Monitoring COVID-19 outbreak at Airport through Adoption of Blockchain Technology

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ABSTRACT

The latest novel coronavirus (COVID-19) outbreak has devastated the entire world. It spreads from person to person contact with an infected person and through respiratory droplets from an infected person. In many countries the spread of the deadly virus is getting intensified from outsiders or own citizens, having recent history of travelling abroad. Since most of the travelers (or own citizens coming from outside) via air routes. Many countries are taking preventive measures in airports and even cancelled flights from different parts of the World. In this article we have proposed a new mechanism at airports to monitor the spread of COVID-19 disease. The proposed mechanism will adopt blockchain technology to access a database which combines United States Aviation Security Model (USASM) and Healthcare Information Exchange (HIE). The blockchain technology, conceptualized a little more than a decade ago (2008) has gained popularity among researchers and practitioners. Initially it was developed for crypto currencies, but for the last couple of years it has been extensively used in different areas like- healthcare, supply chain management, public sector, governance.
Keywords—Block chain; COVID-19; Monitoring; Adoption; Air Traveling

I. INTRODUCTION

Since 1900s, this world has been experiencing an increasing number of both natural and human-related calamities (Hawryluck et al., 2005). Among these natural and man-made catastrophes, the outbreak of epidemic disease creates substantial communication to mankind (Yu et al., 2020). If these epidemics are inefficiently managed, it will further lead to a pandemic situation and end up in global crisis (Queiroz et al., 2020). An epidemic is defined as "the outbreak of disease cases in excess of normal expectancy" (World Health Organization, 2020), which is generally spread by human-to-human and animal-to-human communication or through radioactive and hazardous chemical sources like healthcare wastes (Yu et al., 2020). The epidemic outbreak of diseases such as chikungunya, the severe acute respiratory syndrome (SARS), the Marburg hemorrhagic fever, the H1N1 influenza, the Ebola virus, the Nipah virus, smallpox, cholera, Crimean-Congo haemorrhagic fever, Hendra virus infection, Lassa fever, Meningitis, plague, and the Middle East respiratory syndrome coronavirus (MERS-Cov) and the Novel coronavirus (2019-nCoV or COVID-9), have not only impacted the lives of the man-kind through large number of deaths and sharp upsurge in infections in shorter time, but also has a negative impact on the global economy as a whole (Yu et al., 2020). Furthermore, the anxiety of epidemic outbreak has led to a worldwide panic situation. The abrupt growth on the infected patients within a short span of time due to the contagious nature of these epidemics leads to the increase in demand of doctors, nurses, medical supplies, healthcare facilities, etc., In order to deliver a timely and adequate health service, monitor and control the spread of the disease and reduce the economic impact of the country, effective and efficient management of pandemic on urgent basis is must.

Since December 2019, Numerous cases of atypical pneumonia of unknown source got detected in Wuhan, China, which was later corroborated that the widespread or outbreak is because to human-to-human transmission. This was initially reported to the WHO office on 31 December 2019. Since January 2020, the COVID-19 cases have risen drastically, and a worldwide emergency has been announced by the WHO on January 31st (Amankwah-Amoah, 2020). Though, the COVID-19 pandemic spread quickly in the China's Wuhan zone, it was at first generally ignored by the Governments in other parts of the globe even though intelligence agency of USA

released alerts of a possibly catastrophic incident (Washington Post, 2020). To suppress the spread of the COVID-19 virus, Wuhan was set into lockdown (a mixture of provincial and personal level quarantine measures), and number of cases in China got stabilized at around 80,000 by the middle of February 2020 (ECDC 2020). By that time, the international air transportation had already brought the COVID-19 virus to all the seven continents, and, by the end of June, it had spread to 215 countries. The actual figure of the COVID-19 cases continues to stay unknown as testing facilities are inadequate in most of the countries. The overall reported cases of COVID-19 by June 26th (20:30 h Indian time) had risen to 9,757,432 and deaths has been increased to 492,731 in at least 215 countries as per Worldometers data, among which more than 25% of the cases are reported in America, 12.5% of the cases are reported in Brazil and around 7% of the cases are reported in Russia. Figure 1 shows the global distribution of COVID-19 cases as of 26th of June 2020. As far as India is concerned, Worldometers reported 497,824 of total cases and 15,406 of deaths. As there is no vaccine to treat COVID-19 and because of inadequate medical facilities, different nations including India responded with innumerable ways of nonpharmaceutical interventions such as lockdown (home quarantine, voluntary/compulsory quarantine), societal distancing (susceptible or whole inhabitants), shutting down of educational institutions and non-essential businesses/offices, stopping or delaying the planned events (i.e. main conventions and trade exhibitions, concerts and celebrations, political discussions and polls, and sport events), and prohibitions on get-togethers of mass gatherings.

