Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Health Policy and Technology 9 (2020) 136–138

Contents lists available at ScienceDirect

Health Policy and Technology

journal homepage: www.elsevier.com/locate/hlpt

Defending against the Novel Coronavirus (COVID-19) outbreak: How can the Internet of Things (IoT) help to save the world?

Md. Siddikur Rahman[a], Noah C. Peeri[b,*], Nistha Shrestha[b], Rafdzah Zaki[c], Ubydul Haque[b], Siti Hafizah Ab Hamid[d]

[a] Department of Statistics, Begum Rokeya University, Rangpur, Bangladesh
[b] Department of Biostatistics and Epidemiology, University of North Texas Health Science Center, Fort Worth, TX 76107, USA
[c] Centre for Epidemiology and Evidence-based Practice, Department of Social and Preventive Medicine, Faculty of Medicine, University of Malaya, 50603, Kuala Lumpur, Malaysia
[d] Department of Software Engineering, Faculty of Computer Science & Information Technologies, University of Malaya, 50603, Kuala Lumpur, Malaysia

ARTICLE INFO

Article history:
Available online 22 April 2020

The outbreak of a new coronavirus (COVID-19) that originated in Wuhan, China, seems to be unstoppable. The virus has already infected more than 558,502 people around the world, with at least 25,251 deaths as of March 1, 2020 [1,2]. The outbreak of pneumonia of unknown aetiology started in Wuhan, Hubei province in China [3], linked to the Huanan Seafood Market. The virus is of the genus *betacoronavirus* and is related to the viruses that cause Middle Eastern Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS) [4]. The WHO was first alerted on the 31st of December 2019,although several cases of pneumonia of unknown aetiology were detected much earlier (Dec 8, 2019) [5]. This delay in declaring the occurrence of an outbreak and failure to alert international authorities in a timely manner contributed to the uncontrolled spread of the disease. This pandemicis now the focus of global attention.

In an effort to mitigate the spread of the virus, China expanded a lockdown of the focal city Wuhan that included 20 cities, and encompassed 56 million individuals. Experts initially raised concerns regarding the sustainability of this effort and have warned that the country was at risk for a repeat of an epidemic similar to the SARS epidemic [6,7]. At this time it appears that the pandemic is under control in most of China, although criticism remains regarding the use of what some have termed “draconian” measures for stifling its spread.

The world is now struggling to control the unprecedented spread of the virus which includes a record number of morbidities and mortalities. Since there is no specific treatment for coronaviruses, and efforts to contain the spread have thus far failed [4], there is an urgent need for global surveillance of individuals with active COVID-19 infection. The inclusion of an integrated digital disease surveillance system may be crucial to the control of this disease.

A wealth of new technologies in the form of the Internet of Things (IoT) is gaining growing global attention [8] and becoming increasingly available for predicting, preventing and monitoring emerging infectious diseases [9]. The IoT refers to an interconnected web of smart devices, sensors, and individuals through which data can be collected in its raw form and transmitted through the internet to be analyzed for patterns or trends. State-of-the-art IoT-Enabled Health Monitoring Systems (Health Monitoring Systems) provide real-time surveillance through the use of wearable health-monitoring devices, cloud-based remote health testing, and artificial intelligence (AI). These monitoring systems utilize, in real-time, social media, public data, and health data, combined with the use of supervised, unsupervised, and machine learning. When AI and machine learning merge with distributed cloud, practical blockchain, system software automation, and AI speech recognition, the health monitoring systems enable the creation of a reliable remote monitoring system between patient and doctor. Features of this IoT-Enabled health monitoring systems include online triage, AI secure chat, and telehealth. These technologies are now easily accessed via simple user interfaces on reliable mobile apps and web-based systems due to lightweight Application Programming Interfaces (APIs) and edge computing ability. With the rise of these technologies, data privacy has become an increasing concern specifically regarding the potential for data misuse and abuse. A new field within information technology has emerged, termed *digital ethics* [10]. This branch of ethics is the study of moral problems relating to data and information, algorithms, and corresponding

* Corresponding author at: Department of Biostatistics and Epidemiology, University of North Texas Health Science Center, 3500 Camp Bowie Blvd, Fort Worth, TX 76107, USA.
E-mail address: noah.peeri@my.unthsc.edu (N.C. Peeri).

https://doi.org/10.1016/j.hlpt.2020.04.005

practices and infrastructures, described in detail elsewhere [10]. Therefore, hospital and immigration must be ready to share critical information such as data of an increased number of patients with high fever and people movement going in and out of the country to the IoT system to allow them to be analyzed in real time. In addition, all related equipments, especially edge servers and cloud servers with a 5G network, need to be installed to ensure fast transaction to all devices accessed by the computation engines and the different levels of end users.

