An Information Technology-based Framework for Combating Pandemics

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Abstract
Over the last century, global health-systems have greatly improved in fighting against various medical threats. Despite these advancements, the world has faced several pandemics over the past century including the on-going COVID-19. While global health-systems are doing their best to protect the world from infectious diseases, finding a cure takes time. Avoidance and prevention from such pandemics are paramount, as they not only bring a big death-toll but also disrupt the world's economy. Using existing technologies such as collecting sensory data from individuals, performing analytics, and communicating effectivity to avoid the spread of such a disease. This paper proposes an information technology enabled framework that can collect necessary sensory data to allow healthcare workers and data scientists in taking prompt action to fight off infectious diseases. By providing smart technologies available at an individual level will provide real-time data monitoring thus drastically easing governments', healthcare workers, and experts' effort in combating infectious diseases. The proposed framework should help researchers and experts in managing pandemics better. It will also allow them to build technology-based frameworks capable of preventing and avoiding future pandemics.

Keywords:
COVID-19; Internet of Things; Blockchain; smart technologies; frameworks for pandemics; IT solutions

1. Introduction

The global health systems have much improved over the past century [1]. People are living longer due to better health care facilities available. Moreover, vaccines have allowed several diseases to be eradicated globally including smallpox and rinderpest [2]. It is safe to say that global health systems have been protecting us from all kinds of infectious diseases to the best of their capability [3]. Despite these advancements, in the last century alone the world has seen several pandemics. Here it is important to be able to distinguish between the terms outbreaks, epidemics, and pandemics. The term outbreak is used when there is a sudden rise in infectious disease but is limited to a certain location only [4]. The term epidemic is used when the disease has spread from a certain geographic area to neighboring areas but is limited to a country to a few hundreds of people only [4]. Lastly, the term pandemic is used when infectious diseases have spread across many countries affecting a larger scale of people. In this research, the focus is mainly on avoiding and preventing pandemics. Table **1** shows the history of pandemics that have occurred in the past century alone [5]. The Spanish flu alone resulted in an estimated death toll of forty to fifty million. Additionally, these pandemics lead to huge financial losses, as to how long the pandemic will last is highly unpredictable [6]. As a result, the world's economy is severely affected leading to unemployment, devaluation of the currency, and inflation.

Table 1 - History of Pandemics [5]

Name	Period	Type	Death toll
Spanish Flu	1918-1919	H1N1 virus	40-50M
Asian Flu	1957-1958	H2N2 virus	1.1M
Hong Kong Flu	1968-1970	H3N2 virus	1M
HIV/AIDS	1981-present	Virus	25-35M
Swine Flu	2009-2010	H1N1 virus	200,000
SARS	2002-2003	Coronavirus	770
Ebola	2014-2016	Ebolavirus	11,000
MERS	2015-Present	Coronavirus	850
COVID-19	2019-Present	Coronavirus	6.8 M till 18 Mar, 2023

though health care systems are working hard on finding vaccines/cures for such infectious diseases, the process takes time. Vaccinologist experts state that developing a vaccine usually takes 18 months at the earliest [7]. This is because the process involves multiple testing, animal trials, human trials, approval

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by medical authorities before the vaccine can even be considered for mass production. For instance, work on vaccines for severe acute respiratory syndrome in China in 2002-04, and Middle East respiratory syndrome in 2012 was started but before a vaccine could be found both the outbreaks were contained already [7].

By March 2021, while several Corona Virus Disease 2019 (COVID-19) vaccines have been developed, yet it will still take time to bring the pandemic to an end [8]. This is due to several reasons. Firstly, the vaccines are only approved for adults, and thus teens and children are still prone to the disease. Secondly, it will take time to provide vaccines for every citizen. Even the countries that have access to the vaccine have divided the distribution into triers. As per the economist intelligence unit report, while the rich countries will ensure in getting their citizens vaccinated by late 2021, it may take as late as early 2023 for some countries [9]. Thirdly, not enough vaccine doses have been produced so far. While the approval of multiple vaccines is encouraging, producing them on a massive scale takes time. Additionally, some of the vaccines like Pfizer require them to be stored in ultracold storage, which may not be available to everyone.

The above discussions show that while the production of the vaccine is indeed important, other measures need to be taken to slow the spread of infectious diseases [10]. This is crucial to put less load on the countries health systems. Moreover, if the spread of a disease capable of reaching pandemic levels can be controlled at an earlier stage, then the disease can either be eliminated or managed effectively [10]. While the option of complete lockdown does exist, it is not a favorable option as it is detrimental to the countries' economy. While some might argue to adopt the herd immunity option, there is little evidence that it is effective for every pandemic disease as being seen in the current one [11]. Therefore, having a framework using Information Technology (IT) systems to avoid or prevent a disease from reaching pandemic levels is very important, and a necessity where a vaccine is not available.