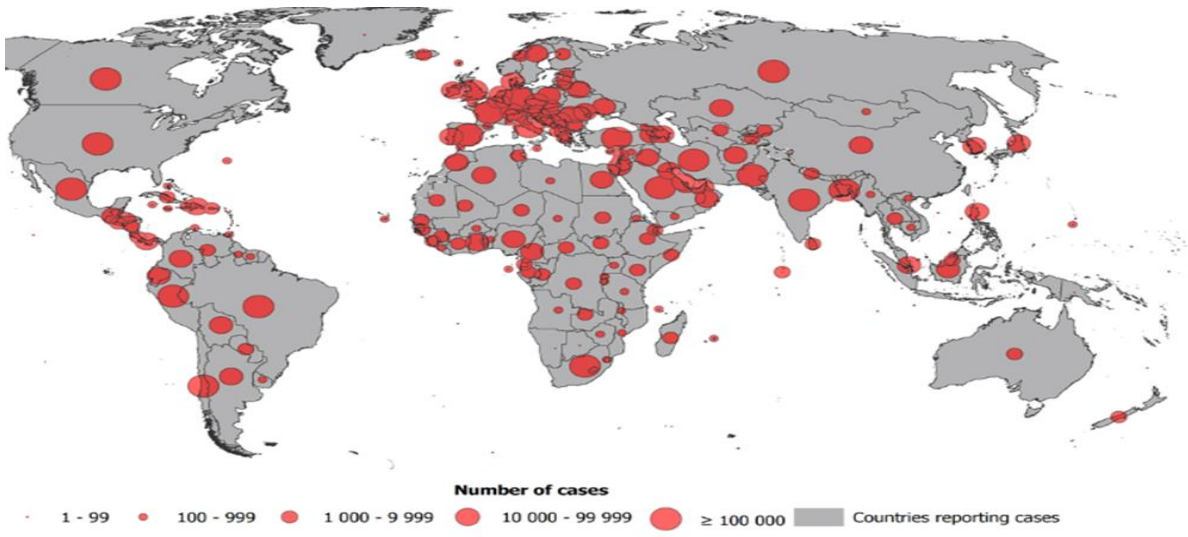

Fig 1: Global distribution of COVID-19 cases as on 26th June 2020 (Source: ECDC 2020)

As COVID-19 is contagious in nature, this disease spread from people to people, and the first three patients of India have recent travel histories outside India, there is a need to screen the passengers in the airport to monitor the spread of the virus. The first three patients of India were detected in Kerala, all of them returned from Wuhan, China. In India thirty-nine among the first fifty patients came from abroad. Another ten among the first fifty patients had no travel history but came in contact with people with travel history (ThePrint, 2020). In most of the cases people from outside entered through air traveling. Unfortunately, it has also been observed that many people who had come from abroad did not revealed complete information (The Hindu, 2020). These situations forced authorities to impose different screening mechanisms in airports. Initially, all the international passengers are getting checked through infrared thermometers in airports (Business Standard, 2020). India announced compulsorily quarantine for passengers from China, Republic of Korea, Italy, Iran, France and Germany, Spain. Further, the government has also expanded the quarantine for passengers from UAE, Qatar, Kuwait, and Oman. Later, India banned entry of Indians from Turkey, UK and EU (The Economics Times, 2020). On 19 March the government of India announced ban on commercial international airlines to operate to India for a week from 22 March (Livemint, 2020), but it further extended. As of now, all the domestic and international airports are closed till the end of July 2020. Not only India, but many countries across the world have imposed restrictions on travelers. President of the USA Donald Trump imposed restriction to travelers who had visited the Schengen Area of Europe, and later expanded to include the UK and Ireland. Many other countries like Poland, Denmark, Latvia, have restricted access for non-citizen (Business Insider India, 2020). The above facts and figures reveal that how monitoring air travelers can be proved essential in a pandemic situation. In this article we have discussed how a

blockchain based database can be helpful to track the travel history of air travelers and monitor them so that early detection and prevention became possible during such situations.

