ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8

International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

Applications of Internet of Things (IoT) and Information Systems in Managing Pandemics: A Case Study of COVID-19

Mohammed Ateeq Alanezi[1*]

[1] *College of Computer Science and Engineering, University of Hafr Al Batin, SAUDI ARABIA.*
**Corresponding Author (Email: alanezi.mohd@uhb.edu.sa).*

Paper ID: 12A13R

Volume 12 Issue 13

Received 24 June 2021
Received in revised form 09 October 2021
Accepted 15 October 2021
Available online 22 October 2021

Keywords:
Integrated Technologies; Data-System-People framework; COVID-19 solution; IoT-based pandemic management; IoT-based Devices.

Abstract

COVID-19 pandemic warranted the rapid development of applications and innovations in the field of information systems and technology during the pandemic. Apart from development, the pandemic's unpredictability and global geopolitical intricacies have shaped up the design and implementation of such technologies. Moreover, there is an urgent need of ascertaining roles and responsibilities shared by information technology professionals so that they may effectively utilize their expertise. This paper examines the concurrent deployment of the Internet of things (IoT) and information system tools that were employed to assist people from all sectors to curb the spread of COVID-19. It also categorizes the various IoT-based devises such as smart thermometers, smart helmets inbuild with smart glasses, individual smart glasses, IoT-Q-Band, Easy band, IoT-based Proximity Tracer, Drone Things (IoDT), IoT buttons, Smartphone Applications based on IoT, etc. to manage the COVID-19 pandemic. Furthermore, the paper highlights challenges faced in the process of technology design, development, and its application. It provides a platform that directs and promotes future research in the light of existing challenges and future trends. Based on the discussion of this article, researchers on IoT and information technology can prepare them for the upcoming pandemics, ahead of time.

Disciplinary: Information System and Computer Science & Engineering .

Cite This Article:

Alanezi, M. A. (2021). Applications of Internet of Things (IoT) and Information Systems in Managing Pandemics: A Case Study of COVID-19. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 12*(13), 12A13R, 1-13. http://TUENGR.COM/V12A/12A13R.pdf DOI: 10.14456/ITJEMAST.2021.270

1 Introduction

Not a single life on earth reportedly went unaffected from the adversities of COVID-19. Be it loss of valuable lives or trickled down yet palpable economic effects, the sufferings are immeasurable, to say the least. Luxury aside, the institutions providing core necessities—hospitals,

schools, businesses, transportation—went through unprecedented crises. In the ongoing dire times, the support provided by Information technology (IT) must be lauded. Online education, remote working, and telemedicine undoubtedly offered much-needed, rather essential, life-support in digital form [1]. Not only it help to curb the spread of the virus [2], IT also promises to evade the devastations of any unforeseen future pandemics.

As a silver lining, the pandemic opened up the gates to vehemently investigate the possible advancements in pre-pandemic IT solutions. As a result, an immense rise in both the production and usage of digital technologies is recorded; it includes but is not limited to the development of online work practices, high-fidelity information management, and faster communication protocols [3]. Another commendable feat of IT professionals is highlighted in [4], where the author points towards the high transition and adaptation speed from in-person activities to their online alternatives. The effectiveness of some of the alternatives has hinted towards their full adaptation even after the end of the pandemic. This adaptation is supported by some earlier claims in the pre-COVID-19 world reporting the important role information technology along with information systems (IT/IS) had been playing in healthcare, emergency response, risk management, clinical decision support, and web-based educational tools [5,6].

The concerted efforts of various IT/IS professionals are crucial in fighting pandemic encompassing ventures as broad as vaccine development [7]. Their role in contact tracing and predicting spread patterns is evident too. Another avenue, where the hard work of IT/IS professionals often got overlooked is protecting hospitals from ominous cyber-attacks [8]. Despite the widespread IT-related applications, a lot needs to be done. Especially with regards to preparing ourselves for the next big calamity, by leveraging the tools we developed in the process and experience we obtained on rapid crises response, remote operations, smart decision making, virtual task-force management, and big data analysis.

Essentially pandemic has demanded a few major alterations in the design, development, and implementation of existing information systems and technologies (IST) [3]. The researchers in collaboration with practitioners can work towards the maturity of emerging IST such as contactless commerce, face recognition while wearing masks, and extending test & trace topologies to other virus portfolios. Moreover, they can also address privacy concerns by introducing high-end data security protocols. Other domains where IT/IS professionals can contribute include crowdsourcing, deliberate data donation, AI-driven supply chains, and breakthroughs in online education. At the institutional level, scholars seek to transform the public health sector from being reactive to proactive. This can be achieved by doing real-time surveillance without breaching privacy requirements. The pandemic also revealed that most of the organizations exhibit little to no preparation in handling a sudden disruptive event. This realization indicates the need of redesigning organizational structures to enhance crisis-driven agility and mitigate crisis-revealed fragility. The changes IT scholars can trigger in an individual's life are by empowering everyone to discern and distinguish between actual happenings and fake news. Fact-checking platforms shall be

introduced and made available to the masses to stem the infodemic. Reference [9] investigates the challenges researchers can face in providing enhanced IT solutions aimed at transforming work, education, and life.

This paper aims at streamlining the ongoing technology integrations from the perspective of data management. It highlights possible dimensions in which IST researchers can contribute to effectively fight the remnant threat of COVID-19 and to ward off the dangers of any upcoming disruptive event of this scale.

2 Information Technology-based Solutions

In this paper, a data-people-system framework proposed by [10] is used to estimate the role of deployed IT solutions in reducing COVID-19 socio-economic impact. It provides a multidisciplinary roadmap to manage chronic diseases. Since pandemics are more serious and challenging in terms of their impact and scope, the proposed framework solicits further extensions. As of now, the framework is composed of three main components:

(1) Health data extraction, integration, and delivery

(2) Inter-functionality of disparate systems

(3) Public awareness and guidance tools.

