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Epidemiological passport system requirements: a roadmap for international travel and tourism recovery

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ABSTRACT

Global tourism demand is vulnerable to pandemics such as the COVID-19 pandemic, which made international travel difficult if not impossible. To improve the robustness of global tourism in the advent of pandemics, this article explores an epidemiological passport system (EPS), which is reported on in this article. To attain different perspectives regarding the use of EPS, this research used a qualitative method approach. It carried out 32 detailed interviews with executive leaders in organizations of different sectors to obtain their views about the main requirements for an EPS. An international EPS could provide traceability to better share important information about such aspects of COVID-19 as testing, contact tracing and vaccination. This research identified the main requirements for a new system that will help with international health and border control organizations' collaboration. The findings of this research study hold significant practical implications for the development and implementation of EPS. This system is designed to address the multifaceted challenges posed by the COVID-19 pandemic, particularly concerning testing and vaccination requirements imposed by various governments. The practical contributions of this research are pivotal in ensuring seamless international travel while maintaining health security and regulatory compliance.

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1. Introduction

Globally, the travel and tourism sector represents significant contributors to economic growth and development, offering opportunities for countries to generate revenue, for people to earn income, and as a labor-intensive sector to generate employment (Abbas et al., 2021; McCabe & Qiao, 2020; Nain et al., 2021). Despite their contribution to the global economy, travel and tourism are vulnerable to global threats and impacts. Epidemic and pandemic outbreaks are ever-present risks with potential global impacts (Ali et al., 2023; Ali et al., 2022).

The tourism and hospitality industry has historically been significantly affected by pandemics (Ali et al., 2023). the SARS outbreak in 2003 for example, led to substantial declines in international travel (Nabil et al., 2022) leading to immediate revenue losses for airlines, hotels, and tour operators but also long-term changes in travel behavior and heightened health and safety protocols within the industry (Škare et al., 2021; Nabil et al., 2022). The H1N1 influenza pandemic in 2009 had a noticeable impact, with many travelers canceling or postponing trips due to fear of infection (Zhang et al., 2021). The financial ramifications were felt globally, as the decreased demand for travel services resulted in economic downturns for countries reliant on tourism (Fotiadis et al., 2021).

The COVID-19 pandemic brought challenges to the global tourism and hospitality sectors. Widespread travel restrictions, lockdowns, and social distancing measures led to a dramatic drop in both domestic

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and international travel (Samha et al., 2022). Hotels, airlines and related businesses experienced massive losses, leading to closures, layoffs and a reevaluation of operational practices (Škare et al., 2021). The industry had to adapt to new health and safety standards, digital transformation and shifts in consumer preferences toward less crowded destinations and more flexible booking options (Chowdhury et al., 2020). Currently, the spread of the monkeypox virus represents a new challenge (de Clercq et al., 2023; Kaler et al., 2022; Ortiz-Martínez et al., 2022), and a multi-country outbreak (Ortiz-Martínez et al., 2023). Elkhwesky et al. (2023) highlighted the importance of educating hotel employees about the virus to ensure they are well-prepared to manage potential outbreaks. That knowledge about monkeypox's source, symptoms, transmission, prevention and treatment is crucial for maintaining health safety standards and minimizing the impact on the hospitality sector. By enhancing awareness and implementing effective health protocols, the industry can better mitigate the effects of such emerging infectious diseases on tourism and hospitality.

As the immediate impact of lockdowns travel suspension and containment measures diminished during the second half of 2020, countries started seeking balanced measures to overcome the global tourism economic recession while maintaining the safety of their citizens from international arrivals (UNWTO, 2021; IATA, 2021). Accordingly, new international travel requirements such as verified laboratories for COVID-19 testing and vaccination certificates were implemented by many countries (Samha et al., 2022; Škare et al., 2021). Due to this new implementation and the diversity of travel requirements introduced by governments, several challenges regarding global governmental coordination and collaboration have been observed (Angelopoulos et al., 2020). The first challenge relates to the existing digital contract tracing (DCT) applications, which have been developed by the local authorities to assist their COVID-19-related monitoring processes at the local level (Chowdhury et al., 2020). These applications need to be extended to cope with international collaboration needs by offering traceability and data exchange functionalities so that multiple international health and border control organizations can share and verify COVID-19 immune certificates (Quan et al., 2022). The diverse set of COVID-19 testing and vaccination requirements established by governments have created a complex traveling environment for passengers, health authorities, border control authorities and airlines to navigate this diversity (Zhang et al., 2021). Another challenge relates to the passengers' need for an accurate platform that offers information about COVID-19-related testing and vaccination requirements and authorized centers based on the needs of their country of destination (Quan et al., 2022). Airlines and immigration staff need a secure platform to verify the authenticity of the test and vaccine information presented by the arrival passengers (IATA, 2021). Finally, the unavailability of an international digital solution that offers harmonized and global standards and protocols to validate and authenticate all countries' regulations concerning COVID-19 passenger travel requirements is another challenge that prevents the quick recovery of international tourism and a recovery in travelers' confidence (Samha et al., 2022). Accordingly, several research units and organizations have identified the consideration of the long-term implications of this crisis while capitalizing on the digital solution (Abbas et al., 2021). The proposal of a proactive EPS solution is introduced to promote safe travel, build confidence and accelerate economic recovery as the travel and tourism industry restarts (Chowdhury et al., 2020).

This research found support for a cross-border EPS approach to facilitate the traceability of travelers' COVID-19-related testing and vaccination information sharing and exchange across different health systems and countries. This research sought to answer the research question: *What are the main requirements that will help different countries to use the vaccine passport system*? This research used a qualitative method approach involving 32 in-depth interviews at the top management level within organizations in different sectors to obtain their views about the main requirements to use the EPS. As a result, this research provides a framework and system requirements for a novel cross-border EPS solution to promote safe travel, build confidence and accelerate economic recovery as the travel and tourism industry restarts following the pandemic.

This research stands out from prior research by focusing specifically on the comprehensive requirements and practical implications of implementing an epidemiological passport system (EPS) within the context of global travel and tourism recovery. While previous studies have explored various aspects of digital health passports, such as their technological frameworks, potential benefits, and ethical considerations, this research study uniquely addresses the holistic integration of such a system from the

perspectives of multiple stakeholders, including travel industry professionals, healthcare providers, and government officials. The primary purpose of this research is to develop a comprehensive roadmap that outlines the requirements and implications of implementing an EPS. This roadmap aims to facilitate the recovery of international travel and tourism, which have been severely impacted by pandemics, such as COVID-19. The research study seeks to identify and analyze the prerequisites for such a system, assess its potential benefits and drawbacks and provide actionable recommendations for policymakers and industry stakeholders.

The significance of this research lies in its potential to contribute to the stabilization and revitalization of the global travel and tourism industry. By providing a detailed understanding of the necessary conditions for an effective EPS, this research study offers several key benefits such the findings can help countries and organizations better prepare for future health crises by establishing robust systems that can be quickly activated. Policymakers can use the insights from this research study to formulate regulations and guidelines that support the safe and efficient resumption of international travel. By addressing the requirements for a reliable and secure EPS, the research contributes to the protection of public health while facilitating economic recovery through resumed travel and tourism activities. In addition, the research study encourages the adoption of innovative technologies and practices that can enhance the resilience and sustainability of the travel and tourism industry in the face of ongoing and future challenges. The following section introduces the background and associated work that relate to travel and tourism and their contributions to the global service industry; the global health crisis; and the COVID-19 pandemic and its impact on the travel and tourism sectors. Section 3 addresses the proposed conceptual framework in this research, while Section 4 describes the methodology adopted by this research. Section 5 focuses on the results and a discussion of the findings. The final sections provide insight into the research implications and conclusions.

2. Background and related work

2.1. Travel and tourism contribution to the global service industry

For many countries, travel and tourism have become critical industries and leading contributors to the local Gross Domestic Product (GDP) as well as to international economic growth and development (Zhang et al., 2021; Gopalakrishnan et al., 2020). In 2018 and 2019, the travel and tourism sector accounted for the growth in worldwide tourist arrivals (Kumar & Nafi, 2020). 1407 million international tourist arrivals were reported in 2018; a 6% increase was registered in 2017 (UNWTO, 2020; Gopalakrishnan et al., 2020). Around 135 million visited Germany, Austria and Switzerland (Abbas et al., 2021). A 4% increase was reported in 2019, and more than 1500 million international tourist arrivals were reported (Kumar & Nafi, 2020). 2019 travel and tourism statistics, as presented by UNWTO (2020), indicated that there were approximately 61.5 million international tourist arrivals to Middle Eastern countries and 146.4 million in the North American region. European countries were identified as the primary contributors to the global travel and tourism industry as 48% of the entire international travel and tourism activities occurred in Europe, where approximately more than 600 million tourists visit this region yearly (Abbas et al., 2021).