The idea of blockchain technology was first introduced by Satoshi Nakamoto of Bitcoin (Nakamoto, 2008). It is a decentralized database or ledgers of record and data in an encrypted form that are distributed and visible among all the members in a network (Khestri, 2018). The journey of blockchain started in the financial sector, more specifically in the area of crypto currency, but in recent years the use of blockchain has become pervasive across industries. A blockchain based supply chain is better in terms of traceability and authentication. In recent years many authors have reviewed papers in the domain of blockchain technology. Brandão et al. (2017) considered areas like bitcoin, IoT, financial area, crypto-currencies, e-governance, health, while reviewing papers on blockchain. Tama et al. (2017) reviewed papers on blockchain dealt with mainly healthcare, financial services, and business and industry. Casino et al. (2019) presented a literature review on blockchain-enabled applications across different areas such as supply chain management, business, healthcare, IoT, privacy, and data management. Authors like Nakamoto (2008), Wu and Liang (2017) discussed applications of blockchain in financial sectors. Rivera et al. (2017) discussed how blockchain can be used in the area of digital identity. The handling of data and records related to different activities of governance can be managed efficiently with block chain. Reijers et al. (2016) discussed those in their papers quite vividly. Deloitte (2016) discussed the potentiality of blockchain to revamp the healthcare sector and issues related to implementation. In the area of managing supply chain blockchain technology is getting used widely. Ahmed (2018) discussed how blockchain technology is used in supply chain to make it more efficient and transparent. Kshetri (2018) discussed how blockchain applications are useful to handle trust issues in supply chains. Alper (2018) discussed how Airbus (one of the leading aircraft manufacturers) is considering blockchain technology in their supply chain to track the movement of different parts and maintain automated records. Russo (2018) depicted how Walmart has adopted blockchain technology for their food supply chain to increase the traceability of food products. Saberi et al. (2018) discussed the application of blockchain in the context of sustainable supply chain. So, it is quite evident that in recent years authors have discussed the application of block chain in various sectors, but in spite of our sincere efforts we have not found any paper, dealt with a blockchain based data base management system in airports. Which may prove very critical, especially in critical global scenarios, like recent novel corona virus outbreak. Murugan, et. al (2020) has proposed Healthcare Information Exchange using blockchain technology. Murugan and the team have proposed a distributed solution based on blockchain for exchange of medical sensitive data between trusted stakeholders. They used Hyperledger fabric to maintain confidentiality of private data within members of networks. Since adoption of our proposed model is largely based on blockchain technology, in the succeeding section we are going to discuss the basic structure and characteristics of blockchain.

Current paper makes the following three contributions: First, our paper provides an idea of using blockchain for effective airport operations. Second, during the pandemic situation, our paper helps the airport authorities to trace the COVID-19 patients by effectively using the airport databased management system and blockchain technology. Third, our paper gives an idea of dealing with the pandemic situations with the adoption and usage of technology.

The present paper is organized into different sections covering - a brief literature review on blockchain technology, the basic structure and features of block chain technology, proposed database based blockchain system for effective monitoring of COVID-19 on airports and its working. Current paper suggests effective way of monitoring spread of COVID-19 like diseases through airports. It gives new insights to the stakeholders for effective management of pandemic situations.

II. STRUCTURE AND CHARACTERISTICS OF BLOCKCHAIN

Blockchain can be considered as distributed, immutable, transparent databases or ledger of records. It is a disruptive mechanism, which is safe, reliable, and has numerous applications. The concept was first introduced by Nakamoto (Nakamoto, 2008). Blockchain technology stores data as a chain of blocks. Every new entity can be considered as a block, and virtually connected with the previous block with a hash. Each block of a blockchain has a timestamp (Kouhizadeh and Sarkis, 2018). Based on network management and accessibility it can be categorized mainly under two categories private and public (Kouhizadeh and Sarkis, 2018).

2.1 Private Blockchain

In a private blockchain ledgers are shared among a group of participants only, and defined group of users get the access (Kouhizadeh and Sarkis, 2018). In a private blockchain no one can read/write or audit the blockchain without permission. Here the owner of the blockchain is a single entity, which can control the entire blockchain.

2.2 Public Blockchain

In public blockchains all the transactions are public, and users can remain anonymous (Wang et al., 2019). In a public blockchain anyone can join as a new user. It is truly decentralized, but data can't be changed once validated on the blockchain.

