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Role of artificial intelligence-internet of things (AI-IoT) based emerging technologies in the public health response to infectious diseases in Bangladesh

Md. Siddikur Rahman [a,*], Nujhat Tabassum Safa [b], Sahara Sultana [c], Samira Salam [b], Ajlina Karamehic-Muratovic [d], Hans J. Overgaard [e,f,**]

[a] Department of Statistics, Begum Rokeya University, Rangpur 5404, Bangladesh
[b] Department of Statistics, Jahangirnagar University, Bangladesh
[c] Institute of Information Technology, Jahangirnagar University, Bangladesh
[d] Department of Sociology and Anthropology, College of Arts and Sciences, Saint Louis University, United States
[e] Department of Microbiology, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand
[f] Faculty of Science and Technology, Norwegian University of Life Sciences, P.O. Box 5003, 1430 Ås, Norway

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ABSTRACT

Digital technologies are the need of today to predict, prevent and control emerging infectious diseases. Bangladesh is one of the world's poorest and most densely populated countries and faces a double burden of two deadly diseases, COVID-19 and dengue. In response to both these diseases, the absence of a digital healthcare system and insufficient preparedness, lack of public awareness pose unique challenges and a large threat to the population, resulting in epidemics of escalating severity. This paper suggests a digital health care and surveillance system based on the internet of things (IoT) and artificial intelligence (AI) for timely identification of COVID-19 and dengue cases and improving the prevention and control strategies in the country.

1. Introduction

A wealth of new digital technologies through the integration of the internet of things (IoT) and artificial intelligence (AI) is becoming more popular than conventional healthcare in monitoring, predicting and preventing emerging infectious diseases (Christaki, 2015; Memos et al., 2021; Rahman et al., 2020a; Rahman et al., 2022). Using these digital technologies, surveillance of emerging infectious diseases is vital to facilitate risk assessment and timely outbreak detection of public health threats (Christaki, 2015). This paper looks at how emerging technologies such as the IoT and AI-based systems are advancing health care and paving the way to combat infectious diseases. This study aims to discover the IoT and AI technologies and applications available for health monitoring during infectious disease outbreaks. Possible technologies, processes, and tools for pre-screening, early detection, monitoring infected/quarantined individuals, and forecasting future infection rates are discussed. We also look at the research possibilities that have arisen due to the use of emerging technology to handle emerging infectious diseases. (See Fig. 1.)

* Corresponding author at: Department of Statistics, Begum Rokeya University, Rangpur 5404, Bangladesh
** Corresponding author at: Department of Microbiology, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand; Faculty of Science and Technology, Norwegian University of Life Sciences, P.O. Box 5003, 1430 Ås, Norway.
E-mail addresses: siddikur@brur.ac.bd (Md.S. Rahman), hans.overgaard@nmbu.no (H.J. Overgaard).

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Bangladesh is vulnerable to both COVID-19 and dengue epidemics. There is an urgent need to improve COVID-19 and dengue prevention and control strategies in Bangladesh. This study uses COVID-19 and dengue, two highly relevant diseases for Bangladesh and other Asian countries, as models to illustrate how these new digital technologies can improve prevention and control strategies. Such digital technologies can offer accuracy and speed in detecting and treating different infectious diseases that cause the human population to suffer in Bangladesh and other endemic countries (Memos et al., 2021).

2. Health crisis in epidemics

2.1. Covid-19

The novel coronavirus disease (COVID-19) is a new global public health challenge and a major epidemiological threat (Yang and Wang, 2020). The World Health Organization (WHO) on January 30, 2020, named the COVID-19 outbreak a Public Health Emergency of International Concern (PHEIC) (Organization WH, 2020a) and declared it a global pandemic on March 11, 2020 (Cucinotta and Vanelli, 2020; Organization WH, 2020b). Currently, the world is facing a dramatic rise in incidence and mortality due to COVID-19. As of December 08, 2021, there have been more than 267 million confirmed cases of COVID-19 including 5.27 million deaths reported worldwide (WHO, 2020a). The first COVID-19 case was identified on March 7, 2020 by the Institute of Epidemiology, Disease Control, and Research (IEDCR), an epidemiological and communicable disease research institute in Bangladesh (IEDCR, 2020). The number of infected cases began to rise on March 9, 2020 (IEDCR, 2020), and as of December 08, 2021, there were more than 1.5 million infected cases and 28,010 deaths reported in Bangladesh (IEDCR, 2020). Globally, Bangladesh ranks 10th and in Asia 4th in terms of daily increase in COVID-19 cases (Abdullah, 2020). Mass registration for COVID-19 vaccination has been implemented across the country to control the epidemic. Coronavirus has now spread to every district of the country (IEDCR, 2021).

