has caused unprecedented human deaths (2,676,200 at the time of publication (for Disease Control & Prevention (2020))). The introduction of vaccines for the general population creates opportunities to slow down the rapid spread of the virus (News (2021)). However, this opportunity poses new challenges of strategic, equitable, and privacy preserving ways for conducting vaccine administration and distribution. (Bae et al. (2020); MPH (2020)). The current vaccination roll-out has favored highly centralized systems for symptom reporting and vaccine administration. However, a recent paper Bae et al. (2021b) proposed a novel solution for decentralized vaccine coordination through the augmentation of CDC’s vaccine card with encrypted QR stickers.

In the proposed MIT SafePaths Paper Card (MiSaCa), there are four digitally signed QR codes. The distribution mechanism for each, as described in the paper Bae et al. (2021b) are as follows - the first QR code is called “coupon” and contains a digital certificate issued by central authorities and distributed by local governments and employers. The second QR code is termed as “badge” and contains encrypted information such as time, date, and vaccine manufacturer information issued by the vaccination clinics. The third and fourth QR codes are termed as “status” and “passkey” that contain unencrypted vaccination status, and encrypted personal information, such as age, name, and sex, respectively. These four coupon codes formulate an ecosystem that encapsulates the entire user journey for an individual to get vaccines. Furthermore, after a user receives a digital certificate issued by a central authority, they can enter the coupon into an app to continue their vaccine journey with the use of a decentralized smartphone application.

2 COMPARISONS

2.1 SYMPTOM REPORTING

Card-based implementation - Users are required to report their symptoms directly to a centralized system. Since this reveals the user’s personal information to the entire system, a secure card-based implementation would require an efficient and secure reporting hierarchy where systems can register
Comparing card-based vaccine credential systems with app-based vaccine credential systems

and manage data from various locations, while handling healthcare data on a central database.

App-based implementation - Users report their symptoms anonymously without revealing any personally identifiable information. Because apps have the ability to generate noise on servers while registering data, all the information provided can be securely added and transferred across different databases [Bae et al. (2021a)]. Furthermore, this implementation’s approach will allow for more symptoms to be reported and improve vaccine related pharmacovigilance.

2.2 FRAUD & IMPERSONATION

Card-based implementation - Counterfeit paper cards adhesed with QR stickers can be easily created for duplication of vaccine cards. Moreover, there is a high possibility of identity impersonation when a card is lost or stolen from an individual. A recent statement from the Better Business Bureau exemplifies how scammers in Britain were able to sell fake vaccination cards on digital platforms (like eBay) by extracting personal information from publicly shared vaccination cards [Bureau (2021)]. Since MiSaCa’s QR codes are encrypted, an individual’s digital certificate and vaccination data is secure from such events. Still, the physical limitations of a paper card prevent it from being tracked and traced for recovery purposes which creates significant challenges as well.

App-based implementation - Digital credential apps with authentication systems like one-time passwords (OTPs) and biometric barriers like fingerprints prevent access to digitally stored QR codes. Also, the risk of being hacked is negligible as the security of the application can always be updated and improved to prevent any possible data breach from happening.

2.3 FEASIBILITY

Card-based implementation - The coupon QR code sticker is issued by a central authority, while the status, badge and passkey stickers are issued by vaccination clinics. Thus, implementing this system will be challenging because it would require adequate supplies of printers and stickers at vaccination sites.

App-based implementation - Since the vaccine badges are digitally issued by central authorities and vaccination clinics, they can easily be uploaded into the app. Also, the fear of losing QR codes stickers will be eliminated because the QR codes are stored onto the app’s permanent storage.

2.4 SCALABILITY

Card-based implementation - The paper card containing a coupon badge and the status, passkey, and badge QR sticker allocated at vaccination sites will be harder to safely produce with an expanding user base. The ability to increase paper card productions with distinct digital certificates will require an airtight system that coordinates QR sticker productions in new locations.

App-based implementation - The app will always be accessible on the AppStore and Play Store for every user. Thus, an expanding user base will not require the system to change in order to meet user demand. However, ensuring that every software update reaches a user is improbable and uncertain. Moreover, the inertia in making a user sign-up for the application is incredibly high. To fully integrate a user into the ecosystem through an application would require excessive advertisement and outreach which makes the process slow and expensive.

2.5 EQUITY

Card-based implementation - State-issued paper cards are the only way vaccines can be distributed to rural and urban populations while ensuring access to all socio-economic sectors in society. Thus, card-based vaccine credentials formulate the lowest common denominator for distributing vaccines in an equitable manner.