As stated by Gopalakrishnan et al. (2020) between 2010 and 2019, the statistical data on international travel and tourism indicated a yearly increment in international travelers' number. Developed countries such as France, Spain, the USA and China were identified as the most popular destinations by the year 2019 (Gopalakrishnan et al., 2020). This growth acceleration in developing countries has occurred due to the active sustainability of infrastructure, mobility, and participation. This acceleration has a significant impact on these countries' economies. Travel and tourism industries offer a significant contribution to business operations, and to the worldwide economy's GDP (Gopalakrishnan et al., 2020). For example, statistics from 2018 to 2020 data related to the travel and tourism sector in Germany, Austria, and Switzerland have shown a contribution of 5.1 trillion dollars to their GDP (Abbas et al., 2021). In 2019, the travel and tourism sectors directly contributed 2.9 trillion dollars to the global economy, which is almost 10% of the global GDP (Grech et al., 2020; Kumudumali, 2020). Another visible and significant impact of the travel and tourism industry on the economy is related to the employment level, as in 2018,

travel and tourism created 14.4 million job opportunities in the European Union countries, and in 2019, it created 300 million job opportunities worldwide (UNWTO, 2020). These numbers emphasize the point of considering travel and tourism as significant drivers of worldwide cultural and socioeconomic progress (Škare et al., 2021).

Despite the importance and significant contribution of the travel and tourism sector to local and global economic progress, it also represents one of the most vulnerable industries (Ma et al., 2020). Very often, the travel and tourism industry experiences severe consequences during 'Black swan' crisis events, such as the global financial crisis in 1997 and 2008, the SARS epidemic in 2003, the COVID-19 pandemic in 2020/2021, and recently the monkeypox virus in 2022 (Zhang et al., 2021; Elkhwesky et al., 2023a). These events negatively impact tourists' behaviors and their attitudes toward traveling, and hence, international tourism will become more complicated than in its normal situation (Ma et al., 2020). The international collaboration between governments will be recognized as an urgent need for recovery and regaining tourism activities, and their contribution to the economy.

2.2. Global health crisis

Epidemic and pandemic outbreaks have always been with us, damaging the local and global economy (Mishra, 2022; Elkhwesky et al., 2023a; Elkhwesky et al., 2023b). Epidemic and pandemic outbreaks can cause global health and economic crises. They also negatively affect mental well being and motivation toward traveling (Fotiadis et al., 2021). Due to the fear of infection, tourists cancel their traveling plans to avoid risks and governments close their countries' borders (Aman et al., 2019). SARS in 2003, H1N1 influenza in 2009, Ebola virus in 2014, Zika virus in 2015 and now, COVID-19 are among the notable epidemics and pandemics that have affected worldwide traveling habits and created substantial economic losses (Odoom et al., 2022). The SARS epidemic had an important impact on tourism demand in China, Hong Kong, Singapore and Taiwan (Kuo et al., 2008). SARS and H1N1 epidemics caused a 10 million drop in travelers in the Americas region, and a loss of 2 billion dollars was recorded in tourism spending (Sariişik et al., 2021). During the bird flu, SARS and H1N1 epidemic, the Asiatic and Pacific regions experienced a significant drop of 16 million travelers in tourist arrivals, and by 10 billion in revenue and spending loss. During the H1N1 epidemic, the European region faced a decline in the number of tourist arrivals by 26 million and a 61 billion dollars of spending loss, which is 0.5% of the European Union GDP in 2009 (Škare et al., 2021).

Earlier epidemics had relatively less impact than the COVID-19 pandemic (Sariişik et al., 2021). There was an estimated 30% decline in the number of international travelers with a loss of 450 billion US dollars of global travel and tourism revenue, which is ten times greater than the global economic impact of the SARS epidemic (Shretta, 2020). There is a belief that the COVID-19 outbreak will more critically impact international tourism compared to previous epidemics and for a more extended period (Kumudumali, 2020).

2.3. COVID-19 pandemics' impact on travel and tourism

Different measures, such as social distancing, working from home, travel restrictions, airport and national border closures and full suspension of all international tourism activities are used by different countries to limit the spread of the pandemic (Odoom et al., 2022). By the 27 April 2020, 83% of the worldwide destinations were closed to international travelers, by the 18 May 2020, 74% of the worldwide destinations were closed to international travelers, while by the 1 February 2021, only 28% of the worldwide destinations were completely closed to international travelers and 53% were partially closed to international travelers (Zhang et al., 2021; World Tourism Organization [UNWTO], 2020).

The global lockdown and restrictions that have been widely applied by multiple countries brought the global travel and tourism sector to a complete standstill (Fotiadis et al., 2021). As well as its threat to human health, COVID-19 has been recognized as a financial recession (Abbas et al., 2021). In comparison to 2019, international tourist arrivals have declined by 56% within the first five months of 2020 (Kumar & Nafi, 2020). Moreover, after the complete lockdown of most international borders, these numbers have been increased to reach 97% by April and 98% by May 2020. This dramatic decline in the number of international arrivals

continued as the COVID-19 pandemic and travel restrictions remained high. Globally, international tourist arrivals have declined by 73% in 2020 and by 85% in 2021, while the decline of the international tourist arrivals in the Middle East region was 57% in 2020, and 83% in 2021 (World Tourism Organization [UNWTO], 2020). Asia and the Pacific regions were the worst hit, with an approximately 73% decline in 2020 and 95% in 2021 (Kumar & Nafi, 2020; World Tourism Organization [UNWTO], 2020).

This sharp decline indicates a loss of 460 million international arrivals in comparison to the international arrivals for the year 2019, and a loss of 147 million in the first five months of 2021 (UNWTO, 2021, 2022). Based on UNWTO statistics, the travel and tourism industry from March to July of 2021 continued to report very weak revenues ranging from 50% to 90% declines in comparison to 2019 (UNWTO, 2021) with significant job losses (Škare et al., 2021). There has been an estimated 252-billion-dollar revenue loss for international airline companies, which can be translated into a 1.2 trillion dollars loss in the travel and tourism GDP (Fotiadis et al., 2021; UNWTO, 2021).

Despite the recent increase in international travel, the recovery may take more time to recover due to the uncertainty of the progression of the pandemic, and the revenue loss may continue for several years. A study conducted by Zhang et al. (2021) on the direct effects of the COVID-19 pandemic on Hong Kong travel and tourism income between the years 2020–2024 claimed that an approximate loss of 22,760 million dollars will be observed by 2020. This loss is expected to decrease due to the gradual tourism recovery to reach 1548 million dollars by 2024. This forecasting study claims that the gradual recovery in the tourism sector will more likely begin in 2022. The World Tourism Organization emphasizes the utilization of a phased-action plan for a gradual tourism recovery process (Rashid et al., 2022). Aspects like health infrastructure, tourists' perception of safety and COVID-19-related associations and applications could potentially fasten the recovery process and restore tourists' confidence in international travel, as well as reduce the spread of COVID-19 (Zenker & Kock, 2020). The latest UNWTO world tourism statistics for 2023 showed that the world reached 88% of pre-pandemic arrivals levels in 2019, Europe reached 94% of 2019 arrivals levels, and Asia and the Pacific reached 65% in 2019, while the Middle East is the only region that managed to overcome pre-pandemic levels with arrivals 22% above 2019 (UNWTO, 2024).

2.4. Proactive pandemic containment and a recovery proposal for future tourism (related work)

After this peak of the international border shutdown and the global economic recession, governments have started easing travel restrictions to allow the reactivation of tourism activities and international travel gradually (Rashid et al., 2022). Specific measurements, such as a negative Polymerase Chain Reaction (PCR) test and/or vaccination immunity certificates have become essential requirements to enter many countries (Nabil et al., 2022; Samha et al., 2022). The heterogeneous regulations relating to travel restrictions are taken by several countries for the recovery of international tourism (UNWTO, 2021). Governments are issuing and applying diverse COVID-19-related regulations to allow travelers to enter their countries. The majority of COVID-19 vaccines consist of two doses that should be given within a 1–3-month period, which might require a tourist to take his/her vaccination in two different countries. Different governments are restricting the usage of specific vaccines such as AstraZeneca, Pfizer and Moderna only, while others are considering Sinovac and Janssen (WHO, 2020). Different countries approve different accredited labradorites for the PCR test certificate. This diversity of governments' regulations and restrictions related to COVID-19 testing and entering requirements has created a complex environment for international travelers and immigration authorities to cope with (Angelopoulos et al., 2020; Nabil et al., 2022). International travelers seeking accurate information about their destination's COVID-19 requirements, yet they do not know where to find or understand it (IATA, 2021). Airline check-in staff may still need to deal with extensive data entry requirements guidelines. This issue creates an inefficient health check process with a high chance of errors and fraud (Angelopoulos et al., 2020).