This work investigates the opportunities and challenges which IT/IS professionals can further explore in the light of the data-people-system framework. It covers the discussion relatable to IT/IS scholars published in reputable news websites, white papers, blogs, and academic literature in an attempt to identify their possible contribution to fighting COVID-19 variants and the looming threat of any future pandemic triggered by natural cause or bioterrorism.

The pandemic has highlighted the fragility in our existing health systems demanding a complete redesign of the health sector by transforming it from being reactive to proactive. In proactive systems, data will be made available to decision-making authorities in real-time with high accuracy and low latency enabling rapid response to curtail emergencies. The ongoing challenge of dealing with the pandemic is unprecedented in the sense that its variants are unpredictable and thus estimating their contagiousness beforehand is preeminently beyond determinism. This is the reason that different governments have deployed their national strategies to limit its spread. Their efforts and schemes have been evolving continuously, indicating the underlying fluid nature of the virus response. This makes it clear that information-driven, coordinated efforts are still required to combat the virus and its emerging variants.

During the ongoing hype of Artificial Intelligence (AI), it is pertinent to utilize AI and its derivative technologies, including machine learning, complex pattern recognition, and deep learning. Essentially, it has been used in the detection and diagnosis of disease, rapid drug development, and now in optimizing supply chain vaccine delivery [11, 12]. In addition, AI tools are repurposed to implement effective contact tracing and reporting social distance violations [13]. Big data analytics—an offshoot of AI—is using travel history data of vulnerable people to identify high-risk locations mark them on available maps. All of it is achieved in real-time and more importantly

while ensuring user's privacy. To do so, governments have installed end-to-end encryption protocols to reduce privacy-related concerns. However, a huge chunk of the population is still skeptical about how the information can be used. Taiwan, for example, has used big data analytics fed by a person's clinical visits, travel history, and reported symptoms to identify suspected patients and generate alerts to protect others [14].

As a terminal device to put all algorithms in action, smartphones are surfaced as the best option. The capabilities that a smartphone possesses enable it to easily track and trace a user's movement. The same device can be used to alert people from visiting hotspots and connecting them in both social and professional circles. The trend of online shopping and e-commerce show immense potential and reportedly it saved, along with many other factors, quite a probable crash of stock markets [15]. On the avenue of application development, various apps are being launched at the government level. In the US, the National Science Foundation-funded researchers at Princeton University to update smartphone firmware enabling a secured proximity tracking app for health officials, whereby location data is to be saved only on the user's phone and will be made available for analysis on user's consent. Once the patient is diagnosed with the virus and the data is retrieved by health officials, they can perform the contact tracing and identify vulnerable people in the patient's recent contacts. Subsequently, the health officials can generate an alert to the suspected patients to quarantine and direct them to take the rest. The same strategy has been implemented in various countries worldwide [16].

Other than data collection, filtering, training, and testing, High-Performance Computing (HPC) infrastructure is another important resource to consider for COVID-19 related big data analytics. To prevent the overloading of existing computing power, the COVID-19 HPC Consortium has been established to allocate a specific computing power to deal with incoming COVID-related data. It includes both public and private entities including the US Department of Energy, and IBM [17]. In another multidisciplinary example, drones are used to supply medicines, patrol public spaces, and track violations of stay-at-home rules, if the law of that state/country allows [18]. Similarly, direct surveillance enabled by IoT can be employed within the lawful provisions [19]. Smartphones, smartwatches, and health bands have made health monitoring efficient and easily accessible. A COVID-19 patient, in particular, can be marked and his health-related data—oxygen levels using SPO_2 sensors, temperature, heart rate—can be regularly measured and uploaded to the hospital server for observing the trends and treatments. The ID of the person can be essentially encrypted, and the subject may be used as the source of data collection with his/her consent. However, in case of emergency, prompt assistance could be sent to the GPS location of the patient [14]. A little more restrictive but efficient way to curb the spread of COVID-19 would be to monitor the quarantine period of a suspect using IoT trackers. Such restraining methods can only be implemented with the voluntary participation of suspected and infected citizens [15]. Figure 1 [61, 14-19] summarizes the technologies associated with each center and where the interplay among them becomes advantageous