Different countries adopted various strategies for mitigating and suppressing the current pandemic and previous pandemics [12]. These mitigation and suppression strategies include but are not limited to social distancing, wearing masks, quarantine, isolations, the closing of schools and universities, the closing of community places, travel restrictions, and lockdowns. The countries adopted different strategies due to many reasons including demographics, population density, countries' health systems. Research has indicated strategies adopted by some countries working better than others, thus countries usually reevaluate their strategies to adapt as the situation changes. As scientists and researchers have started to understand the diseases better, IT solutions are being utilized in the detection and prevention of such diseases. Whether it is the use of mobile apps for tracking movement, using machine learning and artificial learning applications for contact tracing and medical diagnosis, sensors for collecting relevant data, and use of drones and robots for performing contactless services, they have proven to be an effective tool for mitigating and suppression infectious diseases. Thus, incorporating these IT solutions in avoidance and prevention strategies for combating current and future pandemics can be very useful and thus is the motivation behind this research [13].

As per our research, little work has been done in providing technology frameworks for avoidance and prevention against pandemics. Some of the related work done in the area includes [14-17]. Studies like [14, 15], have suggested the use of a centralized server for performing data analytics and providing necessary data to decision-makers, where the data can be collected from digital platforms or paper-based forms. However, one of the major disadvantages of these systems is that the data shared is not real-time and the disease may already have spread to several new hosts. Thus, a system capable of providing real-time monitoring is essential for handling pandemic-level infectious diseases. The review papers by [16, 17] shed light on the different methodologies available for the detection of pandemics such as Web portals for real-time surveillance, event-based surveillance, simulation modeling of past pandemics, activity monitoring on social media, mobile/smartphones, wireless sensor networks, etc. However, both of these papers are more than five years old and are not covering the latest technologies available such as the use of internet of things devices, smart wearables, mass surveillance, etc.

This research aims at proposing an IT-based framework for avoiding and preventing pandemics. Thus, this research has reviewed existing and upcoming technologies that can be used for combating infectious diseases during pandemics, and provide a technology framework that can be used for avoiding and preventing infectious diseases from reaching pandemic levels. To the best of our knowledge, there is limited research done in this area. The differences between our research and existing other works done in the same area are briefly highlighted. Alanezi, et al. [12] comparative study focuses on highlighting mitigating and suppression strategies for combating COVID-19, where the use of IT technologies is covered briefly and is not the main focus of the paper. Shaw, et al. [18] survey focuses on governance and citizen behavior, with slight mention of technologies used, and how can these be utilized optimally to mitigate infectious diseases better. Opinion papers from Figueroa and Aguilera [13], He, et al. [19] matches most of the objectives of this research but can be updated covering more smart technologies and are also lacking a potential technology

framework that can be used to avoid and prevent pandemic-level diseases. Dai, et al. [20] discusses how blockchain solution can be used to combat COVID, but does not discuss other IT solutions available that can also be used in strategies to fight pandemics. Therefore, this research will look into all IT solutions that can be used again infectious diseases, and we shall also propose a framework that utilizes these solutions for avoiding and preventing future pandemics. This research aims to propose a technology framework capable of providing real-time monitoring and analytics to avoid and prevent the spread of infectious diseases. To do that, the following contributions have been made in this paper.

- **Review of existing and future IT:** Most of the research done in the area is either limited or outdated. Therefore, extensive research of the existing and emerging smart technologies needs to be done that help making the current and upcoming health systems better for combating pandemics. The findings of this survey can be useful to experts and researchers who wish to do similar research in the area to select the technology most appropriate to them.

- **IT-based framework:** The research intends on proposing a framework that will be capable of preventing and avoiding infectious diseases reaching pandemics level. The framework will provide an infrastructure that can be adopted by cities to apply real-time monitoring by making use of sensor networks and video surveillance. The data collected from them can be used to conduct useful analytics and the relative authorities may be informed to perform the further necessary action

The remaining paper is divided into the following sections. In section 2, this research covers the systematic methodology adopted for the selection of articles and surveys, which are then critically reviewed. In section 3 this research highlights the currently available technologies and upcoming smart solutions for collecting sensory data, movement tracing, health diagnosis, etc. In section 4, this research proposes the technology framework as well as has a detailed discussion on how the technology framework can be used for avoidance and prevention of pandemic-level infectious diseases. Finally, in section 5, we conclude the findings of this research and share the potential for future work in the area.

2. Methodology

This section covers the methodology adopted for the systematic literature review for the paper. This research followed the guidelines of the PRISMA systematic literature review [21]. This research aims to cover a good range of technologies that may be utilized against the upcoming pandemic. Thus, this research is not only looking into the technologies that can be used for COVID-19 but also others such as Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) that reached pandemic levels and whose vaccines are still not developed. In this regard, while most of our research will be looking into IT solutions from 2000 onwards, some solutions dated back to 2003 and 2012 may be looked into as well which are the dates when the SARS and MERS were first reported. The focus of this research was mainly towards the journal and reputable conferences, but government reports were sought out as well. **Table 2** shows the selection criteria defined for finding relevant articles, scrutinizing them as per the scope of the research, and shortlist quality articles.