In this context of complexity and to cope with rapid and diverse containment measurements, the full recovery of international travel and tourism will only be possible with full international coordination between immigration and health authorities, as well as international governments' cooperation on travelers' protection policies and travel restrictions requirements and facilities (IATA, 2020; United Nations, 2020). As a result, safe traveling and regaining traveling confidence will be promoted among international travelers and international travel and tourism will gradually recover (United Nations, 2020).

For this purpose, IATA and WHO have encouraged governments and private sectors to create solutions that focus on harmonizing COVID-19 containment protocols and standardized testing and vaccination certificates, as well as developing technological solutions to facilitate the authentication process of COVID-19 testing and vaccination requirements (IATA, 2020; Mishra, 2022; Nabil et al., 2022; Quan et al., 2022). Such technological solutions can assist international and local travelers in producing a digitally authenticated document of their COVID-19 health-related information (i.e. PCR testing certificate and vaccination information and certificate). This digital document can be accredited through coordination among the local and international health and immigration authorities and approved laboratories (Angelopoulos et al., 2020). By utilizing such information technology (IT) applications, the complex process of handling the rapid and diverse containment measurements will dramatically be reduced and the accuracy of the produced health-related information may be improved.

In addition to the testing, tracing, isolating and vaccinating strategies, several governments have relied on the development of DCT applications to assist their local travelers in entering their COVID-19-related information and/or tracing their quarantine process (Angelopoulos et al., 2020). Several DCT applications and protocols have been developed by different countries and organizations, such as PACT (Chan et al., 2020; CONTAIN (Hekmati et al., 2021), Block-HPCT (Rashid et al., 2022) and CoVista (Culler et al., 2020) and COVID-Safe App (2020). These applications rely on GPS data, Bluetooth and/or QR code scanning (Chowdhury et al., 2020). Nevertheless, Block-HPCT is a blockchain-enabled digital health passport based on vaccination certificates and contact tracing to control the spread of COVID-19. Despite the effectiveness of this DCT reactive approach to remotely identify and self-isolate asymptomatic patients, it fails to provide a proactive solution that assures a safe return for international travel and the tourism industry. As a single application deployed in a specific country, features such as traceability, trust and data exchange and sharing facilities among international health and immigration authorities were not available. These applications may be the unsuitable solution for international travel collaborations (Angelopoulos et al., 2020). Economies that have significant exposure to international tourism remain extremely vulnerable (Salathé et al., 2020). Many public concerns have been raised against such DCT applications due to the vulnerability of their privacy and trust concerns (Angelopoulos et al., 2020). Cases of test fraud, such as the ones that occurred in Bangladesh raised serious trust issues among countries (Nabil et al., 2022). This category of application utilized the personal devices of the newly identified COVID-19 patients to perform rigorous contact tracing, which can be seen as a way to invade people's privacy and private data collection.

Research toward developing proactive technological solutions for cross-border traveling coordination has been initiated (IATA, 2020). These solutions offer a global and/or standardized solution to validate and authenticate countries' procedures concerned with the COVID-19 passenger travel requirements (Angelopoulos et al., 2020). To address this concern, the framework and systems of 'EPS', 'DHP' based on blockchain, 'IATA Travel Pass', 'Digital Vaccine Passport' (DVP) system and 'Borderless' have been respectively introduced by Angelopoulos et al. (2020), Tsoi et al. (2021), IATA (2020), Nabil et al. (2022) and Odoom et al. (2022). Angelopoulos introduced a theoretical framework solution based on the utilization of private blockchain and proof of authority to issue the EPS. The framework offers a distributed infrastructure to support foreign health systems and such relevant stakeholders as airline companies and immigration authorities to issue and verify the EPS for its corresponding traveler. Due to the utilization of blockchain technology and its lack of acceptability and regulations by many governments or organizations, the actual implementation of this framework is a challenging task (Ali et al., 2021; Jaradat et al., 2022; Odoom et al., 2022). Nabil et al. introduced a blockchain-based DP system that seamlessly integrates testing and vaccination systems, allowing the system to be transparent and reducing the corruption in COVID-19 testing and vaccination results. One major limitation of this proposed system is related to the transaction cost due to the usage of a public blockchain (e.g. Ethereum). This system has been developed in a web interface platform as smartphones are available in almost everyone's hand, a mobile application can help to reach more people. IATA introduced a travel pass solution platform to be used by airline passengers only (IATA, 2020).

This proactive solution is offered to the passengers of the airline companies that are part of the travel pass program, which limits the usage of this application to a specific group of travelers. This solution is a mobile-based application that allows passengers to store and manage their verified COVID-19 tests and

vaccine certificates. Four modules were proposed by this solution. The first module is a global registry of all countries' health requirements. The second module is a built-in registry at the passenger's local location. It is used by passengers and by COVID-19 testing and vaccination centers. The third module provides a secure and encrypted communication channel between the passenger and the accredited laboratories to share and verify the passenger's identity and test results. The last module is the travel pass application that allows passengers to share their verified digital identity, test and vaccination status with the relevant local and international authorities. The borderless system had been proposed to foster global traveling by allowing travelers and countries to collaboratively engage in a secure adaptive proof protocol throughout its implementation as a decentralized application leveraging blockchain as a trust anchor and decentralized storage technology.

In conclusion, while several ideas and frameworks solutions for using cutting-edge technologies such as blockchain, mobile computing, and AI to facilitate COVID-19 digital health passport and contract tracing are discussed, most of these solutions were introduced as country-based or regional-based solutions with downplay privacy, often impractical and/or come with blockchain-related complexities that present technological difficulty for end users and travelers. Furthermore, these solutions are mainly in a web-based platform; they are not convenient for travelers. They do not integrate and support Artificial Intelligence (AI) and visualization features for diagnostics, forecast disease transmission, and data analytics to boost swift decision-making by health professionals. Deep learning and other AI techniques can help these solution proposals become smarter and more efficient at identifying COVID-19 cases and forecasting epidemics and pandemics (Rashid et al., 2022; Alghamdi et al., 2024). In general, the development and implementation of such proactive EPS solutions that can accelerate the recovery and safe return of international traveling activities are still in their infancy, with several research efforts yet to come. In comparison with the other proposed solutions, our EPS provides global verification between countries without the need for any prior bilateral relationship. In addition, EPS incorporates a test/vaccination status update ingrained with privacy preservation. Also, this system implements filter parameters that combine parameters from different government regulations, which increases transaction transparency (TT). Finally, we make our solution flexible and adaptable to the dynamic nature of pandemics.

3. Research conceptual framework

Different theories have been utilized to support advanced technologies usage such as the Technology Acceptance Model (TAM) (Davis, 1989; Davis et al., 1989), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), the UTAUT 2 (Venkatesh et al., 2012), Expectancy-value theory (Hsiao, 2019), Mental Accounting theory (MAT) (Park et al., 2019), Innovation resistance theory (IRT) (Khanra et al., 2021) and Diffusion of Innovation (DOI) (Rogers, 1995). Among them, TAM and UTAUT are considered one of the most popular theories adopted to investigate the use of different mobile application studies (Shankar & Datta, 2018; Acheampong et al., 2021; Rosnidah et al., 2019). However, TAM is criticized for providing general information about individuals' opinions and acceptance of adopting mobile applications, while UTAUT is criticized for lacking the characteristics of people who engage with technology that might affect the use of mobile applications (Patil et al., 2020).

These theories have been integrated with other factors to explain certain contexts such as the adoption of the mobile payment application. The perceived risk (PR) and perceived trust are considered the most frequent factors that were used to extend the UTAUT to study the adoption of mobile applications (Al-Saedi et al., 2019). Privacy was included in the study conducted by Lee et al. (2019) as an important factor in investigating the adoption of any new technology. Furthermore, Singh (2020) supported his study that applied UTAUT by the expectation confirmation model (ECM), along with two additional constructs: perceived security, and trust to develop an integrated model. Also, Putri et al. (2019) classified the factors affecting the use of mobile applications into three main groups: technological (feature, user interface, speed, platform and security), behavioral (perceived ease of use), and personal factors (age, occupation, gender, education and income).

In the context of the pandemic, users' perceptions about the benefits of using technology can be positively influenced when the characteristics of that technology can support them in a specific situation. Integrating UTAUT with TAM and two additional variables from the literature review. These variables

included perceived security and trust (Singh, 2020). The research conducted by Zhao and Bacao (2021) indicated that users' technological perceptions conjointly influence their adoption intentions of mobile applications during the COVID-19 pandemic. Furthermore, trust significantly affects the perceived benefits of mobile applications, corresponding with the pandemic situation.