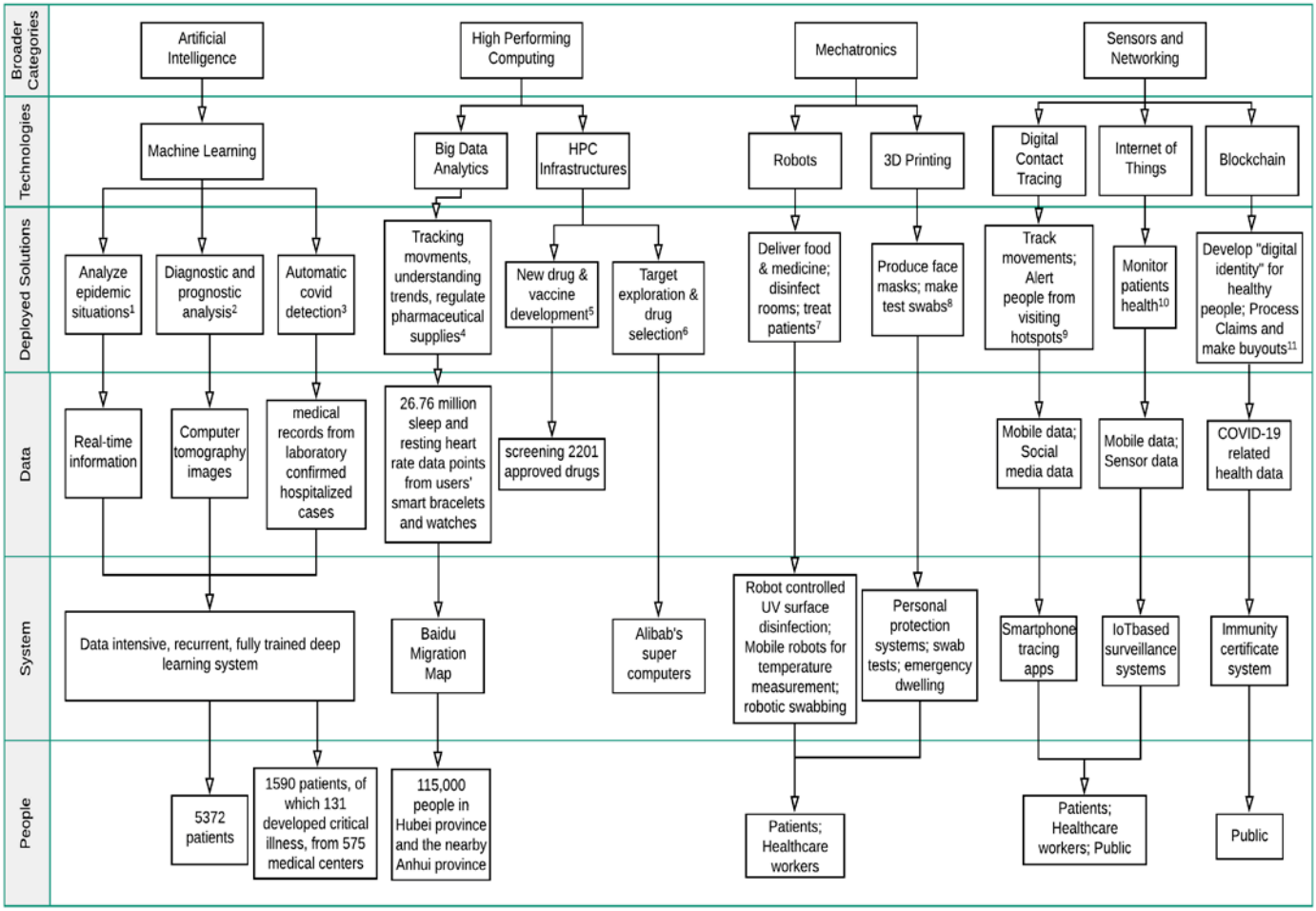

Figure 1: Summary of deployed COVID-19 solutions layered in Data-System-People framework.

3 Challenges Faced During the Covid-19 Pandemic

The pandemic has highlighted severe fragility in the rapid response of the public health system, whereof the lack of coordination among data, people, and systems surface to be the prime cause of delay in providing an effective response [10] Precisely, a discrepancy in the system standards and data formats has been revealed across the different parts of the globe, impeding the implementation of a universal policy plan. An active and vibrant connection between field medical practitioners and policymakers is envisioned to avoid a delayed response, in case a similar scenario arises in the future. The pandemic has also highlighted the crucial role epidemiologists could play in determining and then probably molding the course of the pandemic, which in the past has been somewhat overlooked. In the wake of rising misinformation about vaccines' effectiveness and side effects, the formation of a science-and-data-backed trusted body becomes the need of the hour at both local and international levels.

Employments of technology to combat the epidemic pose numerous problems. Because of the unique nature of the COVID-19 pandemic, strong coordination of interconnected devices, individuals, and technologies [10] is required to support collaborative efforts in combating it. Historically, public health authorities and healthcare providers have not used the same technologies, file formats, or protocols, making it difficult to see trends and devise pandemic-fighting actions. To better comprehend the emerging epidemic and make collaborative decisions on

how to address it, public health experts, public health officials, and government officials must be interconnected via integrated systems with connected data. Because people are so important in the fight against COVID-19, it is critical to use new and integrated technology to connect, manage, and support numerous stakeholders.

3.1 Systems with Integrated Technologies

It has been established that one technology single-handedly cannot tackle the problem humanity is facing. It must be a concerted effort of multiple state-of-the-art technologies including AI, blockchain, IoT, and big data analytics. As of now, most systems are underutilizing the privileges each technology has to offer due to the unavailability of unified standards and systematic framework. Severe challenges in the supply chain of vaccines are observed which could be conveniently avoided if integrated-technology-driven supply chain schemes are put in place. Interoperability of the available data is crucial in developing integrated technologies. It has been reported that some sources are well-structured, and credible, whereas, some of them stem from misinformation [21]. It is pertinent to ensure data security along with credibility. The responsibility falls on the shoulders of leading technology firms, governments, and health service institutions, where they must be able to formulate necessary protocols, standards, and data formats while keeping all stakeholders in the loop.

In the past two decades, IST researchers have proposed technology integration at the institutional level with clear tangible advantages [22, 23]. Specifically, in the backdrop of ongoing crises, scholars have examined frameworks of embedded technologies providing crisis management and emergency rapid response [24]. However, this time the challenge is bigger than ever. It is not limited to proposing institution-level technology integration anymore; the research community is seeking global solutions, hence creating enormous opportunities. Collaboration is the key where various technologies come together synergistically to address the problem that is too big for a single technology.

3.2 Implementing Systems with Integrated Technologies

In the ongoing age of volatile information, numbers are prone to change in real-time. Trends are difficult to ascertain with conventional statistical tools soliciting the need for data curation. Nonetheless, some clear patterns emerge to limit the spread of the virus. These patterns can culminate in the worldwide accepted best practices and must be willingly adopted by the masses. The first lockdown was reported in the epicenter of the virus, Wuhan, appearing then as an extraordinary and strict measure. Later, to some extent, almost every nation has imposed lockdowns of different levels of severity. A practice, first criticized, was later implemented worldwide.