Table 2 Web-based QA system selection criteria

No.	Criteria	Selected
1.	Year	The year 2020 onward
2.	Articles	Journals
		Conference papers Government reports
3.	Language	English
4.	Scope	IT solutions for fighting pandemics
5.	Pandemics	COVID-19
		MERS
		SARS

For finding relevant literature, the research used different research portals such as Google Scholar, ACM, IEEE Xplore, and Scopus. Moreover, the research also went through issues for some of the journals that matched the scope of this research. To find relevant articles, the keywords “smart technologies”, IT solutions”, “ICT solutions”, “Pandemic”, “Smart health systems”, “COVID-19”, “MERS” and “SARS” were used in combination with AND and OR operators. While in most cases on articles from 2000 and onwards were investigated, special attention was also given to IT solutions that have been suggested to be used for SARS and MERS, so the publication date was relaxed on those circumstances. Using the various combinations listed above return more than 300 articles.
As per the selection criteria defined in **Table 2**, the articles returned from our initial result were scrutinized. Firstly, we read the abstracts and titles of the papers to judge whether

they are within the scope of this research. Moreover, only articles written in the English language were considered. To ensure the quality of the articles being shortlisted, reports, thesis, or work not published, or peer-reviewed were discarded. This result in articles being shortlisted that were critically analysed.

3. Literature Review

In this section, the research will cover the different IT solutions available that can help improve the health systems in the fight against infectious diseases. Some of these solutions can either help in stopping the infectious diseases from reaching pandemic levels or help in suppressing the disease from spreading further. Most of these IT solutions are utilizing different technologies that are being used in various applications. Therefore, this section is subdivided into subheadings concerning the technology, in which the technology will be touched upon, the various advancements made using that technology, and its applications.

From existing literature, it can be found that there are nine technologies in this regard. These include 1) artificial intelligence, 2) big data analytics, 3) high-performance computing infrastructures, 4) robots/drones, 5) 3D printing technology, 6) digital contact tracing, 7) internet of things, 8) block-chain, 9) and video surveillance. These sections are discussed in detail below:

3.1 Artificial Intelligence

The use of artificial intelligence, machine learning, and deep learning allows the computer to provide quick decision-making using various intelligence and learning techniques. Thus, it can assist in pandemic situations as well including simulations, testing, and forecasting. Researchers have used artificial intelligence and its sub-branches in disease detection from various medical test samples as well as other mediums such as text data. One such solution proposed uses machine learning for the detection of COVID-19 from the routine blood exam [22]. The system used logistic regression and random forest machine learning classification models on the hematochemical values collected from the routine blood exams. The system was able to achieve a respectable accuracy of 82% and 86%, comparable to the current gold standard, but in less time and computation power required. Yao, et al. [23] proposed a similar model that detects the COVID-19 severeness by using blood and urine samples. This is done by using 28 features that have shown to be significantly associated with COVID-19 severeness. This system was able to produce an overall accuracy of 81.48%. Mackey, et al. [24] proposed an IT solution that can report potential COVID-19 cases based on their self-reporting symptoms, experience with testing, and recovery conversation on Twitter. The system used an unsupervised machine learning approached called a bi-term topic model to detect potential cases. The system can analyze the content based on a group of tweets on the topic and assess the statistical and geographic characteristics. Khanday, et al. [25] developed a system that can read clinical text data written on the medical reports for detecting COVID-19 cases. It does this by using classical and ensemble machine learning algorithms. Additionally, text-processing steps are performed for extracting additional information and refining the data. This allowed the system to achieve an accuracy of 96.2% using the Logistic regression and Multinomial Naïve Bayes classifiers.

Artificial intelligence has also been used in IT solutions for ensuring protocols are being followed for fighting pandemics. Loey, et al. [26] proposed a hybrid model utilizing both deep and machine learning models for detecting face masks. It does this by first extracting essential features and then apply classification models for detecting face masks. The system achieved an impressive accuracy of 99% to 100% for different classification models.

3.2 Big Data Analytics

Big data is a huge collection of data, consisting of various data types on which operations of performed using complex algorithms. Analytics are conducted to provide useful information to users inadequate time. In pandemics, a lot of data is collected whether it is for mobile tracing, health cards, confirmed cases, recovered cases, and much more. All this data can be used to perform useful conclusions that can medical experts and researchers understanding the disease better and take prompt action when needed. Below are some of the IT solutions that have utilized big data analytics in pandemics.

One of the applications of big data analysis is through surveillance systems. Roberts [27] highlighted how different governments are utilizing advanced algorithms to monitor diseases through surveillance systems, which have proved effective in precise and timely reporting of SARS, H1N1, and Ebola diseases. Simonsen, et al. [28] also highlighted the importance of hybrid systems, which combine data from multiple sources such as social media, surveillance, and medical data, to be able to accurately detect infectious diseases during pandemics. Javaid, et al. [29] highlighted the rise of the 4th industrial revolution where health systems are being empowered to combat pandemics by installing surveillance systems that can provide a day-to-day update for infected patients for different demographics.

There are other applications of big data analytics as well for mitigating pandemics. Shah and Patel [30] showed how geospatial technologies can be used to administer clusters, checking the flow of daily needs and medical supplies, and quarantine tracking.