Based on the findings from the literature review, several related challenges have been identified in relation to a new implementation, and to the diversity of travel requirements introduced by governments. Several challenges regarding global governmental coordination and collaboration have been observed (Angelopoulos et al., 2020). The first challenge relates to the existing DCT applications, which have been developed by the local authorities to assist their COVID-19-related monitoring processes at the local level (Chowdhury et al., 2020; Angelopoulos et al., 2020; IATA, 2021). These applications need to be extended to cope with international collaboration needs by offering traceability and data exchange functionalities so that multiple international health and border control organizations can share and verify COVID-19 immune certificates (Chowdhury et al., 2020). The diverse set of COVID-19 testing and vaccination requirements established by governments have created a complex traveling environment for passengers, health authorities, border control authorities and airlines to navigate this diversity (Zhang et al., 2021; Chowdhury et al., 2020). Another challenge relates to the passengers' need for an accurate platform that offers information about COVID-19-related testing and vaccination requirements and authorized centers based on the needs of their country of destination (IATA, 2021). Airlines and immigration staff need a secure platform to verify the authenticity of the test and vaccine information presented by the arrival passengers (IATA, 2021). Finally, the unavailability of an international digital solution that offers harmonized and global standards and protocols to validate and authenticate all countries' regulations concerning COVID-19 passenger travel requirements is another challenge that prevents the quick recovery of international tourism and a recovery in travelers' confidence (Zhang et al., 2021).

To address these gaps, this research developed a model that integrates both UTAUT with TAM and two additional variables from the literature review in purpose to explore the factors affecting the adoption and the use of the new EPS in the context of the COVID-19 pandemic. The proposed research model consists of several variables, such as PR which represents the level of risks perceived when using EPS (Featherman & Pavlou, 2003; Kuisma et al., 2007). TT reflects users' privacy concerns, and it is related to authentic identification and TT (Featherman & Pavlou, 2003). Security Concern (SC) is associated with a set of procedures and programs to confirm the data source and guarantee the integrity and privacy of the information (Fan et al., 2018). Usefulness (MPU) and Performance Expectations (PE) both variables represent smooth transactions, and the benefits consumers expect from the use of EPS (Venkatesh et al., 2003, 2012). Ease-of-Use (EU) which represents the level of innovation is perceived as easy to understand and use (Venkatesh & Davis, 1996). Trust (T) can be deemed as a positive expectation of the consumer toward the service provider (Zhou, 2013, 2014; Hua & Bai, 2020). Social Influence (SI) represents the degree to which an individual perceives that important others believe he/she should use the new system (Venkatesh et al., 2003; Riffai et al., 2012). For more details about the proposed research model see Figure 1.

4. Research methodology

This study adopts a qualitative research design to explore the requirements and implications of an EPS for international travel and tourism recovery. The qualitative approach allows for an in-depth understanding of stakeholder perspectives, experiences and the nuanced dynamics involved in implementing such a system (Busetto et al., 2020).

The conditions that apply while using COVID-19 or EPS in different countries were explored in this research study. The questions were drafted to obtain insight into the requirements considering the level to which these conditions may affect the use of COVID-19 or EPS. They also aimed to elicit conditions to be considered while planning to employ the COVID-19 health passport, the present rules, the advantages that are expected from the use of these health passports and the possible restrictions of these.

Because an epistemological approach is used for this investigation, then for the detailed assessment of the major requirements, qualitative research was carried out as identified by Busetto et al. (2020). Detailed interviews were carried out and this method of information collection may help to determine

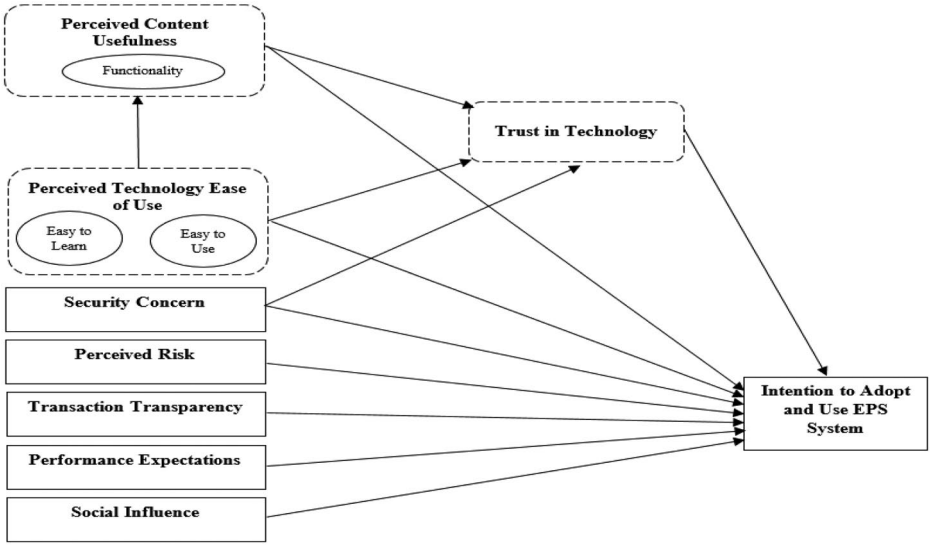

Figure 1. Proposed research model.

all the appropriate conditions and the communication of all stakeholder groups (airline, health and government organizations) in an implementation procedure of ICT modernization (Leedy & Ormrod, 2005; Busetto et al., 2020).

The population for this research study includes a diverse range of stakeholders involved in international travel and tourism. A purposive sampling technique was employed to select participants who were aknowledgeable and experienced in the relevant fields. The sample size is comprised of three categories; (1) Travel industry professionals which include consultant, chief information officer, strategy coordinator, service department manager and executive manager. (2) Healthcare professionals; including chief information officer, information services manager, consultant, technical director, lab manager and strategy coordinator. (3) Government officials; including information services manager, and consultant. The sample size of this research study is considered adequate to achieve data saturation and ensure a comprehensive understanding of the research topic.

4.1. Data collection method

Data was collected using semi-structured interviews; these methods were chosen to allow for flexibility in exploring topics in depth while providing structure to ensure all relevant areas are covered (Ali et al., 2018). Semi-structured interviews were conducted with individual stakeholders across the travel, healthcare and government sectors. To improve the reliability of this research, the process explained by Kirsch (2004) was followed for collecting data. This process defines a set of procedures: firstly, identify and select the research issues, secondly, determine who to interview and, finally, determine how the interviews will be conducted. The research followed a sequence of steps: planning the interview, introductions at the commencement of the interview and establishing rapport with the respondent through small talk (Gaskell, 2000). Each interview was structured around eight questions with the interviewers asking probing questions based on responses.

Prior to the main data collection, a pilot test was conducted to refine the interview guides. The pilot involved: 2 travel industry professionals, 3 healthcare professionals, 2 government officials and 4 academic faculty members from the university. The pilot test aimed to identify any ambiguities or issues with the questions, assess the duration of interviews and ensure the reliability and validity of the instruments. Based on feedback from the pilot test, some questions were rephrased for clarity, and additional probes were added to elicit more detailed responses. The sequence of questions was also adjusted to improve the flow of the conversation (Ali et al., 2018).

Ethical approval was obtained from the relevant institutional review board. Key ethical considerations included: Participants were informed about the study's purpose, procedures and their right to

withdraw at any time without consequence. Written consent was obtained from all participants. Participants' identities and responses were kept confidential, with pseudonyms used in transcripts and reports.

The interview questions were designed with open-ended questions to encourage the interviewees to provide answers that revealed experiences, perceptions, and recommendations regarding the requirements EPS (Carson et al., 2001). From October 2020 to April 2021, interviews were carried out that helped to gain information from 32 various firms' staff working in senior posts as guided by Punch (2013) and Russell and Gregory (2003). These employees were chosen as it was assumed that they were the ones who are responsible for the forecasting and implementation of advanced techniques and innovations for their institutes. The job titles and IT expertise of the participants of this study are shown in detail in Table 1.

The respondents were chosen from various organizations and sectors. The researchers chose numerous organizations from every chosen sector which will help them to attain complete information about the prerequisites of the research subject. The sample comprised 32 professionals from different organizations clarified that these organizations are of direct interest in this subject (refer to Table 1).

According to the findings, 34.38% of participants worked in healthcare, 12.50% worked in immigration, airlines and IT, and 9.38% worked for tourism companies. About 25% of these participants worked as consultants, and 9.38% were researchers, while the information services managers and strategy coordinators shared the same proportion of 12.50%. 6.25% of participants were executive managers, chief information officers, technical advisers, technical directors, and service department managers. 29.13% of them had an IT background for more than 11 years, while 40.75% of participants had experience of 6 to 10 years and 29.13% had experience of 1–5 years. Table 1 shows that all the participants were fully aware of the topic and had the required expertise in the research matter.