The new wave of digitizing medical records has caused a paradigm shift in the healthcare industry. The industry is witnessing an increase in the sheer volume of data in terms of complexity and diversity. Big data is emerging as a plausible solution with the promise to transform the healthcare industry. A paradigm shift from reactive to proactive healthcare may result in an overall decrease in healthcare costs and eventually lead to economic growth. While the healthcare industry harnesses the power of big data, security and privacy issues are becoming increasingly important as emerging threats and vulnerabilities grow. When dealing with healthcare monitoring, privacy and data security should be carefully considered. Developers can help to integrate security into devices, applications, and systems [11]. With regard to data sharing, developers can use a Client-Server model, in which the server shares a certain type of information with clients while keeping other information protected by appropriate credentials [12].

IoT within infectious disease epidemiology is an emerging field, however, the ubiquitous availability of smart technologies, as well as increased risks of infectious disease spread through the globalization and interconnectedness of the world necessitates its use for predicting, preventing and controlling emerging infectious diseases [9] Web-based surveillance tools and epidemic intelligence methods have recently emerged in several countries [9] to facilitate risk assessment and timely outbreak detection, however widespread use of the available technologies is lacking.

Due, in part, to the rapid growth of the Chinese economy and globalization, IoT-Enabled Health Monitoring in a global healthcare infrastructure would provide targeted information for health officials, and has the potential to improve efforts to locate, contain, and prevent infectious diseases. It may help to quickly diagnose infected patients and accurately predict the possible spread of a disease to other locations utilizing travel data. Ultimately, an IoT based surveillance system might help reconstruct the progression of an outbreak and stabilize the economy of the source country rather than having to lock down major cities, borders, and businesses.

Web-based tools for surveillance of the flu virus (Influenza) have been utilized. For example, Google Flu Trends (GFT) was tracking health-related search engine queries in order to monitor, in real-time, influenza activity [13]. However, it is important to note that GFT was discontinued due to concerns regarding data inaccuracy [14]. The flaw in GFT highlights a commonplace issue in big data analysis (and any data analysis), overfitting of data to a small number of cases. The failure of GFT emphasizes the utilization of other real-time health data for predicting trends in infectious diseases [14]. A more critical evaluation of the uses of IoT in surveillance must be addressed, as well as a deeper look into the privacy concerns that its use brings. In addition to web-based tools for surveillance, event-based IoT tracking collects and sends raw data from a multitude of informal sources (news articles, social media posts, internet queries) in an attempt to detect events with potential epidemic spread faster than traditional more conservative methods [9] This has led to advances in infectious disease modeling and pathogen discovery and diagnostics (rapid molecular identification of pathogens) [9].

Mobile computing in the form of mobile health (m-health) can also increase the efficiency of a healthcare system by involving various services, applications, third party APIs, and mobile sensors not otherwise used for health-related purposes [15]. Safety and Health Monitoring Applications such as wearable IoT enables real-time health monitoring and would be beneficial for improving global health.

These technologies could reduce gaps in monitoring systems that exist due to a sheer incapacity to monitor such large geographical areas or populations [8,16]. A data mining module, which is machine learning-based approaches such as the support vector machine (SVM) is also fundamental for detection, forecasting, and diagnosis of potential diseases [8]. These approaches have been applied in the fields of computer science and medical diagnoses but are relatively novel within the field of infectious disease epidemiology [17].