Apart from the government-level activism, running awareness campaigns of best practices and hunting down misinformation has become challenging. Especially after the rollout of vaccines, even credible news outlets are seen divided on the interpretation of the data they are receiving

from the hospitals. At this point, information curation (a rising field of IT) and knowledge management become essential to mitigate the hazards of shallow reporting of data [10]. Another concern surrounding knowledge management is accessibility. The benefits of sharing data include more accurate diagnostic and prediction tools, efficient decision-making support systems, cross-fertilization of ideas, and acceptance of best health practices [25, 26]. Nonetheless, the accessibility concern is two-fold; first, the shared information must be trustworthy, second, it reaches the safe hands where data-security issues are non-existent. As an example, to this date, it has been widely reported that many countries, including China, have underreported the total number of cases. An air of mistrust exists among nations due to political differences which make data-driven sharing more challenging. However, if the technology-driven global regulatory framework is enforced that monitors both authenticity and security of shared data. At the private level, without the intervention of any state-level regulatory body, online communities have been formed on social media platforms to share the well-being habits of COVID-19 inflicted societies including protective hygienic practices, recovery tactics, and mental health care [27, 28]. People have actively engaged in sharing their productive lockdown activities instigating other members to follow such trends and hence initiating a chain of cyclic healthy practices [29].

The negative consequences of data accumulation and sharing are under discussion among IST researchers [30]. Some of the app developers rushed to the development of contact tracing apps which might jeopardize the spread and acclamation of safe and well-regulated apps. These privately owned apps are both pervasive and invasive [31] Users also fear that contact tracing apps, albeit essential for the ongoing dire times, might later serve as surveillance tools in the hand of the government agencies severely breaching the privacy of individuals enacted by the law of many democratic countries. Moreover, the risks of breaching and selling data have been pervasive. Large-scale privacy checks and global encryption might offer the solution to this challenge [32], however, their implementation at the international makes the problem more challenging. Systems developed in the name of ethical hacking have been used to test the fidelity of the encryption used by local governments which are found to be vulnerable at several points [33]. Although some researchers have encouraged offering flexibility in privacy laws to save human lives, the topic is still under debate as others are reluctant to compromise on privacy concerns [34]. The lack of consensus has insinuated the intervention of global powers in establishing privacy guidelines weighing both the health and privacy concerns of citizens [35].

In action, contact tracing apps are effective in identifying the bubble of infected people and hence mitigating the further spread of the virus. However, security trust issues are rife among the populace with regard to contract tracing which requires the immediate attention of policymakers [36]. In Europe and the USA, the use of contact tracing apps is voluntary, to abide by their respective constitutions. In countries, however, where the culture of collectivism is adapted, the use of such apps is deemed mandatory. Yet the statistics report that at least 60 percent of the people must be actively reporting their contacts to see encouraging results of using such apps [37].

There is a need for behavioral change in skeptical citizens by introducing a technology-enabled trust mechanism that ensures across-the-board equity, transparency, security, and privacy [38, 33]

3.3 Integrating the System with Human Behavior

At a first glance, this challenge looks intimidating. Human behavior is generally linked with human expression and independent will. And consequently, people raise concerns that reshaping human behavior is analogous to limiting free will. However, the critiques fail to recognize that rules and regulations are already in action to refine various aspects of human behavior. Similar practices need to be implemented in regulating integrated information systems. Several cases of misreporting of COVID-19 symptoms have been reported which pollute the data endangering the overall analysis of received data. Algorithms can be invoked while data collection to filter out the fraudulent information, however, it needs the collaboration of IST professionals with behavior scientists [39]. Ironically, all big tech companies, Facebook, Google, TikTok, Snapchat have faced multiple cases of cybercrimes, most of which can be narrowed down to unchecked human behavior. A similar irresponsible attitude of users is reflected when they use apps related to COVID-19.

To understand the underlying cause behind such behavior and its possible solution, many theories and models are investigated including innovation diffusion theory, technology acceptance model, health belief model, and social cognitive theory. The response of COVID-19 related apps users can be analyzed with these models not only to spot the anomalies but also to identify the regions of untrustworthy information. Incentivized surveys can be used to obtain representative cases and further guidelines of reshaping human behavior can be published [10]. These ideas, inevitably, fringes into the field of behavioral sciences, however, at this stage the cooperation of these two fields would prove instrumental in gathering reliable data.

As more COVID-19-related systems are produced, incorporated, and used by governments, companies, and individuals, it is critical to understand human behavior while developing, implementing, and using technology. Many efforts to battle the epidemic make use of recent advances in technology and ways to integrate multiple systems and technologies. However, we must recognize that people's technological misconduct may impair the efficacy of technology-related intervention or precautions in managing the coronavirus outbreak. Scholars of information systems and technology can help by applying their knowledge of human behavior into the design and development of technology, resulting in more effective technology [39]. As more COVID-19-related systems are produced, incorporated, and used by governments, companies, and individuals, it is critical to understand human behavior while developing, implementing, and using technology. Many efforts to battle the epidemic make use of recent advances in technology and ways to integrate multiple systems and technologies. However, we must recognize that people's technological misconduct may impair the efficacy of technology-related intervention or precautions in managing the coronavirus outbreak. Researchers of information systems and

technology can help by applying their knowledge of human behavior into the design and development of technology, resulting in more effective technology [39].

Another behavioral discrepancy is answered by the recognition of the digital divide; referring to uneven digital literacy and internet access in many underdeveloped parts of the world, which not only puts in question the extent of the virus spread in those areas but also indicates how much efforts are still required [40]. One can argue that this disparity of access is being rapidly mitigated. However, if the pace of technology evolution is factored in, the position evens out. In fact, [41] reports that with the advent and rapid spread of AI, IoT, and blockchain in developed nations, unequal opportunities and biases are further reinforced. This digital divide is also highlighted by [42] discussing how the digital divide impacts women, underprivileged people, and the elder population. Apart from technology infrastructure development in those areas, the fundamental change in human behavior is equally needed, such that people not only accept the technology but also use it and later contribute with their accurate responses. IST scholars can help in the development of awareness programs for this purpose. An example, discussed by [43], sets a precedent whereby researchers can utilize the current situation as an opportunity to formulate sustainable online health communities reducing rural-urban disparities and supporting vulnerable families. After the vaccination is rolled out, one of the biggest challenges is to induce trust among the masses about its safety and need. IST scholars can contribute by integrating behavioral studies within the disseminated IST tools with a dual-fold objective; to identify and remove false information, and to encourage people to get the vaccination at their earliest availability.