Kirsch (2004) had previously clarified the procedure after gathering relevant information to increase the study's authenticity. According to this process, there were three stages involved: to recognize and select the research topic, define the sample that will be selected for the interviews and then lastly,

Table 1. Interviewee details.

Interviewee code	Job title	Sector	IT experience	Country
COVID-DHP-1	Chief Information Officer	Health Organization	6 Years	Saudi Arabia
COVID-DHP-2	Information Services Manager	Immigration Department	9 Years	Kuwait
COVID-DHP-3	Consultant	Health Informatics Centre	14 Years	USA
COVID-DHP-4	Technical Adviser	IT Company	10 Years	France
COVID-DHP-5	Information Services Manager	Health Organization	3 Years	Australia
COVID-DHP-6	Consultant	Health Research Centre	7 Years	China
COVID-DHP-7	Consultant	Airline Company	5 Years	Saudi Arabia
COVID-DHP-8	Technical Director	Health Organization	4 Years	UK
COVID-DHP-9	Consultant	Health Centre	10 Years	Australia
COVID-DHP-10	Lab Manager	Health Organization	8 Years	UK
COVID-DHP-11	Consultant	Airline Agency	11 Years	Germany
COVID-DHP-12	Technical Adviser	IT Company	14 Years	China
COVID-DHP-13	Chief Information Officer	Airline Agency	6 Years	France
COVID-DHP-14	Strategy Coordinator	Airline Agency	4 Years	Saudi Arabia
COVID-DHP-15	Technical Director	IT Company	7 Years	France
COVID-DHP-16	Service Department Manager	Airline Company	9 Years	USA
COVID-DHP-17	Executive Manager	Airline Company	11 Years	Qatar
COVID-DHP-18	Chief Information Officer	Tourist Company	6 Years	Kuwait
COVID-DHP-19	Researcher	Research Centre	5 Years	Australia
COVID-DHP-20	Information Services Manager	Immigration Department	12 Years	UK
COVID-DHP-21	Strategy Coordinator	Health Organization	4 Years	China
COVID-DHP-22	Researcher	Research Centre	13 Years	USA
COVID-DHP-23	Strategy Coordinator	Tourist Company	5 Years	Turkey
COVID-DHP-24	Consultant	Immigration Department	14 Years	Australia
COVID-DHP-25	Consultant	Health Informatics Centre	9 Years	Kuwait
COVID-DHP-26	Information Services Manager	Health Test Centre	8 Years	Qatar
COVID-DHP-27	Service Department Manager	Airline Company	6 Years	UAE
COVID-DHP-28	IS Coordinator	IT Company	12 Years	USA
COVID-DHP-29	Researcher	Research Centre	5 Years	Italy
COVID-DHP-30	Strategy Coordinator	Health Organization	6 Years	Saudi Arabia
COVID-DHP-31	Executive Manager	Tourist Company	4 Years	Australia
COVID-DHP-32	Consultant	Immigration Department	11 Years	China

determine the mode of interviews. There were several steps involved in this research: planning interviews, having an introductory session at the start of the interview, and with the help of communication, developing a relationship with participants (Gaskell, 2000). Every interview had approximately five questions, and based on the replies, the interviewers asked further questions.

4.2. Data analysis

Two approaches were used to assess the information collected from the interviews: the manual content analysis method (Miles & Huberman, 1984); and the automated tool Leximancer (Middleton et al., 2011). There were three synchronized flows of actions that were used in the manual content analysis: (1) information reduction, (2) data display and (3) conclusion (Faust, 1982; Hsieh & Shannon, 2005; Miles & Huberman, 1984; Miles et al., 2014). All the steps are discussed in detail in the following sections.

The process of concentrating, evolving, selecting, theorizing and simplifying the unprocessed information that is collected by the interviews is called Data reduction (Ali et al., 2018; Miles et al., 2014). At the end of every interview, the recorded responses are written down and with the help of summary sheets, which are sheets involving a sequence of important and thought-provoking queries regarding the relevant area, the theoretical data of the interview was elaborated (Carson et al., 2001; Rao & Perry, 2007). The summary sheets have major topics, crises and brief solutions to every problem that helped to gain an overall view of the research data (Miles et al., 2014; Patton, 2002; Schilling, 2006). For the research information, the summary sheets are judged to establish a pattern code which is the descriptive codes that recognize an immediate subject, pattern or clarification that is recommended to the theorist (Miles et al., 2014; Weber, 1990). These codes change different materials into economically significant centers for assessment that are divided into smaller groups of major themes and structures.

To establish the data display is the second stage. Data display enables the theorist to derive conclusions and take appropriate steps by showing the data in an arranged order (Faust, 1982; Miles et al., 2014). In this stage, for the subjective info, there are the rows and columns of a matrix designed when the previously established summary sheets and pattern codes are evaluated.

In the procedure of the manual content analysis, the last and final stage is the conclusion. The qualitative researcher opts to assign meanings to different collected notes, patterns, details, probable relationships, underlying flows and propositions to derive conclusions and check them while gathering information (Bradley, 1993; Miles et al., 2014). There is an inflow of newer ideas about what must be filled in the matrix for data display because of the summary and coding of the information in the data reduction phase. Further data reduction is needed for computing data into a matrix and a basic conclusion is drawn as the matrix fills up.

After the completion of manual coding, the information is analyzed again using computer equipment that will help to increase the authenticity of the outcomes (Middleton et al., 2011; Biroscak et al., 2017). The software, called Leximancer, is an example of such an instrument (Smith & Humphreys, 2006). This software is used for data mining which is also used to evaluate the variables of information of text data and to show the given data (Ward et al., 2014; Smith, 2007). For arranging the units of data into proper models, ontological relativity and dynamics are used and enable the judging of the principles (Ali et al., 2015; Cummings & Daellenbach, 2009). To develop concepts (thematic analysis) and identify relationships (semantic analysis) between concepts, words are arranged together. A 'concept map' exhibits the main notions in the empirical data, showing the relationships via visual summaries of concepts and their co-occurrences – similar to a mind map (Cummings & Daellenbach, 2009). The simultaneous use of both manual and software analytical approaches provided a strong foundation for clearly delineating ideas, themes and aggregate dimensions (Ali et al., 2018; Middleton et al., 2011; Smith & Humphreys, 2006).

5. Research findings and discussion

Information systems (ISs) play a significant role in the development of the tourism industry (Balouchi et al., 2017; Kamboj & Rahman, 2017). It has been determined that an organization's IT infrastructure is

a key success component contributing to strategic management (Bilgihan et al., 2011; Müller et al., 2018), and a significant driver for the tourism industry (Wang et al., 2015). In general, adopting advanced technologies in tourism is often used to improve the client experience to boost their purchase intent (Sox et al., 2016; Müller et al., 2018).

The development of smartphone applications (Apps) is expanding quickly, especially in the world's largest industries such as the travel and tourism domain (Hua et al., 2021). Destinations and tourism companies are developing applications to provide better services for travelers. Smartphones, however, place new and additional cognitive demands on users because the use of such technology requires increased attention and more complex thought patterns (Alshehri et al., 2013).

As a result, the major areas of the research findings related to the new proposed system are (1) the country-level scenario of the EPS, (2) the filtration system that is related to the regulations between different countries and (3) the cross-country level scenario of the EPS. The findings from these three major areas are linked to the requirements that influence the use of EPS. Each of the critical finding areas is discussed in detail next.

EPS is a disease (virus) spread control system. When a travel/move request is issued, the EPS system collects disease information from the region of the requesting user and the intended destination regions. EPS, then, either permits or prevents the travel request. Many Epidemic Indicators (EIs) used by EPSs are based on the most updated globally collected data by WHO and other local and international organizations; those EIs are then fused into EPSs to decide whether to permit moving from one region/state to another or not.

> It is required to develop a system that can share the health information between countries. Then, this system will help in controlling the movement of passengers between countries. This type of system will make the travel procedure easier, and it will increase the trust of the passengers to use the system and encourage others to use it. (COVID-DHP-7).

Figure 2 shows the high-level design (HLD) of the EPS: the main gateway (MGW), local gateway (LGW) and State-Level system (SLS). Both MGW and LGW form the cross-state system (CSS).

SLSs can be implemented at the state or regional level, depending on the desired implementation. In the case of state-level implementation, the restrictions and regulations are implemented throughout the whole state, while in the case of regional-level implementation, the restrictions and regulations are only enforced in that region. EPSs can also be implemented within one state or country; in this case, each SLS represents a region or a province. SLS is a stand-alone system so that states can implement any additional restrictions and regulations of their choice based on the local EIs. More technical details are given on each constituent of the EPS in the following sections.