Considering the present global situation, IoT based smart disease surveillance systems have the potential to be a major breakthrough in efforts to control the current pandemic. With much of the infrastructure itself in place already (i.e. smartphones, wearable technologies, internet access) the role this technology can have in limiting the spread of the epidemic involves only the collection and analysis of data already gathered. The combined role of IoT and related new technologies might shape early recognition of outbreaks and prevent the spread of zoonotic infectious diseases including the COVID-19, if potential steps are taken to enhance and utilize the data. Smart disease surveillance systems based on IoT would provide simultaneous reporting and monitoring, end-to-end connectivity and affordability, data assortment and analysis, tracking and alerts, as well as options for remote medical assistance to be adopted, to detect and control zoonotic infectious disease outbreaks in China and other affected countries. More research must be carried out for the development of automated and effective alert systems to provide early and timely detection of outbreaks of such diseases in order to reduce morbidity, mortality and prevent global spread. These prompt and effective public health measures need to be taken to avoid the risk of continuing outbreaks and the possibility of a local outbreaks turning into a global pandemic such as this one.

Author Statements

Funding

None.

Competing interests

None declared.

Ethical approval

Not required.

CRediT authorship contribution statement

Md. Siddikur Rahman: Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Noah C. Peeri:** Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Nistha Shrestha:** Conceptualization, Data curation, Formal analysis. **Rafdzah Zaki:** Conceptualization, Data curation, Formal analysis. **Ubydul Haque:** Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Siti Hafizah Ab Hamid:** Conceptualization, Data curation, Formal analysis.

References

[1] Lauren Gardner. Mapping the Wuhan Coronavirus (2019-nCoV). 2020. https://systems.jhu.edu/ (accessed 24 January, 2020).

[2] World Health Organization (WHO). Novel Coronavirus (2019-nCoV) situation reports. 2020. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports.

[3] World Health Organization (WHO). Novel Coronavirus 2019. 2020. https://www.who.int/emergencies/diseases/novel-coronavirus-2019.

[4] WORLd Health Organization (WHO). Coronavirus. 2020. https://www.who.int/health-topics/coronavirus.

[5] Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet 2020.

[6] Bloomberg News. China locks down 40 million people as anger grows over virus. 2020. https://www.bloomberg.com/news/articles/2020-01-23/china-expands-travel-limits-who-says-virus-remains-local-crisis (accessed 26 January 2020).

[7] Chris Buckley and Javier C. Hernández. China Expands virus lockdown, encircling 35 million. 2020. https://www.nytimes.com/2020/01/23/world/asia/china-coronavirus-outbreak.html (accessed 26 January 2020).

[8] Wan J, Al-awlaqi MA, Li M, et al. Wearable IoT enabled real-time health monitoring system. EURASIP J Wirel Commun Netw 2018;2018(1):298.

[9] Christaki E. New technologies in predicting, preventing and controlling emerging infectious diseases. Virulence 2015;6(6):558–65.

[10] Floridi L. Soft ethics, the governance of the digital and the general data protection regulation. Philos Trans A Math Phys Eng Sci 2018;376(2133).

[11] Kotz D, Fu K, Gunter C, Rubin A. Security for mobile and cloud frontiers in healthcare. Commun ACM 2015;58(8):21–3.

[12] Castiglione A, DAmbrosio C, De Santis A, Castiglione A, Palmieri F. On secure data management in health-care environment. In: 2013 seventh international conference on innovative mobile and internet services in ubiquitous computing; 2013. IEEE; 2013. p. 666–71.

[13] Christaki E. New technologies in predicting, preventing and controlling emerging infectious diseases. Virulence 2015;6(6):558–65.

[14] Lazer D, Kennedy R, King G, Vespignani A. Big data. The parable of Google Flu: traps in big data analysis. Science 2014;343(6176):1203–5.

[15] Nazir S, Ali Y, Ullah N, García-Magariño I. Internet of Things for healthcare using effects of mobile computing: a systematic literature review. Wirel Commun Mob Comput 2019;2019.

[16] Wu F, Wu T, Yuce MR. An internet-of-things (IoT) network system for connected safety and health monitoring applications. Sensors 2019;19(1):21.

[17] Hammad TA, Abdel-Wahab MF, DeClaris N, El-Sahly A, El-Kady N, Strickland GT. Comparative evaluation of the use of artificial neural networks for modelling the epidemiology of schistosomiasis mansoni. Trans R Soc Trop Med Hyg 1996;90(4):372–6.