4 IoT-based Solutions

In recent years, IoT technology has risen in popularity in the healthcare industry, where it plays a key role in various stages of identifying and managing infectious diseases [44]. Due to the high frequency of COVID-19 in the ongoing pandemic, it is critical for patients to be connected to and followed by their doctors at various stages of COVID-19. This section presents the role and applications of IoT in managing COVID-19. This can be done in three stages such as early detection, isolation, and recovery.

Due to the high rate of infectiousness of COVID19, even asymptomatic patients can easily transfer the virus to others. Also, faster detection is critical during the initial phase of COVID-19 early diagnosis [45]. The earlier a patient is identified, the better the virus's transmission can be halted and the patient can obtain proper treatment. In reality, by recording data from patients, IoT devices help speed up the identification process. This can be done by employing various instruments to capture body temperatures, obtaining samples from questionable cases, and so on. The second stage known as quarantine time [46] occurs after the patient has been identified with COVID-19 and therefore should be quarantined for the duration of treatment. In this phase, IoT devices can remotely monitor the patients' treatments and stay-at-home directives from the authorities. They can also maintain the spaces without interacting with people. Implementing

tracking wearable bands, disinfection devices, and other similar technologies are some of the examples of these types.

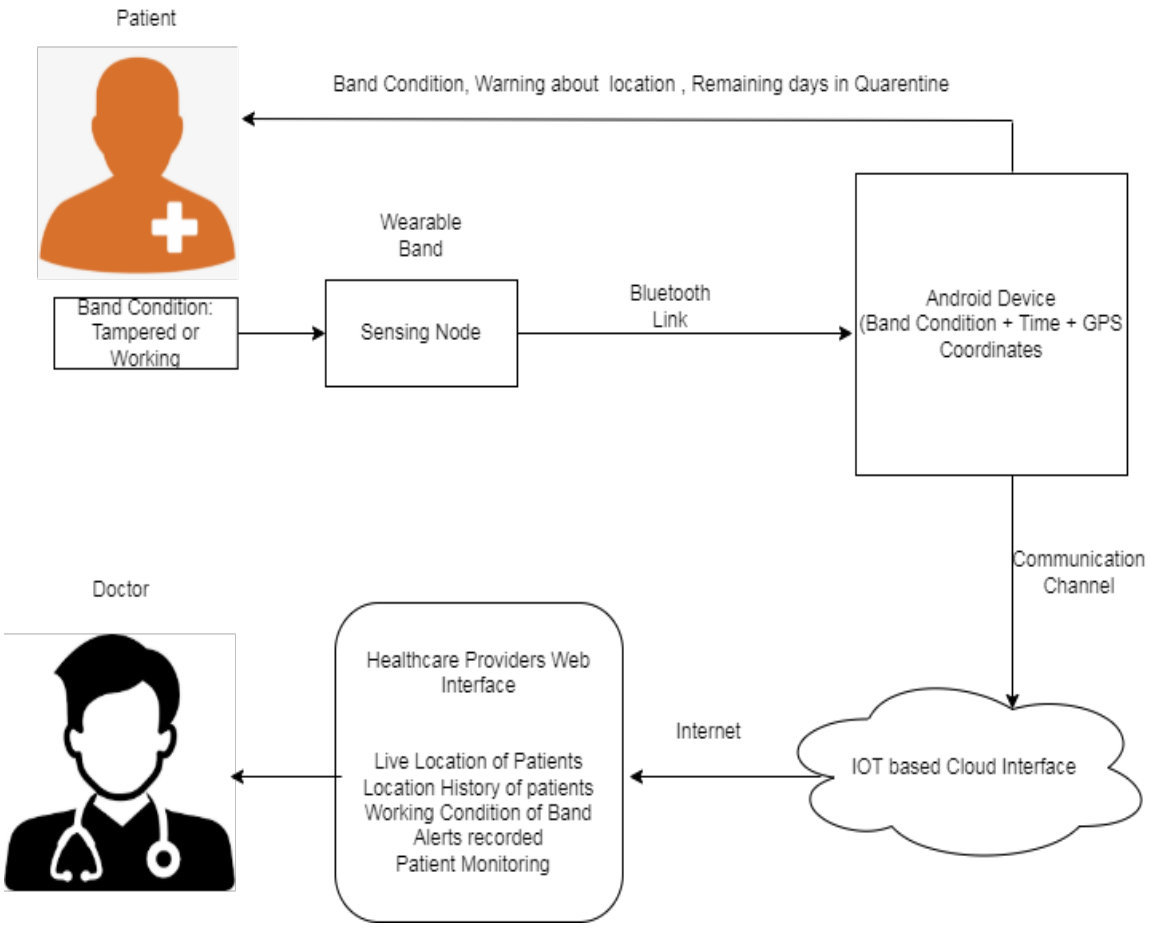

Figure 2: Schematic representation of the IoT-based Pandemic Management

Figure 2 shows the workflow process of IoT-based Covid-19 monitoring and management. This approach has been deployed where authorities use an IoT-enabled sensor device with a smartphone application to track the patients affected with Covid-19 during their isolation period of 14 days. To avoid this, a new concept called social distancing is introduced by the World Health Organization (WHO). This procedure distances the affected individual from spreading the infection to others or from being re-infected with COVID-19. Various IoT-based devices such as smart bands, and crowd management and monitoring devices were used in this process. These IoT-based devices were used to make sure that the person who is infected is isolated and also to monitor weather appropriate distancing is followed in the crowded areas. In general, the IoT-based methodology is most useful to control and maintain the pandemic by assisting the infected patients, healthcare providers, COVID protocol monitoring agencies, etc. IoT-based devices such as smart thermometers, smart helmets inbuild with smart glasses, individual smart glasses, IoT-Q-Band, Easy band, IoT-based Proximity Tracer, Drone Things (IoDT), IoT buttons, Smartphone Applications based on IoT, etc. were deployed. Table 1 depicts the additional summary of IoT-based devices deployed for managing the COVID-19 pandemic.