2.3 Feature of the Blockchain

Decentralization: In blockchain there is no point of central control. Decentralized databases allow participants of a blockchain to directly interact via a peer-to-peer network (Kouhizadeh and Sarkis, 2018). Decentralization characteristic of blockchain gives the freedom to the users of not trusting any providers or authorities (Chu and Wang, 2018). Every participant can access the same copy of the ledgers, which get updated with new information or changes in a decentralized manner (Swan, 2015), every update requires consensus among the partners (Kouhizadeh and Sarkis, 2018).

Immutable: In blockchain data and information cannot be changed without network member consensus. The append-only feature of blockchain technology ensures that new data can only be added, no data can be modified (Kouhizadeh and Sarkis, 2018). The data in blockchain is immutable because the flow of transactions is saved in chronological ordered records, known as blocks (Tian, 2016). In case any change in a blockchain takes place, it becomes visible to all network participants and if the majority of participants wish they can prevent any unauthorized action.

Anonymity: One of major characteristics of blockchain is anonymity. As the concept of blockchain evolved in the financial area, the anonymity and confidentiality of this technology used to be considered as indispensable characteristics of blockchain. In blockchain all the transactions are transparent, yet users can remain anonymous (Wang et al, 2019). It allows users to only be identified by public keys, and users generate as many public keys as necessary (Clohessy et al., 2019). The concept of anonymity is valid only for public block chains. In public blockchain the parties are known to each other, so the concept of anonymity doesn't hold true there (Saberi et al, 2018).

Smart contracts: Smart contracts allow credible transactions without involvement of any third party. A smart contract is a software program, storing rules and policies for negotiations between parties (Saberi et al, 2018). Smart contracts automatically execute the terms of a contract in a blockchain (Wang et al, 2019). Smart contracts help to reduce the time and costs of contract process (Gupta,2017).

Peer-to-peer communication: Blockchain supports decentralized peer-to-peer communications (Clohessy et al., 2019). It facilitates transactions among the participants without intermediaries or a central point of control. Peer-to-peer communication helps to reduce the number of transactions in the blockchain and thus reduces the potential frictions (Gupta, 2017).

Transparency: Public blockchains are completely transparent ledger systems, where all the participants can view all the transactions. Due to the immutability characteristic participants can view previous transactions, and hence make it more transparent (Nakamoto, 2008; Clohessy et al., 2019). Due to the transparency blockchain is impervious to alternations and tampering to a large extent (Iansiti and Lakhani, 2017).

Now the question is why and how the blockchain technology will help us at Airports to monitor Outbreak of COVID-19 and other virus-related diseases.

III. PROPOSED MODEL

The two sets of international passenger data are required to make the proposed system work efficiently.

Passenger Name Record (PNR): Details provided by the traveler to air carriers for reservation purpose; these includes name of the passenger, contact number, address and billing information.

Passenger Advance Information Systems (PAIS): This data set should incorporate passenger name, date of birth & location, citizenship details, recent travel history which should be derived from passport and visa and passenger health details which should be accessed through integrated health information system.

The proposed model required international traveler's travel as well as medical history details to monitor outbreak of virus-related diseases in a secure way across the globe. Salient features of block chain technology allow various agencies /stakeholders to access the passenger details in decentralized, transparent, updated and non-editable manner.

Proposed model is a combination of United States - Aviation security model, Healthcare Information Exchange (HIE) using blockchain followed by Interim guidance by World health organization (WHO) on 'Ebola Event Management at Points of Entry'. The HIE model was proposed by A. Murugan and team.

Main objective of the proposed model is early detection of potentially infected persons to stop transmission of COVID-19 and other life-threatening infectious diseases to human beings through air travel across borders which are claiming lives and putting pressure on health systems. To manage suspected cases at point of Entry (PoE) travel history and health history of the air travelers is required. System also provides alerts to the air travelers who have unknowingly accompanied life threatening contaminated travelers in real time till specified time period (incubation period). If a traveler is carrier of virus but is absolutely normal i.e. incubation period of the infection and after travelling it is confirmed that he/she is infected, then through Passenger Advanced Information System & HIE information will be communicated to the co-passengers and respective authorities for further necessary actions to stop further spread of virus.

We are adopting the Health Information Exchange (HIE) system proposed by Murugan, et. al, 2020 to exchange Electronic Health Records (EHR) with Passenger Advanced Information System (PAIS) through blockchain technology. Figures 2 depicted below shows the proposed model.