3.3 High-Performance Computing Infrastructures

When dealing with huge volumes of data and being able to process it in real-time requires high-performance computing infrastructures. This is especially true during the fight against infectious diseases in pandemics where data is growly exponentially, while health workers and data analyst experts are still required to provide timely feedback. Many companies including IBM and AMD have provided sufficient resources for this purpose and are working tougher with agencies in establishing future infrastructures that prepare them beforehand for the next pandemic [31, 32].

3.4 Robots/Drones

During pandemics, people are advised to practice social distancing and avoiding physical contact. In this regard, drones and robots have shown immense practicality. They are being used for serving in restaurants, sanitizing public places and streets, delivery, and much more. Some of the areas where they are used are discussed below:

Scientists and researchers have been using robots and drones in different areas. Anggraeni, et al. [33] share how drones can be used for supplying medical supplies including drugs, medical kits, equipment to avoid human contact. They are also be used to transporting them to remote areas that are otherwise difficult to reach. In Dubai, drones are being used for sanitizing the streets during the COVID pandemic. Moreover, autonomous robots are being used for surveillance and other purposes. The same has been seen in China, where drones are being used for sanitization, medical test samples, medical supplies, and citizens' daily needs. This has proved very effective in providing timely delivery and avoid human contact at the same time. Additionally, companion robots have been deployed to fight loneliness during the pandemic, due to social distancing [34]. In short, robots and drones are being used in multiple areas surgery, telehealth, social care, disinfection, logistics, manufacturing, agriculture, security, and much more.

3.5 3D Printing

3D printing allows for three-dimensional designs of objects to be printed out. These have been very useful in the current pandemic. They have been helpful in the current pandemic where a shortage of supplies was observed, and manufacturers were facing supply and demand issues. There are many areas where 3D printing was used during the pandemic. They were used for producing medical supplies, protection equipment, and isolation wards [35]. For personal protection, 3D printings have been used extensively for making face masks, door openers, and face shields. For medical supplies ventilator vales, respiratory devices, swabs, respirators, bio-models, and medical manikins have been produced. Also, isolation wards have been constructed in record time using huge 3D printers. The use of 3D printers has not only made these items cost-effective but also ensure timely availability [22]. Over a few months, the prices of face masks and face shields have reduced drastically, and while their availability is almost everywhere [36].

3.6 Internet of Things

Internet of things has allowed physical objects to gain sensor, hardware, and software support to enable them to be connected over the internet. This has allowed governments to track multiple features that can help in the detection of infectious diseases whether through individuals or groups of them. Several sensors are being used to detect diseases and the data is being shared over the internet using IOT devices so prompt action can be taken.

Researchers and health experts are making use of multiple devices using different sensors for diseases. Strik, et al. [37] shared the smart devices capable of performing ECG, such as the Apple Watch 4 and above, can help in the detection of COVID before it can be detected via a medical test. The best thing is that these readings can be monitored remotely, thus allowing prompt action to be taken as soon as symptoms of the disease. Jeong, et al. [38] also shared similar findings where multiple features can be monitored remotely to detect COVID early with good precision. Seshadri, et al. [39] also emphasized the importance of smart wearables. Sensors that can provide data relating to cardiovascular monitoring, cardiovascular strain, sleep, and activity levels, respiration monitoring, blood oxygen saturation, and temperature can help in early disease detection. Using data provided from the sensors, researchers can use algorithms to predict early in case the individual is infected or not.

3.7 Blockchain

While blockchain is popular in cryptocurrency, it can also be used as a platform for managing pandemics. This is because blockchain technology provides excellent features such as decentralization, privacy, transparency, and immutability. All these features can in early outbreak detection, medical supplies delivery while at the same time ensuring privacy [20, 40]. Some of the research done in this area is discussed below:

Several studies have shown the great potential of blockchain platforms during pandemics. Khurshid [41] provides a blockchain framework that can be used in pandemics. They also shared the advantages of this platform and how it can help in pandemic situations. Tan, et al. [42] proposed the use of blockchain for automotive pandemic control for transport systems as well for healthcare monitoring use a novel cloud infrastructure. The system performs non-contract surveillance using random vehicles, and other block-chain technologies for ensuring confidentiality. Besides these, the blockchain platform has proven to provide an excellent storage option to avoid the disadvantages of centralized storage and tampering of data

[43]. Moreover, it has also been used successfully for contact tracing [44].

3.8 Video Surveillance

Many government authorities have given strict instructions to follow pandemic protocols including wearing masks, keep social distance, and others. However, only a limited number of officials can be utilized. Moreover, place these officials also make them vulnerable to the disease as well. In this regard, video surveillance provides an excellent mechanism to address both issues.