5.1. Main gateway (MGW)

MGW is the primary and most innovative component of EPS. Each state or region enforces its requirements and regulations to control the virus' spread. These restrictions and regulations can be expressed as a list of pandemic management factors (PMFs). States regularly update PMFs based on local EIs. The following is a quote from COVID-19's restrictions and regulations implemented in Canada as of January 2023.

> Proof of COVID-19 vaccination is not required, Pre-board testing is not required, Using ArriveCAN is not required, COVID-19 pre-entry and arrival tests are not required, Quarantine after you enter Canada is not required.

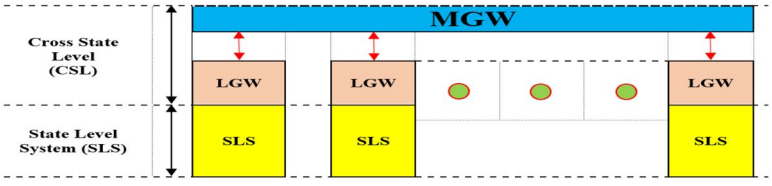

Figure 2. Stages of EPS system.

From this sample, the following PMFs can be extracted: vaccination, pre-board testing, app usage (ArriveCAN), pre-entry testing, quarantine after entry, etc. Some states have strict rules, and they use many PMFs. In contrast, other states have an amenable pandemic response; they use fewer PMFs. From a broad perspective, mediating between disorganized and unclassified regulations and restrictions enforced by different states is a big challenge. For example, restriction R in a state or region A either does not exist or is not entirely similar in state B. Finding the perfect match among the regulations of different states is not always viable. Because the states regularly update their PMFs according to EI changes, even similar regulations will not stay unchanged for a long time. Cross-restriction matching in such a continuous change of regulations and restrictions is challenging and requires continuous monitoring. To overcome the cross-restriction matching problem, this work proposes building one joint restrictions and regulations database called the *Epidemiological Filter* (EF). EF is configured using a joint list of all PMFs that are extracted from all restrictions and regulations published by all states. The joint list of PMFs can be created in two ways: manually or automatically. The manual approach has two options: Option 1: manually extracting all PMFs from all restrictions and regulations and then combining these MPFs into one joint PMF document. Option 2 of the manual method is to ask the pandemic domain experts to propose a PMFs list based on their experience. They specialize in understanding the dynamics of infectious diseases, such as how they spread and what factors contribute to their development. Figure 3 visualizes the MPFs building concept.

> It is necessary to collect all the regulations, compare them and come up with one world regulation as a filtration system. This led to increase the transaction transparency. (COVID-DHP-18).

> We need one regulation that identifies all the main important points in one itemized list, which helps countries to control the movement of passengers without any confusion and also leads to reduced perceived risk. (COVID-DHP-22).

In this study, we collected most of the restrictions and rules about coronaviruses that were published by the International Air Transport Association (IATA) (IATA, 2020) to manually build the PMFs. After many hours of comparing different COVID-19 restrictions imposed by different states, the following common factors are identified:

1. Vaccine types: vaccine A, vaccine B, vaccine C, etc.
2. PCR test result: positive/negative
3. PCR validity: 24, 48, 72, or 96
4. Quarantine required: Yes/No
5. Quarantine place: home, institutional
6. Quarantine period: 7, 14, 21 days
7. # Vaccine dose taken: 1, 2

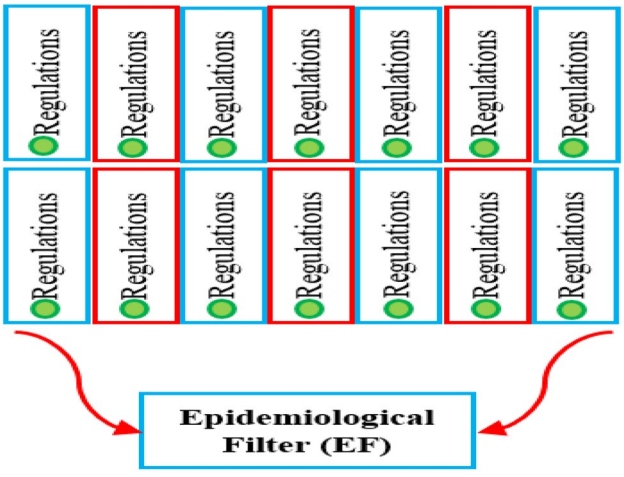

Figure 3. Epidemiological filter.

8. Groups exempted from the vaccine: pregnant, x-disease, range of ages, or none
9. Days recovered from COVID-19: 30, 60, 120 days
10. state or region infectious level: Red, Amber, or white
11. Reason for the traveling: family, leisure, medical, Etc.
12. COVID-19 symptoms: None, mild

> It is important that the regulation should cover many different items such as vaccine types, PCR test results, quarantine required, and quarantine period. This type of regulation will give a clear idea to the passengers about the requirements of the travel to each country. This also led to increase in the usefulness of the system. (COVID-DHP-21)

An option to build PMFs is to automate the search and comparison of different restrictions and regulations published by states. To combat the virus spread, states adopt different approaches to control the virus spread. While some states are taking a stricter approach, others are taking a more relaxed stance. Each state has its own needs and resources when developing strategies for combating the virus. Manually building the combined PMFs in a world of continuously changing restrictions and regulations (implemented by various states) is a challenge. This study utilizes the advanced tools created by AI to automate the building of the combined PMFs. Several AI-based text summarization tools exist, such as Gensim, SUMY, OpenText, etc. The main differences between these tools include their algorithms, the available customization level and the output format. In this work, the Gensim algorithm is used (Haider et al., 2020).

Gensim is an open-source Python library for natural language processing (NLP) that includes a summarization module, topic modeling, document indexing, and similarity retrieval. Gensim uses the TextRank algorithm (Zaware et al., 2021), which is based on the idea of treating a document as a graph of words and phrases and using the PageRank algorithm (Chen et al., 2007) to identify the most important words and phrases. TextRank algorithm is an extractive method, which means it will select the most relevant sentences from the source text to form the summary. Gensim also has additional functionality like topic modeling and word embedding. The Gensim algorithm incorporates the following phases to generate the final document summary:

1. Tokenization: The first step is to divide the text into individual words, also called tokens.
2. POS tagging: Part of speech tagging is used to identify the grammatical role of each word in the text.
3. Similarity matrix: A similarity matrix is constructed to represent the similarity between words based on their co-occurrence in the text.
4. TextRank score: The TextRank score is calculated for each word, which is based on the scores of the words that are most similar to it.
5. Sentence extraction: The most important sentences are selected based on the TextRank scores of their constituent words.
6. Summary generation: The selected sentences are combined to form a summary of the text.

In this work, the Gensim algorithm is implemented by feeding a compiled list of restrictions and regulations files that are downloaded from the internet. The Gensin algorithm is executed to generate a summary document. The resulting summary is then manually processed to generate the final PMFs list. PMFs are then used to establish the EF. Note that, currently, EF building operations are not fully automated, as manual work still has to be applied to generate the final PMFs. Future research for this article will consider fully automating this component to handle the ongoing shifts in pandemic restriction and regulation across states.

Figure 4 shows an example of how the generated PMFs list can be used to configure EF. Managing the pandemic becomes as simple as activating or deactivating the EF parameters as needed to accommodate their local pandemic management plans. For example, states can use the management factor '*Vaccine*' to indicate which vaccine type is accepted, and they can use the '*Region Infectious Level*' management factor to indicate which infectious levels are allowed to enter a state.

States can configure EF to implement a high-level restriction zone, where people cannot move or travel from or to these states, or a low-level restriction zone, where people can move or travel freely between states or regions. Figure 5 shows how each state is interfaced with the EF filter. To enter another state, travelers must fulfill the travel requirements presented in the state EF filter. States are free to have different configurations that reflect their local pandemic management plans.

For example, if users from state 1 want to travel to state 2, EPS obtains the EF configuration of state 2 *via* MGW and LGW. EPS then determines whether or not the users from state 1 meet the conditions to pass through the filter of state 2. Users from state 1 can only travel to state 2 if their epidemiological characteristics satisfy the EF conditions requested by state 2.

5.2. Local gateway (LGW)

As identified by the participant in COVID-DHP-28 'each country needs to develop a local platform to operate, manage, and monitor the internal processes. This platform needs to be designed to perform specific processes. This will lead to improving the security of the system'.

In the proposed system, LGW has been created to handle all of the interactions between SLS and MGW. LGW handles two distinct duties when processing requests: when it receives requests from its local SLS, and when it receives the request from MGW. For outgoing requests, it performs the following:

1. Isolates all private information from going outside the state; many encryptions and decryption programs are implemented in LGW to administer SLS privacy and integrity. For example, it removes private information like name, national ID, passport number, etc., and replaces them with a local code ID; all interactions are anonymous.