App-based implementation - The digital divide as stated has already created vast socio-economic barriers within society [Wikipedia (2005)]. Thus, implementing an app-based solution for
Comparing card-based vaccine credential systems with app-based vaccine credential systems

vaccine administration would only decrease accessibility of resources while preventing a significant portion of the population from getting vaccines because they lack access to smartphones and/or a stable internet connection.

2.6 Future Data Aggregation

Card-based implementation - Because paper cards will be issued by central authorities and distributed by employers and regional entities, the collection and triangulation of data will be easier to gather and compute with highly specific demographics based on different regions. Furthermore, because the source of this data is an indirect issuer and not the direct vaccine recipient, there would not be any loss of user identity while gathering and computing data. However, the garbage data rendered after linking vaccination records to a central entity for data aggregation poses a significant challenge. Another issue occurs when a card-based vaccine credential gets lost or is misplaced since there is no methodology to trace them back for data aggregation.

App-based implementation - With a direct user-to-issuer pipeline implemented in the app, gathering and computing logistical data would come at the loss of user privacy. Because the app is fully decentralized, triangulating its data would be harder and more troublesome for health authorities.

2.7 Importability of Health Data

Card-based implementation - Paper cards act as effective end-to-end touch points across the entire vaccination journey. Because of this, they can operate with existing legacy systems such as V-safe and VAMS while also entering and transmitting health data using digitally signed QR codes.

App-based implementation - With the implementation of differential privacy in a fully decentralized application, the data stored onto a smartphone will require additional layers of adjustment to integrate with existing legacy systems such as VAMS and V-safe.

2.8 Operability

Card-based implementation - Because digitally signed QR codes can function with intermittent connectivity, their implementation does not require additional infrastructure such as cellular data connection and internet access. Moreover, this implementation works for resource constrained environments in an effective and equitable manner.

App-based implementation - To generate and render additional QR codes into a vaccine recipient’s smartphone, internet and cellular data access is required. Thus, transmitting QR codes from a vaccine administrator to a vaccine recipient in a cellular dead zone creates barriers for vaccine administration.

3 Overall Challenges and Consequences

Card-based implementation - With a paper card implementation, various systems must be put in place for effective QR sticker generation, allocation, and secure symptom reporting. However, a card-based implementation allows for an ideal entry point into a user’s vaccination journey where vaccine authentication can be done in an offline environment.

App-based implementation - An app based implementation allows for quick, secure, and efficient delivery of QR stickers. However, these apps wouldn’t be able to function in an environment where both the vaccine administrator and user are offline.
Comparing card-based vaccine credential systems with app-based vaccine credential systems

Figure 1: Comparing different vaccine credential initiatives in online/offline environments

4 Other Digital Credential Initiatives

4.1 Vaccination Credential Initiative (VCI)

VCI Initiative (2021) is a user-centric initiative program started in collaboration with Microsoft, Oracle, and Mayo Clinic. VCI’s goal is to empower individuals with digital access to vaccination records using open and interoperable standards so that an individual can protect and improve their health, and demonstrate their health status to safely return to travel, work, and school while preserving data privacy. The digital COVID-19 Vaccination Credential Initiative (VCI) makes vaccination records available to patients using an accessible and inter-operable digital format based on globally-accepted standards such as HL7FHIR. Through VCI, digital vaccination records are provided with a unique QR code that acts as proof for vaccination. These QR codes are stored in health wallets like CommonHealth and AppleHealth and act as a pass for entering public places.

4.2 COVID-19 Credentials Initiative

A decentralized digital credentials initiative hosted by the Linux Foundation Public Health that focuses on gaining the public’s trust by implementing an online digital identity called self-sovereign identity. This approach is an alternative to traditional authentication mechanisms through which an individual has unique pivot points for sharing their health records in a digitalized manner without the involvement of any 3rd party medium or legacy system integration.