Researchers and experts have provided solutions that can be used for checking facemask, ensure social distance is being maintained, and use of infrared cameras for checking temperatures. Some of these studies are discussed. Shorfuzzaman, et al. [45] proposed how smart cities can help in the fight against COVID-19. Their research proposed a data-driven deep learning algorithm that can identify whether citizens are maintaining social distancing through real-time object detection models. Loey, et al. [26] proposed a hybrid model that can be used for detecting facemask with an accuracy of 99%. Yaghi, et al. [46] also proposed a real-time object tracking model based on computer vision and video processing techniques. The system can use video feed provides by stationary cameras to provide a bird's eye view and to estimate the distance between objects using Euclidean distance. Hossain, et al. [47] proposed the FluSense surveillance system, which is capable of forecasting seasonal cases of flu and outbreaks. In Dubai, cameras have been installed at public areas entrances that check for mask and temperature using video surveillance following the protocols set by the government during the pandemic [48].

3.9 Digital Contact Tracing

Many countries and smartphone manufacturers are working together to stop the spread of infectious diseases during pandemics. This is done by developing smart applications that can track citizen's movement, check their health record, and alert them about zones that have high infection rates [49]. They do this by using a smartphone's global position system and Bluetooth features [50]. One study shows that the mitigation strategy using these apps can reduce the R_0 (the disease reproductive number) by 2.4 folds.

Both android and iOS platforms have been working with governments to support their official applications COVID-19. Applications like Tawakkalna [51], COVIDSafe app [52], and TraceTogether [53] are examples of contract tracing applications being used by Saudi Arabia, Australia, and Singapore. These applications allow the government to show the updated health status of the citizen which is essential when they are visiting any public place. Moreover, the same application is being used to trace movements and alert the citizen in case he/she enters an area where the number of infected cases is high. In addition to smartphones, smart wearables have also been used for mobile tracing [54]. The Singapore government has also provided smart tokens that can act as smart wearables for contact and movement tracing for TraceTogether.

4. Proposed Framework

In this section, we propose the framework that can be used for the avoidance and prevention of infectious diseases. The framework has been designed by looking at the strategies utilized by countries that we are able to mitigate previous pandemics much better than other countries and incorporating existing IT solutions into the framework. What makes this framework unique from existing ones is the use of IT solutions and the internet of things to gather necessary data from sensors that can allow health workers and government official to take Figure 1 shows the proposed framework and is discussed in greater detail below:

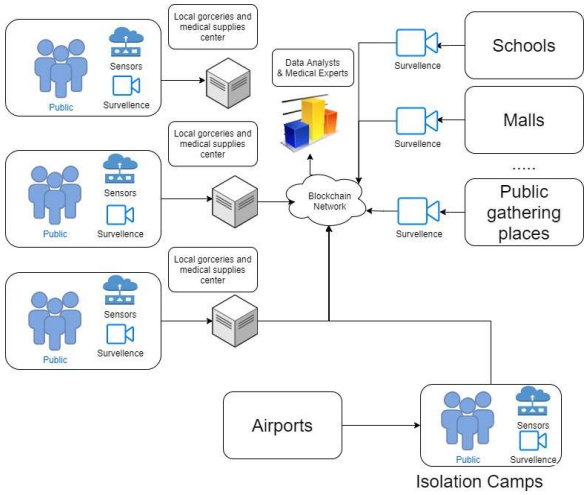

Figure 1 - Framework for avoidance and prevention of infectious diseases

4.1 Airports

The ease of international travel has enabled people in reaching far reaches of the globe in moderate time. However, this also makes countries vulnerable to new disease outbreaks. Thus, it is one of the most important checkpoints to manage. For this, we would suggest a separate terminal for new incoming foreign passengers. Ideally, all the staff members should be replaced with computers, telecommunication or robots to avoid human contact. This would allow local staff members not to be infected with the new disease. Also, the new passengers should be shifted to an isolation camp, where they should be helpful for an incubation period. Moreover, the passengers should be given smartwatches or accessories to

act as sensors for monitoring vital features that can be used to monitor the infectious disease if any. Once the incubation period is over, tests can be performed to ensure that the passengers are not carriers of the new infectious disease.

4.2 Districts

Every district should be contained, where movement within a district may be allowed if no cases are reported. However, if cases are reported then that part of the district should be sealed completely, not allowing anyone from moving out of their homes thus creating their eco bubble. To monitor people's health and other features that can be used to detect whether the person has been infected or not, smartwatches or accessories should be used. They can help in detecting movement, temperature, heart rate, and other features useful for early disease detection. Moreover, every town should have their groceries and medical supplies that can be supplied to the public on-demand, without requiring them to visit the grocery stores and medical shops themselves. The smaller the eco-bubble, the quickly the disease can be contained.

4.3 Public Gathering Places

Government offices, cinemas, wedding halls, schools, universities, and other public places can become a hotspot for the spread of infectious diseases. Ideally, all such activities should be in complete lockdown to avoid spread at a massive scale. If the disease has been suppressed then artificial intelligence-enabled video surveillance should be used. These can help in citizen tracing, ensure that social distancing protocols are being followed, wearing of masks, and more. These measures are taken to ensure that the public is taking enough precautionary measures to stop the disease from spreading further, while at the same time helping the government and health system in tracing diseases and performing analytics in the data collection.