2.2. Dengue

The threat of dengue, a mosquito-borne viral disease, continuing to loom on the horizon (Zahid, 2020). In 2021, as of December 08, 2021, 27,779 dengue cases had been admitted to hospitals and 100 deaths were recorded across the country (Molla, 2020). Dengue epidemics are not new in Bangladesh and have been a concern since the first outbreak was reported in 2000 (Mamun et al., 2019). The number of hospitalized dengue cases were between 3000 and 7000 during 2002 and 2018 (Mamun et al., 2019). This number of cases increased to 101,354 in 2019 (Directorate General of Health Services, 2019), surpassing all the previous annual records of dengue outbreaks in the nation. According to 2021 estimates, dengue infection is again rising in Bangladesh (IEDCR, 2020; Molla, 2020; WHO, 2020b).

The high rates of COVID-19 and dengue in Bangladesh raise the threat of a simultaneous outbreaks of both diseases. While this threat has not yet been investigated scientifically, instances of both diseases co-occurring by anecdotal evidence have already been

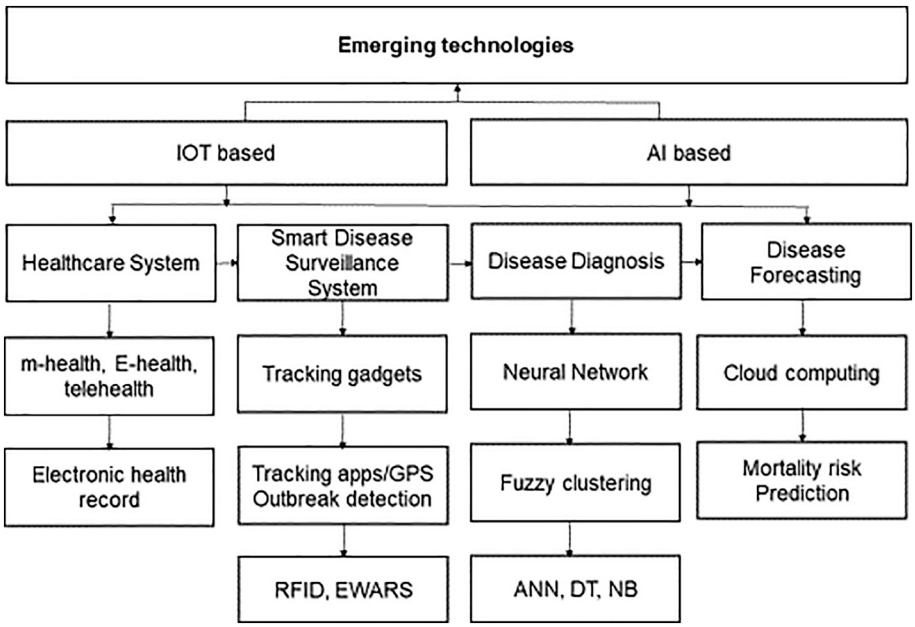

Fig. 1. Internet of things (IoT) and artificial intelligence (AI) based emerging technologies to defend against infectious diseases including COVID-19 and dengue. GPS: Global positioning system; RFID: Radio frequency identification; EWARS: Early warning and response system; ANN: Artificial neural network; DT: Decision tree; NB: Naive Bayes.

documented in Bangladesh (Ahmed and Tazmeem, 2021). Co-infection and co-occurrence of Covid-19 and dengue have introduced a significant burden on healthcare systems in dengue-endemic regions, particularly in developing countries in Asia (Harapan et al., 2021). Continuing the battle against the COVID-19 and coping with dengue will likely pose a dual challenge to the health authorities, triggering yet another health crisis such as the complexity of diverse disease severities, prolonged infectious periods, and shared clinical manifestations and pathogenesis have made their diagnosis, treatment, and resource allocation challenging (Harapan et al., 2021; Zahid, 2020).