5 Conclusion

In this early draft, we have evaluated the benefits and potential challenges posed by the implementation of card-based vaccine credential system and an app-based vaccine credential system while discussing other digital vaccine credential initiatives. The verticals of comparison included domains of symptom reporting, fraud and impersonation, feasibility, scalability, equity, future data aggregation, importability, and operability. Some domains favored the implementation of a card-based vaccine credentials system with benefits of equity, future data aggregation, and operability while others favored the implementation of an app-based vaccine credentials system with benefits of privacy-preserving symptom reporting and ease of scalability.
## REFERENCES

Joseph Bae, Darshan Gandhi, Jil Kothari, Sheshank Shankar, Jonah Bae, Parth Patwa, Rohan Sukumaran, Sethuraman T. V., Krtitika Mishra, Srinidhi Murali, Aishwariya Saxena, Kasia Jagi-mowicz, Vivek Sharma, Rohan Iyer, Ashley Mehra, Alex Radunsky, Priyanshi Katiyar, Sunaina Anand, Shailesh Advani, Jagjit Dhaliwal, and Ramesh Raskar. Challenges of equitable vaccine distribution in the covid-19 pandemic, 2020.

Joseph Bae, Rohan Sukumaran, Sheshank Shankar, Saurish Srivastava, Rohan Iyer, Aryan Mahindra, Qamil Mirza, Maurizio Arseni, Anshuman Sharma, Saras Agrawal, Orna Mukhopadhyay, Colin Kang, Priyanshi Katiyar, Apurv Shekhar, Sifat Hasan, Krishnendu Dasgupta, Darshan Gandhi, Sethuramen TV, Parth Patwa, Ishaan Singh, Abhishek Singh, and Ramesh Raskar. Mobile apps prioritizing privacy, efficiency and equity: A decentralized approach to covid-19 vaccination coordination, 2021a.

Joseph Bae, Rohan Sukumaran, Sheshank Shankar, Saurish Srivastava, Rohan Iyer, Aryan Mahindra, Qamil Mirza, Maurizio Arseni, Anshuman Sharma, Saras Agrawal, Orna Mukhopadhyay, Colin Kang, Priyanshi Katiyar, Apurv Shekhar, Sifat Hasan, Krishnendu Dasgupta, Darshan Gandhi, Sethuramen TV, Parth Patwa, Ishaan Singh, Abhishek Singh, and Ramesh Raskar. Mit safepaths card (misaca): Augmenting paper based vaccination cards with printed codes, 2021b.

Better Business Bureau. Bbb tip: Don’t share your covid-19 vaccine card on so-cial media, 2021. URL https://www.bbb.org/article/news-releases/23875-bbb-tip-dont-share-your-vaccine-card-on-social-media

---

|                          | Card-based implementation                                                                 | App-based implementation                                                                 |
|--------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| QR stickers              | User has a paper copy of the encrypted QR codes.                                          | Users will enter a code in the app to generate encrypted QR codes that get stored in the app digitally. |
| Symptom Reporting        | Users will have to call healthcare administrations directly for reporting symptoms while revealing their personally identifiable information. | Users will be able to report their symptoms anonymously without revealing any personally identifiable information. |
| Fraud & Impersonation    | Paper-based cards will be easier to duplicate, high possibility of impersonation through a lost or stolen copy of the paper card. | Implementation of authentication systems using OTPs and passwords prevent access of the digitally stored QR codes. |
| Efficiency               | Paper-based cards will be easier to carry around at times because they don’t rely on cellular battery and are easy to display. | App generated QR stickers will be hard to display at venues. Lack of cellular battery charging points will create uncertainty. |
| Feasibility              | Paper cards are difficult to produce and distribute because there is no clear issuance authority. | App-generated QR stickers are easy to produce and distribute to every potential vaccine recipient. |
| Scalability              | Paper card distributions will be harder to safely deliver with an expanding user base.    | App’s will always be accessible on AppStore/Play Store and will not face the issue of distribution to everyone. |
| Equity                   | State-based paper cards are the only way vaccines can be distributed to rural and urban populations while ensuring equitable access to all socio-economic sectors in society. | The technological divide is quite significant in all countries. Thus, creating an app based solution automatically disqualifies lower socio-economic sectors of society. |

Figure 2: An overview of the comparisons
Comparing card-based vaccine credential systems with app-based vaccine credential systems

Center for Disease Control and Prevention. Cdc covid data tracker, 2020.

Linux Foundation Public Health. Covid-19 vaccine credentials initiative, 2020. URL [https://www.covidcreds.org]

HLV.org. Hl7fhir release 4, 2021. URL [https://hl7.org/FHIR/]

Vaccine Credentials Initiative. Vaccination credential initiative, 2021. URL [https://vaccinationcredential.org]

Kathleen Dooling MD MPH. Phased allocation of covid-19 vaccines, 2020.

BBC News. Covid-19: Study showing oxford vaccine slows virus spread ’superb’ - hancock, 2021.

Wikipedia. Information, people, and technology, 2005.