Table 1: Additional summary of the IoT devices deployed for managing Covid-19.

IoT-based Devices	Description	Applications
Smart Thermometers	It comes in a variety of forms, including touch, patch, and radiation, and can be worn or attached to the skin or under the clothing.	This can be used to discover questionable individuals in the early stage [47, 48]
Smart Helmets, Smart Glasses [50],	Due to less interpersonal contact, smart wearable helmets and smart glasses with a thermal imaging camera are safer than infrared thermometers	When the thermal camera present in the smart helmet detects a high temperature, the camera records the location and image of the person's face. Then, an alert is sent to the designated mobile device, allowing the department of the public to identify the infected person [49, 50, 56]
IoT-Q-Band [51], EasyBand [52]	To perceive and detect the mobility of Covid-19 patients, an IoT-enabled sensor device attached to a smartphone application was used.	It can be used to track the patients affected with Covid-19 during their isolation period
IoT-based Proximity Tracer [53].	IoT-based proximity sensors connected with mobile phones	Using proximity sensors, workplace safety can be improved by implementing social distance policies. To sustain social distancing, tracking and contact tracing are necessary. This can be done by calculating the distance between people based on their physical proximity
Drones based on Internet of Drone Things (IoDT)	Sensors, GPS, and communication services based on the Internet of Things are used.	Locating, tracking, and delivering [54, 55].
IoT Buttons	Through wireless connectivity, a programmed button is connected to the cloud.	Patients can use a button to report if any hospital facilities need cleaning, and the authorities or doctors will be notified. [57, 58]
Smartphone Applications based on IoT	For tracking purposes, IoT-enabled smartphone applications use information from the Global Positioning System (GPS) and Geographic Information System (GIS)	Patients will benefit from smartphone applications that use the Internet of Medical Things (IoMT) to provide them with suitable therapies while they are at home. [59, 60]

5 Conclusion

The ongoing pandemic has had a devastating impact on multiple aspects of human life. The ill-prepared human response has exposed the limitations of our capacity in taking proactive action against a calamity of global level. This article has explored the responsibility on the shoulders of IST researchers and professionals. Admittedly, IST practitioners have played a pivotal role in bringing the situation into control. The duration of information and field-level implementation of IT devices has made it possible to keep the world running while people stay at home. This article provides an overview of deployed IT and IoT-based solutions and discussed how they are being used to minimize the adverse impact of the Covid-19 pandemic. These technologies are evaluated based on the data-system-people framework to assess the role of each faction in the framework. Later, the article also highlights the challenges faced by the IST community in terms of security, ethics, privacy, and the digital divide.

6 Availability of Data and Material

Data can be made available by contacting the corresponding author.

7 References

[1] Young, J. 2020. “Scenes from College Classes Forced Online By COVID-19 | EdSurge News.” 2020. Accessed December 2021. https://www.edsurge.com/news/2020-03-26-scenes-from-college-classes-forced-online-by-covid-19

[2] O’Leary, D. E. 2020. “Evolving Information Systems and Technology Research Issues for COVID-19 and Other Pandemics.” Journal of Organizational Computing and Electronic Commerce 30 (1): 1-8.

[3] Sein, M. K. 2020. “The Serendipitous Impact of COVID-19 Pandemic: A Rare Opportunity for Research and Practice.” International Journal of Information Management 55 (December): 102164.

[4] Richter, A. 2020. “Locked-down Digital Work.” International Journal of Information Management 55 (December): 102157. DOI: 10.1016/j.ijinfomgt.2020.102157.

[5] Angst, C. M., and Ritu A. 2009. “Adoption of Electronic Health Records in the Presence of Privacy Concerns: The Elaboration Likelihood Model and Individual Persuasion.” MIS Quarterly: Management Information Systems 33 (2): 339-70. DOI: 10.2307/20650295

[6] Thompson, B. C. 2019. “Collaborative Action Research In Academic Administration.” West East Journal of Social Sciences 8 (3): 227-52. DOI: 10.36739/wejss.2019.v8.i3.30.

[7] Johnstone, S. 2020. “A Viral Warning for Change. The Wuhan Coronavirus Versus the Red Cross: Better Solutions Via Blockchain and Artificial Intelligence.” SSRN Electronic Journal, February.

[8] Mingis, K. 2020. “Tech Pitches into Fight COVID-19 Pandemic | Computerworld.” 2020. https://www.computerworld.com/article/3534478/tech-pitches-in-to-fight-covid-19-pandemic.html.

[9] Dwivedi, Y. K., Hughes, D. L., Coombs, C., Constantinou, I., Duan, Y., Edwards, J. S., et al. 2020. “Impact of COVID-19 Pandemic on Information Management Research and Practice: Transforming Education, Work and Life.” International Journal of Information Management 55 (December): 102211.

[10] Bardhan, I., Chen, H., & Karahanna E. 2000. “Connecting systems, data, and people: A multidisciplinary research roadmap for chronic disease management”, Management Information Systems Quarterly, 44(1), 185-200.