COVID-19 is a severe respiratory illness caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) (Tsheten et al., 2021). COVID-19 is characterized mainly by fever and cough (Tsheten et al., 2021). Dengue is the most common arboviral infection affecting humans, and it presents with a wide range of signs and symptoms, including fever, headache, arthromyalgia, retro-orbital pain, and rash. The COVID-19 pandemic in dengue-endemic countries like Bangladesh is a public health concern because of these diseases' overlapping clinical and laboratory features. This causes challenges in the correct diagnosis and management of both diseases (Tsheten et al., 2021). Despite similarities in signs and symptoms (like fever, headache, and body pain), and laboratory characteristics (like thrombocytopenia and leukopenia) of these two diseases, the management of these diseases are entirely different (Tsheten et al., 2021).

Particularly evident in South Asian countries, COVID-19 has exposed glaring gaps in sufficient public health preparedness and adequate robust infectious disease epidemic surveillance, prevention and control systems (Bhutta et al., 2020). With its 168 million inhabitants, Bangladesh is one of the world's poorest and most densely populated countries (Vince, 2020). In response to COVID-19 and dengue, the struggling healthcare system and insufficient preparedness, including inadequate public health infrastructure, lack of digital health systems and emerging technologies, lack of public awareness, pose unique challenges and a large threat to the population, resulting in potential epidemics of escalating severity (Banik et al., 2020; Hsan et al., 2019). While the simultaneous transmission of COVID-19 and dengue is a pressing issue for Bangladesh, digital health interventions should be prioritized for addressing this issue in the Bangladeshi context. Digital health ecosystems and applications will deliver an additional dimension to support national health services.

2.3. Role of internet of things (IoT) and artificial intelligence (AI) in health care

Two main driving technologies IoT and AI, pioneering automation and digitalization of healthcare enable smart healthcare solutions to sustain and improve health services (Raza et al., 2021). For instance, early in the outbreak of COVID-19, when China responded to the virus, it relied on AI for facial recognition to monitor infected patients with a travel history, robots to deliver food and medication, drones to disinfect public places, patrol and transmit audio messages to the public to persuade them to stay at home (Kumar et al., 2020; Ruiz Estrada MAJAaS, 2020). Countries like Taiwan have incorporated data from the immigration and customs agencies into the national health insurance program, thereby addressing COVID-19 patients based on their travel history and symptoms (Wang et al., 2020). Screening of population, medical support, warning and suggestions about managing infections for both dengue and COVID-19 viruses can be done using AI technology (Haleem et al., 2020; Rahman et al., 2020b; Vaishya et al., 2020a; Vaishya et al., 2020b). This technology can monitor and forecast the disease outbreaks from the available data, social media, and media outlets about the infection risk and its possible spread. In addition, AI based technology helps to identify the most vulnerable regions, communities and countries and take effective steps (Vaishya et al., 2020b). For dengue monitoring, a mobile application based on global positioning system (GPS) can be enabled by AI technology (Reddy et al., 2015). The early warning and response system (EWARS) toolkit can also be useful for efficient and cost-effective local responses for management of dengue fever, chikungunya and Zika outbreaks (Hussain-Alkhateeb et al., 2018a; Organization WH and UNICEF, 2020).

Internet of things (IoT) is an advanced technology which is used for biometric tests such as blood pressure, heart rate, and level of glucose (Mohammed et al., 2020; Singh et al., 2020; Vaishya et al., 2020b). IOT based health care system using mobile computing can access necessary information from users easily as smartphones are widely available nowadays (Nazir et al., 2019; Ye, 2020). Home hospitalization systems based on IoT, Fog computing, and Cloud computing are the most important technologies that have contributed to the development of the healthcare sector in a significant way (Hassen et al., 2020). Since there is no effective tool for directly monitoring or detecting *Aedes* mosquitoes that transmit arboviruses, IoT supported fog safety monitoring system can be used to monitor *Aedes* mosquito outbreaks in vulnerable regions and help government agencies for dengue prevention and control (Sood and IJCII, 2017).

2.4. Healthcare system

Healthcare solutions using smartphones or utilization of emerging health technologies and digital practices in health care, such as AI, telemedicine or telehealth, mobile health, e-health, electronic health records are powerful tools to fight against pandemic-prone infectious diseases, including COVID-19 and dengue (Ye, 2020). Electronic medical records (EMR) was successfully implemented during the COVID-19 pandemic for tracking suspect or confirmed COVID-19 cases (Pryor et al., 2020).