4.4 Blockchain Network

A blockchain network is used to enable privacy and security as well as providing to collect data from devices provided data. The idea is to collect all the necessary data that can be used in understanding the disease better. This will allow all individual to provide their health data with health workers and government officials without worried about security and privacy. Moreover, a blockchain-enabled network also ensures that data is protected, not allowing other people to change it.

4.5 Data Analytics

Data scientists and medical experts can perform data analytics on the datastore to draw out a useful conclusion. This can include citizen tracing, disease tracking, health monitoring, simulation, future projects, and much more. Data analytics can allow officials to impose smart lockdowns, take pre-emptive actions, isolate infected individuals early, more importantly, learn about the disease as more data is collected.

5. Conclusion

This research conducted an extensive systematic literature review of existing IT systems for fighting infectious diseases. These systems can immensely assist government authorities and health workers before infectious diseases reach pandemic levels. There are many technologies available and each one of them plays a specific role. However, the ones that stand out the most are internet of things sensors, video surveillance, and data analytics. The proposed framework utilizes various technologies to collect data and provide important analytics in addition to existing extensive measures. This research strongly believes that the proposed framework can be used effectively to avoid pandemics as well as preventing infectious diseases from reaching unmanageable numbers. We hope that other researchers and experts can use the results from this survey and framework in their work.

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References

[1] E. National Academies of Sciences and Medicine, *Global health and the future role of the United States*: National Academies Press, 2017.

[2] G. Lopez. (2016, 1st April 2020). *What diseases have vaccines eradicated?* Available: https://www.vox.com/2018/8/21/17588074/vaccines-diseases-wiped-out

[3] D. E. Bloom and D. Cadarette, "Infectious Disease Threats in the Twenty-First Century: Strengthening the Global Response," *Frontiers in immunology,* vol. 10, pp. 549-549, 2019.

[4] B. Oppenheim, M. Gallivan, N. K. Madhav, N. Brown, V. Serhiyenko, N. D. Wolfe, *et al.*, "Assessing global preparedness for the next pandemic: development and application of an Epidemic Preparedness Index," *BMJ global health,* vol. 4, p. e001157, 2019.

[5] N. LePan. (2020, 1st April 2020). *Visualizing the History of Pandemics*. Available: https://www.visualcapitalist.com/history-of-pandemics-deadliest/

[6] O. Jorda, S. R. Singh, and A. M. Taylor, "Longer-Run Economic Consequences of Pandemics," *The Review of Economics and Statistics,* vol. 104, pp. 166-175, 2020.

[7] L. Spinney. (2020, 4th April 2020). *When will a coronavirus vaccine be ready?* Available: https://www.theguardian.com/world/2020/apr/04/when-will-a-coronavirus-vaccine-be-ready

[8] World Health Organization. (2021). *Coronavirus disease (COVID-19): Vaccines*. Available: https://www.who.int/news-room/q-a-detail/coronavirus-disease-(covid-19)-vaccines

[9] Economist Intelligence Unit, "More than 85 poor countries will not have widespread access to coronavirus vaccines before 2023," 2021.

[10] C. E. Madubueze, S. Dachollom, and I. O. Onwubuya, "Controlling the Spread of COVID-19: Optimal Control Analysis," *Computational and Mathematical Methods in Medicine,* vol. 2020, p. 6862516, 2020/09/17 2020.

[11] A. Fontanet and S. Cauchemez, "COVID-19 herd immunity: where are we?," *Nature Reviews Immunology,* vol. 20, pp. 583-584, 2020/10/01 2020.

[12] F. Alanezi, A. Aljahdali, S. M. Alyousef, H. Alrashed, H. Mushcab, B. AlThani, *et al.*, "A Comparative Study on the Strategies Adopted by the United Kingdom, India, China, Italy, and Saudi Arabia to Contain the Spread of the COVID-19 Pandemic," *Journal of healthcare leadership,* vol. 12, pp. 117-131, 2020.

[13] C. A. Figueroa and A. Aguilera, "The Need for a Mental Health Technology Revolution in the COVID-19 Pandemic," *Frontiers in psychiatry,* vol. 11, pp. 523-523, 2020.

[14] J. A. Al-Tawfiq and Z. A. Memish, "Mass gathering medicine: 2014 Hajj and Umra preparation as a leading example," *International Journal of Infectious Diseases,* vol. 27, pp. 26-31, 2014/10/01/ 2014.

[15] A. S. Alqahtani, N. F. BinDhim, M. Tashani, H. W. Willaby, K. E. Wiley, A. E. Heywood, *et al.*, "Pilot use of a novel smartphone application to track traveller health behaviour and collect infectious disease data during a mass gathering: Hajj pilgrimage 2014," *Journal of Epidemiology and Global Health,* vol. 6, pp. 147-155, 2016/09/01/ 2016.

[16] E. Christaki, "New technologies in predicting, preventing and controlling emerging infectious diseases," *Virulence,* vol. 6, pp. 558-565, 2015/08/18 2015.

[17] E. O. Nsoesie, S. A. Kluberg, S. R. Mekaru, M. S. Majumder, K. Khan, S. I. Hay, *et al.*, "New digital technologies for the surveillance of infectious diseases at mass gathering events," *Clinical Microbiology and Infection,* vol. 21, pp. 134-140, 2015/02/01/ 2015.