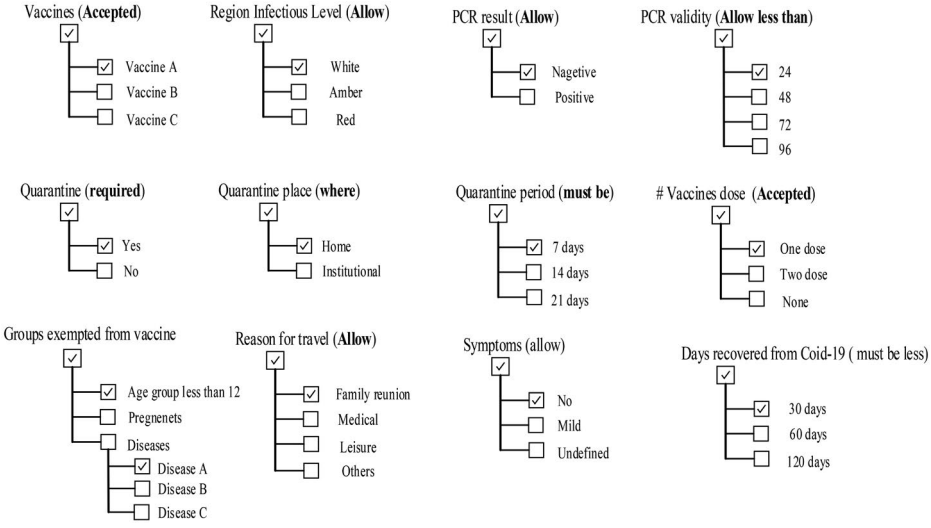

Figure 4. Epidemiological filter parameters.

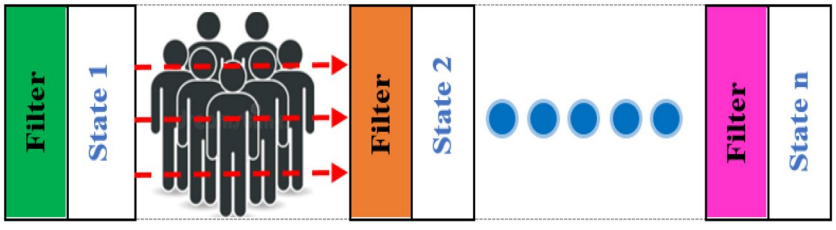

Figure 5. Implementation of epidemiological filter.

2. Regularly communicates with the auditing body (government) to keep the most updated EF configuration and shares it with MGW upon request.
3. Authenticates EF and confirms that EF configuration is done by the auditing body, the government, *via* using the digital signature.

For incoming requests, LGW handles the following tasks:

1. Share the most updated EF configuration.
2. Confirm whether the information on the coming requests satisfies the local EF configurations.
3. Based on the request status, LGW can accept or indicate what is missing to approve the request.

5.3. State-level system (SLS)

Participant COVID-DHP-11 pointed out that '*it is very important to have a state platform to integrate it with the local platform.*' Figure 6 displays the HLD of SLS. It consists of the following components, as recommended by the research participants:

- *Issuing body (IB):* The government appoints this entity to better ensure that certificates are distinct and trustworthy proof of the medical test. This entity is also responsible for regulating how medical reports are transferred between different parties and their usage.
- *Auditing body (AB):* Medical auditing bodies are organizations that provide oversight and regulation of medical practices. They help ensure that all healthcare providers adhere to the highest standards of quality care, patient safety, and ethical conduct. AB reviews provider records for accuracy, assesses compliance with regulations and guidelines set forth by governing entities, such as state boards or national accreditation agencies, analyzes billing data for potential errors or fraudulent activity, and performs audits on health plans to identify wastefulness in spending habits, among other duties.
- *User app:* Specific applications that the user installs on his smart devices to request, complete or monitor specific tasks. This type of application will link all the processes and make them one system for the passengers to complete their travel requirements.

The IB represents any institute authorized to issue any epidemic-related documents, like PCR results, vaccination proof, hospital admittance, recovery reports, etc. IB can be either a hospital, virus test center or health authority. IB is the only entity with the qualifications to perform PCR tests, give vaccinations, or treat virus-infected inmates. As a result, it is the only body to issue certified documents related to the pandemic. Each IB should have a *digital signature* that uniquely identifies and validates its authenticity and integrity. The digital signature is initiated by the IB and approved by the authorizing body.

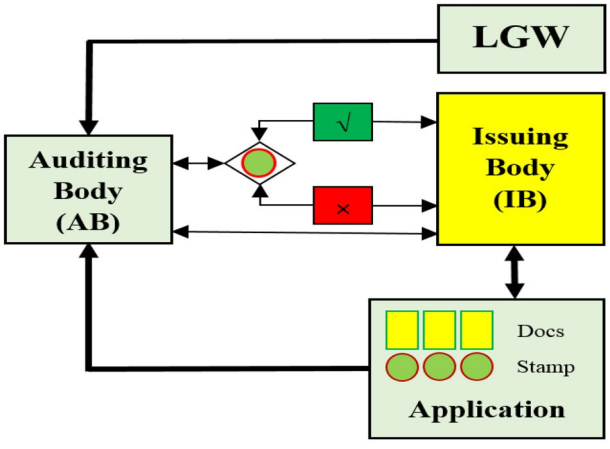

Figure 6. State-level system.

The digital signature is a preliminary condition for IB to interact with LGW, AB and the user app. The validity of the certified documents issued by IB depends on the validity of the digital signature. AB, LGW and the user app frequently use the digital signature to verify the authenticity of the IB.

The AB component in Figure 6 represents the auditing body or entity. It can be a government or health advisory committee related to the pandemic and has the following responsibilities: (1) Regularly examine and assess the local pandemic situation and activate or deactivate the EF parameters. AB is responsible for keeping EF configurations up to date following the current pandemic situation. (2) The AB periodically examines the IB to affirm that IBs are working according to the AB's regulations. Not strictly following AB's regulations leads to not approving documents issued by IB. (3) Provide the most updated EF filter to LGW. (4) It stores the database of all users' account information. When they first install the app, the latter communicates with AB to create accounts. (5) In the case of the request for an account shared by a foreign AB, the latter communicates with LGW to help ensure private and secure data transfer. Account data sharing can help users finish the creation of their Epidemiological Passport (EP) in case they change countries.

The other component of SLS is the user app. When the user first installs the app, the latter compiles the user's credentials, like the national number, name, face photo, etc., and sends them to AB for account creation. As IB might be changing or disappearing upon the regular checking done by AB, this research findings recommend that the user account information be stored in AB proprietaries. Once the AB creates an account for the user, the latter can go to IB to create the EP. IB communicates with AB to get the most updated EF and start issuing the related documents. For each operation done by IB, the user's app checks the authenticity of IBs by initiating validation requests to the AB via exchanging the digital signature. The IB then starts only doing the related medical work related to the EF-configured parameters. IB sends all certified medical articles and the finished parameters of EF to AB. As stated, AB keeps all users' information in a structured database; if any change happens to the users' file, AB sends the most updated copy to the user's App.

5.4. Workflow of the Epidemiological passport system

Figure 7 depicts the workflow sequence. The EPS starts when a user in a state wants to get an electronic EP. The user is considered a client of the EPS. Once it is installed, the app forwards the users' credentials to the auditing body to create an account for this user; this is done in Step 1. Using the app, the user can view the authorized IB list and send a request to perform the medical work, as shown in Step 2. IB then communicates with AB to get the most updated EF configurations and starts performing medical compositions only for the needed parameters as indicated in the EF; this is done in Step 3. For each medical work, the IB issues a certified document using its digital signature. After completion, the user's file at the AB receives both the certified and EF documents. AB then sends a copy to the user's app to be displayed on the user's phone. Since AB approves the EF in this state, the user can visit all places as directed by AB.

The cross-state level is only initiated when the user requests travel approval from the EP of another state. The user initiates a request for travel approval to x-state from its AB; this is done in Step 4. AB then forwards the request to LGW of state A along with a copy of the EF local configuration; this is done in Step 5. In Step 6, LGW of state A hides the user's private information replaces it with local code, and sends the request to MGW. In Step 7, the MGW requests the LGW of state B to send its local EF configuration. Subsequently, the MGW checks which parameters of EF are satisfied and which are not. If all parameters of the EF for state B are satisfied, MGW sends an approval message indicating eligibility to travel to that state. But if there are unsatisfied parameters, MGW sends a report informing LGW of state A, which is missing parameters; this is done in Step 8. In Step 9, LGW of state A has two cases:

1. All parameters of EF of state B are satisfied. In this case, the LGW of state A informs its AB. The latter then updates the user's file and sends an approval message to the user's app. The user's app shows the approval of EP.