2.5. Smart disease surveillance system

Sign-tracking gadgets - most commonly used AI-based tracking apps such as bracelets and rings, can be used to trace infected persons. Different tracking apps (corona tracer bd, corona identifier, etc.) and GPS can be generated to identify COVID-19 and dengue patients to detect outbreaks and effective control measures. Radio frequency identification (RFID) can be used to identify a tagged

patient by browsing an internet address or database entry (Mathew et al., 2015). Emerging technologies using IoT and AI significantly strengthen capacities for disease and vector surveillance, monitoring the environmental and social risks of COVID-19 and dengue. The frequency-based detection of primary dengue vector female *Aedes* mosquitoes using surface acoustic wave technology is also useful to exterminate *Aedes* mosquitoes as soon as discovered, and to evacuate the location until it be treated (Salim et al., 2017).

2.6. Disease diagnosis

Classifying individuals at higher risk for COVID-19 and dengue using neural network and fuzzy clustering methods can be a great step for the progressive diagnosis sector. Three prevalent machine learning methodologies, including, Artificial Neural Network (ANN), Decision Tree (D.T.), and Naive Bayes (N.B.) are being evaluated for designing a diagnostic model for early detection of dengue cases and utilizing available dengue datasets (Gambhir et al., 2018).

2.7. Disease forecasting

The application of IoT and AI-based emerging technologies can be used for the probability of infecting, identify the trends of viral diseases including COVID-19 and dengue by predicting the nature of the particular disease and hence minimize the harm caused by the outbreak. The developed IoT and AI based monitoring system help in tracking the infected persons from the previous data and makes them get isolate from the non-infected person. The implementation of these technologies in the pandemic situation in healthcare application has proved its performance in tracking and prevents the spreading of pandemic disease. (Sitharthan and Rajesh, 2021). The early warning and response system (EWARS) is also a useful toolkit that uses outbreak and alarm indicators to derive prediction models that can be used prospectively to predict a forthcoming dengue outbreak at district level (Hussain-Alkhateeb et al., 2018b; Rahman et al., 2021a). Forecasting weather via cloud computing framework is used to find out the early warning of dengue outbreaks and disinfect public places via drone to create precaution and social awareness among the public.

3. Conclusion

The increasing incidence of COVID-19 and dengue in Bangladesh highlights the importance of employing digital health policy through the integration of IoT and AI-based emerging technologies, health behaviors and attitudes about predicting, preventing and controlling both infectious diseases. There is an urgent need to improve prevention and control strategies in Bangladesh. Besides that, AI or IoT based emerging technologies can help collect necessary data and predict future situations, making it easy for health ministry to take any effective decision to control the situation. Effective research must be initiated using IoT and AI-based technologies to detect outbreaks of viral diseases to reduce morbidity mortality and prevent global spread. Currently, there are no effective vaccines or cures for COVID-19 and dengue (WHO, 2020c), but positive individual and collective actions can also minimize the transmission of viral diseases and potentially save lives (Andersen et al., 2020; Rahman et al., 2020b; Rahman et al., 2021b; Rahman et al., 2021c). Targeted campaigns by public health authorities through various media can play a crucial role in preventing and controlling COVID-19 and dengue infection. Multi and interdisciplinary teams of scientists who can address public health, economic, historical, legal, medical, political, and social implications of COVID-19 and dengue should be advocated for. Likewise, community participation in preventing and controlling the spread of diseases is encouraged to incorporate social mobilization and behavior change at the community level. Diagnostic laboratory systems and services and training of partners and clinicians in Bangladesh are also necessary to control these deadly diseases. Several priorities will need to be addressed to scale up digital health in Bangladesh, such as strengthening governance and regulation of technologies, including data privacy and security, and accreditation of different health apps (Khan et al., 2019). Finally, the continued investment will be needed to support the capacity to maintain, develop, promote, and expand the use of emerging digital technologies and sustain the coordination of health partners and programmes towards an integrated system for tackling COVID-19 and dengue.

Author's contributions.

MSR conceived the idea, wrote the literature review and drafted the first version of the paper. All authors read, contributed and approved the paper.

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Ethics approval and consent to participate

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Consent for publication

Not applicable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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