[11] Bansal, A., C. Garg, and R. P. Padappayil. 2020. “Optimizing the Implementation of COVID-19 ‘Immunity Certificates’ Using Blockchain.” Journal of Medical Systems. Springer.

[12] Brohi, Sarfraz Nawaz, NZ Jhanjhi, Nida Nawaz Brohi, and Muhammad Nawaz Brohi. 2020. “Key Applications of State-of-the-Art Technologies to Mitigate and Eliminate COVID-19,”.

[13] Sipior, J. C. 2020. “Considerations for Development and Use of AI in Response to COVID-19.” International Journal of Information Management, vol. 5, pp.102-117.

[14] Wang, C. Jason, Chun Y. Ng, and Robert H. Brook. 2020. “Response to COVID-19 in Taiwan: Big Data Analytics, New Technology, and Proactive Testing.” JAMA - Journal of the American Medical Association. American Medical Association.

[15] Ozturk, Tulin, et al. 2020. "Automated detection of COVID-19 cases using deep neural networks with X-ray images." Computers in biology and medicine 121: 103792. DOI: 10.1016/j.compbiomed.2020.103792.

[16] Choong, Yu Ying Clarrisa, et al. 2020. "The global rise of 3D printing during the COVID-19 pandemic." Nature Reviews Materials 5.9, 637-639. Nature Research. DOI: 10.1038/s41578-020-00234-3.

[17] Budd, J., et al. 2020. “Digital Technologies in the Public-Health Response to COVID-19.” Nature Medicine. Nature Research. DOI: 10.1038/s41591-020-1011-4.

[18] Rahman, M. S., et al. 2020. "Defending against the Novel Coronavirus (COVID-19) outbreak: How can the Internet of Things (IoT) help to save the world?." Health policy and technology 9(2), 136. DOI: 10.1016/j.hlpt.2020.04.005.

[19] Kumar, K., Kumar, N. and Shah, R. 2020. “Role of IoT to Avoid Spreading of COVID-19.” International Journal of Intelligent Networks 1: 32-35. DOI: 10.1016/j.ijin.2020.05.002.

[20] Nasajpour, M., et al. 2020. “Internet of Things for Current COVID-19 and Future Pandemics: An Exploratory Study.” Journal of Healthcare Informatics Research 4 (4): 325-64. DOI: 10.1007/s41666-020-00080-6.

[21] Pham, Q. V., et al. 2020. “Artificial Intelligence (AI) and Big Data for Coronavirus (COVID-19) Pandemic: A Survey on the State-of-the-Arts.” IEEE Access. Institute of Electrical and Electronics Engineers Inc.

[22] Henningsson, S., Yetton, P. W., and Wynne, P. J. 2018. “A Review of Information System Integration in Mergers and Acquisitions.” Journal of Information Technology 33 (4): 255-303.

[23] Ravichandran, T., and Arun R. 2000. “Quality Management in Systems Development: An Organizational System Perspective.” MIS Quarterly: Management Information Systems 24 (3): 381-410. DOI: 10.2307/3250967.

[24] Ravichandran, T., and Rai, A. 2000. “Quality Management in Systems Development: An Organizational System Perspective.” MIS Quarterly: Management Information Systems 24 (3): 381-410. DOI: 10.2307/3250967.

[25] Chen, R., et al. 2008. “Emergency Response Information System Interoperability: Development of Chemical Incident Response Data Model.” Journal of the Association for Information Systems 9 (3-4): 200-230. DOI: 10.17705/1jais.00153.

[26] Rehfuess, E. A., et al. 2019. “The WHO-INTEGRATE Evidence to Decision Framework Version 1.0: Integrating WHO Norms and Values and a Complexity Perspective.” BMJ Global Health 4 (Suppl 1): e000844. DOI: 10.1136/bmjgh-2018-000844.

[27] Yan, L., and Yong, T. 2014. “Feeling Blue? Go Online: An Empirical Study of Social Support among Patients.” Information Systems Research 25 (4): 690-709. DOI: 10.1287/isre.2014.0538.

[28] Ziebland, S., et al. 2004. “How the Internet Affects Patients’ Experience of Cancer: A Qualitative Study.” British Medical Journal 328 (7439): 564-67.

[29] Nabity-Grover, T., Cheung, C. M., & Thatcher, J. B.. 2020. “Inside out and Outside in: How the COVID-19 Pandemic Affects Self-Disclosure on Social Media.” International Journal of Information Management 55: 102188. DOI: 10.1016/j.ijinfomgt.2020.102188.

[30] Chiasson, M., Davidson, E. and Winter, J. 2018. “Philosophical Foundations for Informing the Future(S) through IS Research.” European Journal of Information Systems 27(3): 367-79. DOI: 10.1080/0960085X.2018.1435232.

[31] O’Neill, P. H., Ryan-Mosley, T. and Johnson, B. 2020. “A Flood of Coronavirus Apps Are Tracking Us. Now It’s Time to Keep Track of Them. | MIT Technology Review.” Accessed March 2021. https://www.technologyreview.com/2020/05/07/1000961/launching-mittr-covid-tracing-tracker/.

[32] Huang, Y., Sun, M. and Sui, Y. 2020. “How Digital Contact Tracing Slowed Covid-19 in East Asia.” Accessed December 2021. https://hbr.org/2020/04/how-digital-contact-tracing-slowed-covid-19-in-east-asia

[33] Lee, N. T., and J. Roberts. 2020. “Managing Health Privacy and Bias in COVID-19 Public Surveillance.” 2020. https://www.brookings.edu/blog/techtank/2020/04/21/managing-health-privacy-and-bias-in-covid-19-public-surveillance

[34] Cho, H., Ippolito, D. and Yu, Y. W. 2020. “Contact Tracing Mobile Apps for COVID-19: Privacy Considerations and Related Trade-Offs.” ArXiv, March. http://arxiv.org/abs/2003.11511.