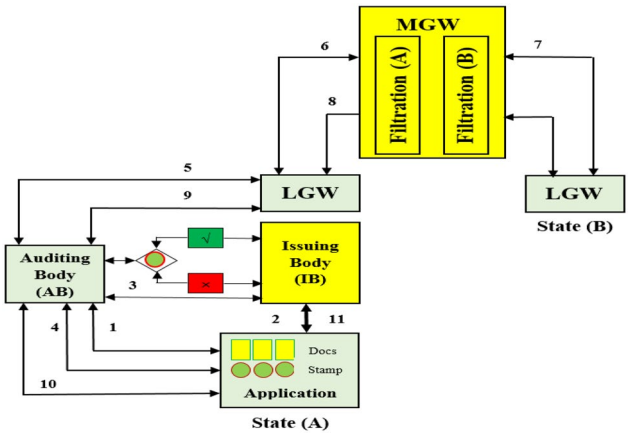

Figure 7. Overall system.

2. Some parameters of EF of state B are not satisfied. In this case, the LGW informs the AB. The latter, then, informs the user to finish missing medical work. After performing the required medical work, the EPS starts the same process again to get the travel approval to state B.

6. Research implications

There is a need for an approach that allows for continuous, scalable, reliable, secure, trustworthy and timely sharing of information across different health systems and countries to determine whether individuals are infected with COVID-19. The main contributions of this research are summarized as follows:

6.1. Theoretical implications

This research study provides significant theoretical implications for the understanding of trust formation in EPS adoption, particularly by elucidating the nuanced relationship between perceived ease of use and trust. Previous studies, notably by Vance et al. (2008), have established a general link between perceived ease of use and higher trust levels in technology. However, the mentioned research did not delve deeply into which specific aspects of ease of use contribute most significantly to trust. This study fills that gap by distinguishing between two critical facets of ease of use: the simplicity of use and the ease of understanding.

The research demonstrates that simplicity in the use of technology – a straightforward, intuitive interface that minimizes user effort – directly contributes to higher trust levels. Users are more likely to trust a system that they find easy to navigate and operate. This aligns with the notion that when EPS is simple to use, it reduces the cognitive load on users, allowing them to focus on achieving their goals rather than figuring out how to use the system. Beyond simplicity, the ease with which users can understand how to use the EPS also plays a pivotal role. If users can quickly grasp the functionality and benefits of the EPS, their confidence in the system increases. This ease of understanding reduces the ambiguity and uncertainty associated with the EPS, fostering a sense of competence and reliability.

The study shows that these two dimensions – simplicity of use and ease of understanding – not only enhance trust but also bolster users' competency beliefs. When users perceive a technology as both easy to use and easy to understand, they feel more capable and confident in using it. This perception of competency is crucial because it further reinforces trust: users believe that the system will reliably meet their needs, reducing the PR associated with its adoption.

A key theoretical implication of this research is the relationship between cognitive effort and trust. The study reveals that technologies requiring less cognitive effort foster higher trust levels. When technology is easy to use and understand, users expend less mental energy, which positively influences their trust in the EPS. This finding underscores the importance of designing user-friendly systems that minimize cognitive load, as this directly correlates with increased trust and likelihood of adoption.

This research reinforces the idea that trust functions as a control mechanism in technology adoption. Trust mitigates PRs and uncertainties, making users more comfortable and willing to adopt new technologies, such as EPS. By establishing that specific aspects of ease of use – simplicity and ease of understanding – are crucial for building trust, the study provides a more detailed framework for understanding how trust can be cultivated in the context of technology use.

This research study advances the theoretical understanding of trust formation in technology adoption by highlighting the specific aspects of ease of use that influence trust. It clarifies that both the simplicity of use and ease of understanding are critical for fostering trust and competency beliefs among users. These findings suggest that reducing cognitive effort through user-friendly design can significantly enhance trust, thereby promoting technology adoption.

6.2. Practical implications

The findings of this research study hold significant practical implications for the development and implementation of EPS. This system is designed to address the multifaceted challenges posed by the COVID-19 pandemic, particularly concerning testing and vaccination requirements imposed by various governments. The practical contributions of this research are pivotal in ensuring seamless international travel while maintaining health security and regulatory compliance. The key practical implications of this research study are as follows:

The proposed EPS facilitates better coordination between international health and border control organizations by providing robust traceability and data exchange functionalities. This system allows for the efficient sharing and verification of COVID-19 immune certificates, thereby simplifying the travel process. The practical benefits of enhanced coordination and traceability include; streamlined processes; by enabling real-time data exchange, the EPS reduces administrative burdens and delays at border control points. Increased efficiency; health authorities and border control organizations can quickly verify the authenticity of health documents, enhancing overall operational efficiency.

The system utilizes EF parameters to simplify the diverse COVID-19 requirements set by different countries. This approach ensures that the requirements are easily navigable and comprehensible for all stakeholders, including passengers, health authorities and airlines. The practical benefits of simplification of COVID-19 requirements include a user-friendly interface. The EPS presents also COVID-19 requirements in a straightforward manner by reducing the cognitive burden on users. Clarity and accessibility; passengers and authorities can easily understand and comply with travel health regulations, promoting smoother travel experiences.

The EPS offers a secure platform for airlines and immigration staff to verify the authenticity of COVID-19 tests and vaccine information presented by passengers. This security feature is critical for maintaining trust and ensuring compliance with health regulations. The practical benefits of a secure verification platform include; enhanced trust; secure verification processes build trust among passengers and an authority, ensuring that health information is accurate and reliable. Compliance assurance; airlines and border control agencies can confidently enforce health regulations, minimizing the risk of fraudulent documentation.

The EPS provides a digital solution that harmonizes global standards and protocols for validating and authenticating COVID-19 travel requirements. This harmonization is crucial for the recovery of international travel and tourism, as it promotes consistency and reliability across different countries. The practical benefits of harmonizing global standards include; consistency across borders; and standardized protocols ensuring that passengers experience uniform procedures, regardless of their travel destinations. Support for tourism recovery; by providing a reliable framework, the EPS supports the revival of the international travel and tourism industry, fostering economic recovery.

The design of the EPS takes into account the long-term implications of the pandemic, offering a scalable and adaptable solution that can evolve with changing health regulations and containment measures. The practical benefits of scalability and adaptability include; future-proofing; the system's adaptability ensures it remains relevant and effective in managing future health crises. Scalability; the

EPS can scale to accommodate varying volumes of travel and developing regulatory requirements, making it a robust tool for ongoing and future health security needs.

The practical implications of this research study underscore the critical role of the proposed EPS in enhancing the coordination, security and efficiency of international travel in the post-pandemic era. By simplifying the complex landscape of COVID-19 requirements, providing a secure verification platform, harmonizing global standards and ensuring scalability and adaptability, the EPS emerges as a pivotal tool for fostering the safe and efficient recovery of international travel and tourism. Furthermore, its ability to disseminate accurate health information to front-line workers ensures that they remain safe and prepared, reinforcing the overall resilience of global health systems.

7. Conclusion

Globally, the travel and tourism sector represents significant contributors to economic growth and development, offering opportunities for countries to generate revenue, for people to earn income, and for a labor-intensive sector to generate employment (Abbas et al., 2021; McCabe & Qiao, 2020; Nain et al., 2021). Despite their contribution to the global economy, the travel and tourism sector is one of the most vulnerable industries to global threats and impacts. Human beings and the world, in general, have always been facing epidemic and pandemic outbreaks with potential global impacts. As a result of that, Decision-makers, experts, and specialists in the travel and tourism industry must develop a new crisis-readiness mechanism to best respond to pandemic crises. This study compared the international tourist arrivals outlook for January 2018–July 2021 to find out the effect of the COVID-19 pandemic on the travel and tourism industry. This comparison indicated that there was a sharp decline in the number of international tourist arrivals, and the global travel and tourism industry faced a massive loss in its 2020 and 2021 revenues. This comparison demonstrates that pandemic crises may have long-lasting negative effects on the travel and tourism industry and the economy as well. As a result, safe traveling and regaining traveling confidence will be promoted among international travelers, and international travel and tourism will gradually recover. For this purpose, this research offers a unique contribution in the form of identification of the main requirements for a novel system that will help cope with international health and border control organizations' collaboration. The proposed EPS offers traceability and data exchange functionalities so that multiple international health and border control organizations can share and verify COVID-19 immune certificates. The proposed system based on these requirements is expected to help passengers, health authorities, border control authorities and airlines to improve information sharing for travel during and following pandemics. Furthermore, this research provides a framework and system requirements for a novel cross-border EPS solution to promote safe travel, build confidence and accelerate economic recovery as the travel and tourism industry restarts following the pandemic.

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