[18] R. Shaw, Y.-k. Kim, and J. Hua, "Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia," *Progress in Disaster Science,* vol. 6, p. 100090, 2020/04/01/ 2020.

[19] W. He, Z. Zhang, and W. Li, "Information technology solutions, challenges, and suggestions for tackling the COVID-19 pandemic," *International Journal of Information Management,* vol. 57, p. 102287, 2021/04/01/ 2021.

[20] H. N. Dai, M. Imran, and N. Haider, "Blockchain-Enabled Internet of Medical Things to Combat COVID-19," *IEEE Internet of Things Magazine,* vol. 3, pp. 52-57, 2020.

[21] D. Moher, A. Liberati, J. Tetzlaff, and D. G. Altman, "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement," *Annals of internal medicine,* vol. 151, pp. 264-269, 2009.

[22] D. Brinati, A. Campagner, D. Ferrari, M. Locatelli, G. Banfi, and F. Cabitza, "Detection of COVID-19 Infection from Routine Blood Exams with Machine Learning: A Feasibility Study," *Journal of Medical Systems,* vol. 44, p. 135, 2020/07/01 2020.

[23] H. Yao, N. Zhang, R. Zhang, M. Duan, T. Xie, J. Pan, *et al.*, "Severity detection for the coronavirus disease 2019 (covid-19) patients using a machine learning model based on the blood and urine tests," *Frontiers in cell and developmental biology,* vol. 8, p. 683, 2020.

[24] T. Mackey, V. Purushothaman, J. Li, N. Shah, M. Nali, C. Bardier, *et al.*, "Machine Learning to Detect Self-Reporting of Symptoms, Testing Access, and Recovery Associated With COVID-19 on Twitter: Retrospective Big Data Infoveillance Study," *JMIR Public Health Surveill,* vol. 6, p. e19509, 2020.

[25] A. M. U. D. Khanday, S. T. Rabani, Q. R. Khan, N. Rouf, and M. Mohi Ud Din, "Machine learning based approaches for detecting COVID-19 using clinical text data," *International Journal of Information Technology,* vol. 12, pp. 731-739, 2020/09/01 2020.

[26] M. Loey, G. Manogaran, M. H. N. Taha, and N. E. M. Khalifa, "A hybrid deep transfer learning model with machine learning methods for face mask detection in the era of the COVID-19 pandemic," *Measurement : journal of the International Measurement Confederation,* vol. 167, pp. 108288-108288, 2021.

[27] S. Roberts, "Big Data, Algorithmic Governmentality and the Regulation of Pandemic Risk," *European Journal of Risk Regulation,* vol. 10, pp. 94 - 115, 2019.

[28] L. Simonsen, J. R. Gog, D. Olson, and C. Viboud, "Infectious Disease Surveillance in the Big Data Era: Towards Faster and Locally Relevant Systems," *The Journal of Infectious Diseases,* vol. 214, pp. S380-S385, 2016.

[29] M. Javaid, A. Haleem, R. Vaishya, S. Bahl, R. Suman, and A. Vaish, "Industry 4.0 technologies and their applications in fighting COVID-19 pandemic," *Diabetes & Metabolic Syndrome: Clinical Research & Reviews,* vol. 14, pp. 419-422, 2020/07/01/ 2020.

[30] P. Shah and C. R. Patel, "Prevention is better than cure: an application of big data and geospatial technology in mitigating pandemic," *Transactions of the Indian National Academy of Engineering,* vol. 5, pp. 187-192, 2020.

[31] H. Collins. (2020). *COVID-19 High Performance Computing Consortium Enters New Phase Focused on Helping Researchers to Identify Potential Therapies for Patients*. Available: https://newsroom.ibm.com/2020-11-16-COVID-19-High-Performance-Computing-Consortium-Enters-New-Phase-Focused-on-Helping-Researchers-to-Identify-Potential-Therapies-for-Patients

[32] D. Black. (2020). *AMD COVID-19 HPC Fund Adds 18 Institutions and 5 Petaflops of Supercomputer Processing Power to Assist Researchers Fighting COVID-19 Pandemic*. Available: https://insidehpc.com/2020/09/amd-covid-19-hpc-fund-adds-18-institutions-and-5-petaflops-of-supercomputer-processing-power-to-assist-researchers-fighting-covid-19-pandemic/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+InsideHPC+%28insideHPC.com%29

[33] S. Anggraeni, A. Maulidina, M. W. Dewi, S. Rahmadianti, Y. P. C. Rizky, Z. F. Arinalhaq, *et al.*, "The deployment of drones in sending drugs and patient blood samples COVID-19," *Indonesian Journal of Science and Technology,* vol. 5, pp. 193-200, 2020.

[34] G. Odekerken-Schröder, C. Mele, T. Russo-Spena, D. Mahr, and A. Ruggiero, "Mitigating loneliness with companion robots in the COVID-19 pandemic and beyond: an integrative framework and research agenda," *Journal of Service Management,* vol. 31, pp. 1149-1162, 2020.