[35] Fahey, R. A., and Hino, A. 2020. “COVID-19, Digital Privacy, and the Social Limits on Data-Focused Public Health Responses.” International Journal of Information Management 55 (December): 102181.

[36] Ferretti, L., et al. 2020. “Quantifying SARS-CoV-2 Transmission Suggests Epidemic Control with Digital Contact Tracing.” Science 368 (6491)

[37] Scott, D. 2020. “Contact Tracing Apps for Coronavirus Are the New Trend. Here’s Why. - Vox.” 2020. https://www.vox.com/2020/4/22/21231443/coronavirus-contact-tracing-app-states

[38] Ienca, M., and Vayena, E. 2020. "On the Responsible Use of Digital Data to Tackle the COVID-19 Pandemic." Nature Medicine. Nature Research.

[39] Pfleeger, S. L., and Caputo, D. D. 2012. "Leveraging Behavioral Science to Mitigate Cyber Security Risk." Computers and Security 31 (4): 597-611. DOI: 10.1016/j.cose.2011.12.010.

[40] Newman, L., Browne-Yung, K., Raghavendra, K., Wood, D. and Grace, E. 2017. "Applying a Critical Approach to Investigate Barriers to Digital Inclusion and Online Social Networking among Young People with Disabilities." Information Systems Journal 27 (5): 559-88.

[41] Park, S., and Humphry, J. 2019. "Exclusion by Design: Intersections of Social, Digital and Data Exclusion." Information Communication and Society 22 (7): 934-53.

[42] Venkatesh, V. 2020. "Impacts of COVID-19: A Research Agenda to Support People in Their Fight." International Journal of Information Management 55 (December): 102197. DOI: 10.1016/j.ijinfomgt.2020.102197.

[43] Friedman, E. M., Trail, T. E ., Vaughan, C. A. and Tanielian, T. 2018. "Online Peer Support Groups for Family Caregivers: Are They Reaching the Caregivers with the Greatest Needs?" Journal of the American Medical Informatics Association 25 (9): 1130-36.

[44] Christaki E (2015) New technologies in predicting, preventing and controlling emerging infectious diseases. Virulence 6(6):558-565

[45] Phelan AL, Katz R, Gostin LO (2020) The novel coronavirus originating in Wuhan, China: challenges for global health governance. Jama 323(8):709-710

[46] Nussbaumer-Streit B, et al. (2020) Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. Cochrane Database Syst Rev (4)

[47] Chamberlain SD, Singh I, Ariza CA, Daitch AL, Philips PB, Dalziel BD (2020) Real-time detection of COVID-19 epicenters within the United States using a network of smart thermometers. medRxiv

[48] Tamura T, Huang M, Togawa T (2018) Current developments in wearable thermometers. Adv Biomed Eng 7:88-99

[49] Mohammed M, Syamsudin H, Al-Zubaidi S, AKS RR, Yusuf E (2020) Novel COVID-19 detection and diagnosis system using IoT-based smart helmet. International Journal of Psychosocial Rehabilitation 24(7):2296-2303

[50] Mohammed M, Hazairin NA, Syamsudin H, Al-Zubaidi S, Sairah AK, Mustapha S, Yusuf E (2020) 2019 novel coronavirus disease (COVID-19): detection and diagnosis system using IoT-based smart glasses. International Journal of Advanced Science and Technology 29(7 Special Issue):954-960

[51] Singh VK, Chandna H, Kumar A, Kumar S, Upadhyay N, Utkarsh K (2020) IoT-Q-Band: a low cost internet of things based wearable band to detect and track absconding COVID-19 quarantine subjects. EAI Endorsed Transactions on Internet of Things

[52] Tripathy AK, Mohapatra AG, Mohanty SP, Kougianos E, Joshi AM, Das G (2020) Easyband: a wearable for safety-aware mobility during pandemic outbreak. IEEE Consumer Electronics Magazine

[53] Contact tracing IoT solution. (2020). https://bit.ly/2B60rF2. Accessed June 2020

[54] Rouse, M. (2019) Drone (UAV). https://bit.ly/2ZHuonE. Accessed July 2020

[55] Nayyar A, Nguyen B-L, Nguyen NG (2020) The internet of drone things (IoDT): future envision of smart drones. In: First International Conference on Sustainable Technologies for Computational Intelligence. Springer, pp 563-580

[56] Mohammed M, Hazairin NA, Al-Zubaidi S, AK S, Mustapha S, Yusuf E (2020) Toward a novel design for coronavirus detection and diagnosis system using IoT-based drone technology. Int J Psychosoc Rehabil 24(7):2287-2295

[57] AWS IoT button. https://aws.amazon.com/iotbutton Accessed December 2021.

[58] Chai PR, et al. (2019) An internet of things buttons to measure and respond to restroom cleanliness in a hospital setting: a descriptive study. J Med Int Res 21(6):e13588

[59] El Khaddar MA, Boulmalf M. (2017). Smartphone: the ultimate IoT and IoE device. Smartphones from an Applied Research Perspective, 137.

[60] Yang T, Gentile M, Shen C-F, Cheng C-M (2020) Combining point-of-care diagnostics and internet of medical things (IoMT) to combat the COVID-19 pandemic

[61] Punn, N. S., Sonbhadra, S. K., and Agarwal, S. 2020. "COVID-19 Epidemic Analysis Using Machine Learning and Deep Learning Algorithms." MedRxiv. medRxiv. DOI: 10.1101/2020.04.08.20057679.

Dr. Mohammed Alanezi is an Associate Professor in the Department of Computer Science and Engineering, University of Hafr Al-Batin. His research interests include E-Government, E-Services, E-Health, IOT and Knowledge Management. He has had contributions in developing systems and projects. Much of his work has been in embracing digital transformation and improving the current technology to solve challenges facing the University of Hafr Al-Batin.