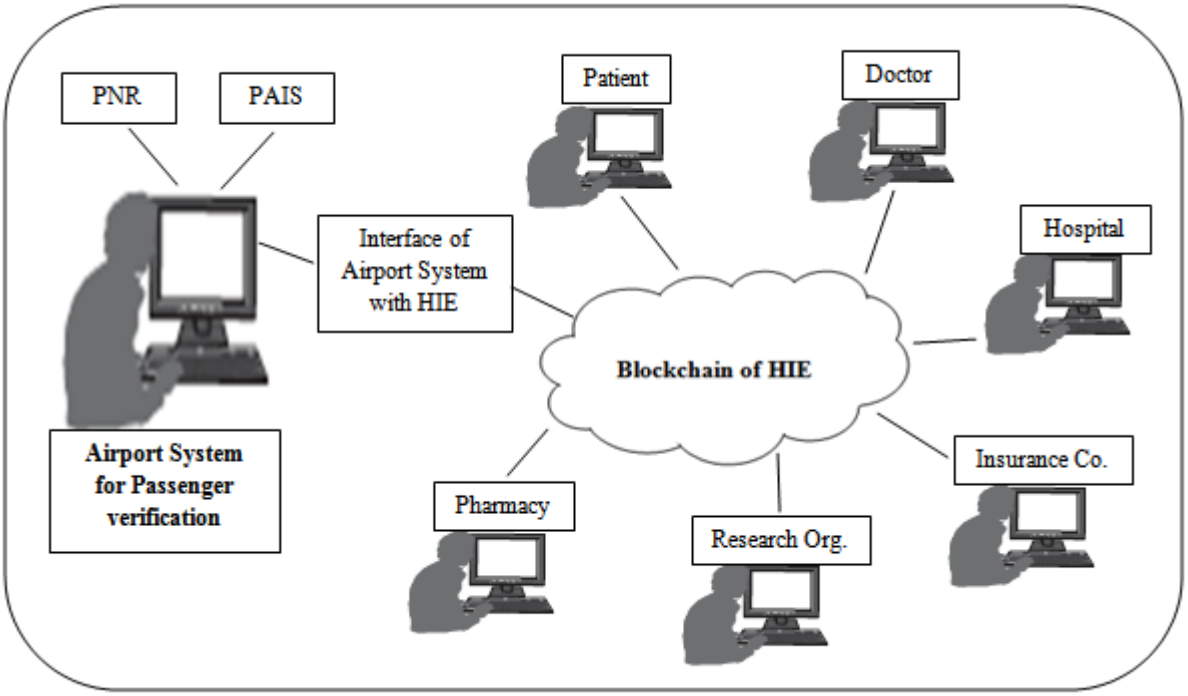

Fig 2: Proposed model to monitor contamination of viruses through air travelers.

Health Information Exchange:

Objective of Health Information Exchange (HIE) system is to provide secure channel to share patient owned EHR with various stakeholders. Figure-2 represents an overview of the HIE system.

System incorporates Patient/user, hospital, doctor, research organization, insurance companies, pharmacist, and emergency contact as blockchain network members. Within the network the patient has ownership of the network and has complete control over personal and medical data. As per requirement, patients can grant permission of Electronic Health records to various stakeholders for the purpose.

Patient being an air traveler must grant access to authority at airport for his/her medical history as emergency stakeholder so that life threatening contamination / incubation details will be accessible at airport. Government authority at airport will access patient's electronic medical records along with the travel history of the passenger available through passport and visa records. If these details revel that passenger has travelled from the high-risk zone of contamination or having history of life-threatening contamination or he/she is in the phase of

contamination incubation, authority will take decision about boarding of the passenger. Based on incubation time frame Passenger Advance Information System will track the medical details of the patient for required time frame and based on the result of incubation necessary alerts will be issued to the passengers, co-passengers and various authorities associated with management of life-threatening contamination at country level/regional level/local level. Integration of Blockchain of HIE and airport system for passenger verification makes this data integration possible.
The proposed activities of concerned authorities in different stages of traveling and follow-up activities have been discussed in the next section.

Management of Events:

A potential case of life-threatening contamination or incubation may be detected at various points during travel. Depending on the nature of exposures appropriate responses / alerts and awareness will be communicated to patients, air carriers and government agencies so that necessary action should be initiated. Figure 3 shows different stages of travel where the proposed model can be used to either retrieve data or take some follow up actions. These stages are taken from interim guidelines provided by WHO to manage contamination of Ebola, here we have updated these stages to management contamination of all life-threatening viruses.