[35] Y. Y. C. Choong, H. W. Tan, D. C. Patel, W. T. N. Choong, C.-H. Chen, H. Y. Low, *et al.*, "The global rise of 3D printing during the COVID-19 pandemic," *Nature Reviews Materials,* vol. 5, pp. 637-639, 2020/09/01 2020.

[36] D. Amin, N. Nguyen, S. M. Roser, and S. Abramowicz, "3D Printing of Face Shields During COVID-19 Pandemic: A Technical Note," *Journal of oral and maxillofacial surgery : official journal of the American Association of Oral and Maxillofacial Surgeons,* vol. 78, pp. 1275-1278, 2020.

[37] M. Strik, T. Caillol, F. D. Ramirez, S. Abu-Alrub, H. Marchand, N. Welte, *et al.*, "Validating QT-interval measurement using the apple watch ECG to enable remote monitoring during the COVID-19 pandemic," *Circulation,* vol. 142, pp. 416-418, 2020.

[38] H. Jeong, J. A. Rogers, and S. Xu, "Continuous on-body sensing for the COVID-19 pandemic: Gaps and opportunities," *Science Advances,* vol. 6, p. eabd4794, 2020.

[39] D. R. Seshadri, E. V. Davies, E. R. Harlow, J. J. Hsu, S. C. Knighton, T. A. Walker, *et al.*, "Wearable Sensors for COVID-

19: A Call to Action to Harness Our Digital Infrastructure for Remote Patient Monitoring and Virtual Assessments," *Frontiers in Digital Health,* vol. 2, 2020-June-23 2020.
[40] A. Sharma, S. Bahl, A. K. Bagha, M. Javaid, D. K. Shukla, and A. Haleem, "Blockchain technology and its applications to combat COVID-19 pandemic," *Research on Biomedical Engineering,* 2020/10/22 2020.
[41] A. Khurshid, "Applying Blockchain Technology to Address the Crisis of Trust During the COVID-19 Pandemic," *JMIR Med Inform,* vol. 8, p. e20477, 2020.
[42] H. Tan, P. Kim, and I. Chung, "Practical Homomorphic Authentication in Cloud-Assisted VANETs with Blockchain-Based Healthcare Monitoring for Pandemic Control," *Electronics,* vol. 9, p. 1683, 2020.
[43] A. Azim, M. N. Islam, and P. E. Spranger, "Blockchain and novel coronavirus: Towards preventing COVID-19 and future pandemics," *Iberoamerican Journal of Medicine,* vol. 2, pp. 215-218, 2020.
[44] S. M. Idrees, M. Nowostawski, and R. Jameel, "Blockchain-Based Digital Contact Tracing Apps for COVID-19 Pandemic Management: Issues, Challenges, Solutions, and Future Directions," *JMIR Med Inform,* vol. 9, p. e25245, 2021.
[45] M. Shorfuzzaman, M. S. Hossain, and M. F. Alhamid, "Towards the sustainable development of smart cities through mass video surveillance: A response to the COVID-19 pandemic," *Sustainable Cities and Society,* vol. 64, p. 102582, 2021/01/01/ 2021.
[46] M. Yaghi, T. Basmaji, R. Salim, J. Yousaf, H. Zia, and M. Ghazal, "Real-time Contact Tracing During a Pandemic using Multi-camera Video Object Tracking," in *2020 International Conference on Decision Aid Sciences and Application (DASA)*, 2020, pp. 872-876.
[47] F. A. Hossain, A. A. Lover, G. A. Corey, N. G. Reich, and T. Rahman, "FluSense: A Contactless Syndromic Surveillance Platform for Influenza-Like Illness in Hospital Waiting Areas," *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.,* vol. 4, p. Article 1, 2020.
[48] E. Bourke, "Innovating out of lockdown," in *Euro news*, ed, 2020.
[49] N. Ahmed, R. A. Michelin, W. Xue, S. Ruj, R. Malaney, S. S. Kanhere*, et al.*, "A Survey of COVID-19 Contact Tracing Apps," *IEEE Access,* vol. 8, pp. 134577-134601, 2020.
[50] H. Gorji, M. Arnoldini, D. Jenny, W. Hardt, and P. Jenny, "STeCC: Smart testing with contact counting enhances Covid-19 mitigation by bluetooth app Based contact tracing," 2020.
[51] Tawakkalna. (2020). *Tawakkalna (Covid-19 KSA)*. Available: https://play.google.com/store/apps/details?id=sa.gov.nic.tawakkalna&hl=en&gl=US
[52] COVIDSafe. (2020). *COVIDSafe app*. Available: https://www.health.gov.au/resources/apps-and-tools/covidsafe-app
[53] TraceTogether. (2020). *TraceTogether, safer together*. Available: https://www.tracetogether.gov.sg/
[54] T. Lee and H. Lee, "Tracing surveillance and auto-regulation in Singapore:'smart'responses to COVID-19," *Media International Australia,* vol. 177, pp. 47-60, 2020.

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