Fig 3: Potential point of detection of life-threatening contamination.

The activities, supposed to be performed in every stage of travel of traveler are shown in the Table1.

Table 1: Recommended actions to be taken at specific stages of travel.

Steps	Questions	Source of information	Recommendation for action
Detection at PoE at departure (PoE: point of entry)	Does the passenger appear to be unwell? Are the symptoms consistent with suspected life-threatening contamination? If the country is unaffected by life threatening contaminated disease: Has the passenger had previous contact with anyone suspected or confirmed to have life threatening contaminated disease? Does the passenger‘s recent travel history include a country where there is a life threatening contamination outbreak?	Health authority at PoE. PAIS – HIE	PoE government / health authority with appropriate setup to test and treat life threatening contamination. Share details of life-threatening contamination with appropriate authority to monitor its spread using proposed system. Prevent travelers from boarding if suspected or found with life threatening contamination.
Detection during transit	Does the traveler require medical attention upon arrival at the PoE. Are any precautions for the disembarkation of ill and healthy travelers needed? All procedures of departure and arrival need to be followed.	Health part of the Aircraft General Deflations. Passenger Locator Form.	The PoE health authority should make prior arrangements in coordination with stakeholders at the PoE, and the national health authority to Ensure sufficient availability of PoE staff, personal protective equipment for responders and disinfectants.

	As per guidelines provided by the authority to the air carriers appropriate measures needs to be implement.		Provide regional or national public health contact information.
At destination	Are special measures needed upon arrival at the point of entry? Procedures followed at PoE need to be followed at departure by local health authorities so that no infected traveler should exit from the airport.	Health Part of the Aircraft General Declaration Passenger Locator Card. Health authority at departure; PAIS – HIE.	Government / health authority with appropriate setup to test and treat life threatening contamination at arrival point. Share details of life-threatening contamination with concerned authorities as per policy to monitor its spread using proposed system. Determine a suitable product for disinfection with the aircraft operator. Sodium hypochlorite (bleach) is not an acceptable disinfectant on board an aircraft. Raise awareness among relevant stakeholders and personnel at arrival.
After travel	Are patients consistent with symptoms of life threading contaminated diseases? Does previous travel history indicate contact with anyone suspected of infection? Does the passenger have a history of recent travel in the contaminated affected areas?	Health authority on arrival. PAIS – HIE	The ill person should seek medical assessment and care at a hospital. If traveler's recent history indicates contact with anyone suspected of life treating contamination, contact tracing should be undertaken to identify close contacts. PoE or point of arrival health authorities should make arrangements to facilitate repatriation of cases and transpiration of specimens. Strengthen communication between national health surveillance and PoE using proposed system.

Based on the interim guidelines issued by WHO for control of Ebola event Management at Points of Entry, inTable1 we have recommended activities along with source of information to find out the questions at various stages of traveling to be carried out to monitor the contamination of COVID-19 like life threatening viruses infection or chances of infection.

IV. CONCLUSION

Present work proposes an integrative approach of blockchain technology and Passenger Advance Information System to monitor or stop the contamination of COVID-19 like life threatening disease across borders through air ways. In different countries the widespread COVID-19 has taken place through the people with travel histories. In most of the cases when they arrived at the airport no or little symptoms of infection were visible, but later they fell prey to it and within a short span of time they contaminated to large section of people. Many of them did not pay heed of self -isolation of self-quarantine. Many times, the people who come from abroad move from one city to another with a high risk of spreading disease. An effective blockchain based database system will help government and regulatory authorities to gather information of travelers. That will help them track passengers for a long time, if required. If people with travels history get effected, their co- passengers can also be found easily from the database. It may help to contain highly infectious diseases like COVID-19. The proposed blockchain based model will help to prevent data from any unauthorized accessing, will also ensure transparency and immutability.

The newly blockchain based proposed model discussed in the research paper will provide effective mechanisms to monitor and indirectly support to stop the spread of COVID-19 like diseases through air transport. It provides new insights to the researchers and policy makers.

In the proposed model only air travelers are considered, and discussion revolves around proposed system and its functions only. This work can be extended with developing codes to implement the systems. The legal, security, privacy issues can also be considered while implementing the models.

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