COVID-19 PANDEMIC: PROBLEMS AND PROSPECTS IN ADVANCING BIOMEDICAL ELECTRONICS AND INFORMATICS

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Abstract

The world is facing an unprecedented economic, social and political crisis with the spread of COVID-19. However, the global advancements made in Biomedical Electronics and Informatics (BMEI), have brought about a better understanding of the human genome and unraveled new perspectives in the study and containment of novel and complex diseases like the dreaded Corona Virus Disease (COVID-19). Yet, the rapid global spread and havoc wrecked by the advent of Covid-19 expose how grossly under-utilized, these advancements have remained in many parts of the world. This paper depicts the COVID-19 pandemic in the light of the consternation and prospects it portents for Advancing Biomedical Electronics and Informatics (BMEI) in particular and Information and Communication Technology (ICT) in general. The data for the study was collected and collated through online content review and surveys starting with a preliminary set of electronic resources. This qualitative research approach adopted for the study not only explores the prominence of ICT interventions in combating the spread of the COVID-19 pandemic but also highlights the inherent challenges and prospects it portents for the advancement of Biomedical Electronics and Informatics (BMEI). The implication is the growing need to efficiently integrate and translate the advances made in information and communication technologies (ICT) and electronic technologies with the increased knowledge about the human genome into concrete benefits for all citizens for effective repression of the pandemic spread of not only COVID-19, but also in dealing with other imminent pandemics and for future potential research endeavours and healthcare technological development.

Keywords: Covid-19, Biomedical Electronics and Informatics (BMEI), Coronavirus, pandemic, information and communication technology (ICT).

Introduction

Advances in technology have revealed enormous capacities to deliver effective remote management of pandemics thereby protecting caregivers, medical personnel and the general public from contracting a myriad of diseases. The global shock brought about by the advent of Covid- 19 brings to the fore the exigent necessity to strengthen and exploit the inherent potentials of interdisciplinary synergy.

Biomedical Electronics and Informatics (BMEI) is a web of multidisciplinary and interdisciplinary fields that effectively integrates Information and Communication Technology (ICT), medical informatics, bioelectronics, bioinformatics and neuro-informatics to provide a framework for developing, integrating and sharing biomedical knowledge related to human health from very different research disciplines such as electronics, information and telecommunication technologies, genomics, proteomics, clinical research and

epidemiology. The ultimate objectives of BMEI are to support molecular medicine and personalized healthcare (Zobel, 2005).

Thus, BMEI lies at the crossroads with life sciences and the challenge for the future activities of the world to create favourable environments for such multidisciplinary research products to accelerate the harvesting of societal and economic benefits. BMEI deals not only with the integration of ICT in health related data on different levels (molecular, cellular, tissue, organ, person and population) but also with computationally demanding tasks of data mining, modelling, simulation and visualization. New in-silico modelling and simulation has the potential to accelerate new drug design and development, improve understanding of underlying biological processes, support predictive medicine as well as provide novel tools for training and surgery planning. (Zobel, 2005).

Accordingly, effective BMEI utilization would necessarily involve value addition to the data that is stored in huge, publicly accessible research databases around the world generated by functional genomics and proteomics research by linking it with patient's clinical and genetic information that is stored in mostly smaller and secured clinical information databases and electronic health records.

This paper highlights the interventions of BMEI systems in the effort to curb the spread of COVID-19 and also brings to the fore the trepidations and prospects in Biomedical Electronics and Informatics Advances. The endeavour is to spur deliberate affirmative action toward maximizing the enormous potentials that abound in BMEI systems.

Materials and Methods

From a methodological perspective, this study paper follows an online review (Kozinet, 2020) and survey where in the study data for this paper was collected and collated through online content review and appraisals starting with a preliminary set of electronic resources. This qualitative research approach adopted for the study was necessary since there is no academic literature available in the focused area and likewise, that the topic in many ramifications is quite novel and emerging.

The objective of the online content review was to explore the existing ICT vis-à-vis BMEI interventions around the world to fight against the COVID-19 pandemic. Yahoo search and Google search engines were used to find the related online content. The search strings used to find the available online content include "Biomedical informatics systems" "information and communication technology and digital services and Coronavirus", "ICT intervention and COVID-19", "ICT intervention and Coronavirus", "information technology and COVID-19", "information and communication technology and digital services and COVID-19", "electronic health services and mobile applications and Coronavirus", "electronic health services and mobile applications and COVID-19", "artificial intelligence and COVID-19 and Coronavirus", "big data and data science and Coronavirus and COVID-19","robotic and wearable technology and COVID-19", and "robotic and wearable technology and Coronavirus."

The search results produced more than 200 sites of content. The exclusion criteria included: (a) online content that discussed the same topic, especially the news articles that focus on the same digital/ICT interventions but published in multiple newspapers; (b) online contents that are not focused on our research objectives; and (c) the contents written in other languages rather than the English language. After applying this inclusion – exclusion process, 37 online resources that include electronic news articles, online press --releases, websites/web contents of different organizations, and the article written as a blog were finally selected.

Finally, the selected articles were reviewed systematically to extract data primarily related

to the BMEI technology or digital solution used in the pandemic spread of COVID-19; and the purpose of using such digital technologies in COVID-19 pandemic. The extracted data were synthesized and analyzed to explore the subject matter and consequently, the outcomes of the review study were analyzed to attain the trepidations and prospects in Biomedical Electronics and Informatics Advance.

This approach not only showcases the growing prominence of BMEI interventions in combating the spread of the COVID-19 pandemic but also highlights the inherent challenges and prospects it portents for the advancement of this novel interdisciplinary field of science and technology. The objective is to project and foster the growing need for this synergy that efficiently integrate and translate the advances made in information and communication technologies (ICT) and electronic technologies with the increased knowledge about the human genome into concrete benefits for all citizens for effective repression of the pandemic spread of COVID-19 and imminent pandemics and also for future potential research endeavours and healthcare technological development.

Results

The 80% of the on-line literature sieved and sampled for this paper cumulatively point to the increase in use, significance and prominence of BMEI as a result of the outbreak and spread of COVID-19. Two out of every five sources selected and consulted highlighted the critical roles played by ICT vis-a-vis BMEI systems to contain the spread of Covid-19 alluding that BMEI stands out as a veritable solution to confronting the outbreak dreadful pandemics.

The research provides an in-depth view of BMEI interventions by providing (a) the type of BMEI solutions that are deployed during the COVID-19 pandemic (b) the way BMEI is being used to provide the health services (c) the types of services or supports that are received from digital innovations (d) explore the concerns and opportunities of BMEI interventions to combat with COVID-19 pandemic and to mitigate future pandemics. Thus, the outcomes of this research will greatly contribute to the practitioners, government, policymakers, doctors and individuals to be aware of the ICT tools and their roles during pandemic situations. The government of developing or infected countries may take the necessary initiative to develop an affordable useful ICT-based system to provide health service and aware people to reduce the pandemic spread of COVID-19.

Furthermore, the outcome of this research would contribute as an eye opener to researchers, practitioners and government to take necessary advance initiatives to deploy and develop such digital interventions to combat the pandemic spread of novel diseases.

BMEI Systems Interventions on COVID-19 Pandemic

As Covid-19 continues to spread globally, studies and surveys reveal that sweeping measures have been adopted to curb the pandemic. In many other countries, closure of public places of worship, institutions of learning, entertainment spots and borders; prohibition of mass gatherings, travel bans, curfews, mandatory quarantines, have been imposed on the populace (Okereafor, 2020).

At the centre of these measures, the adoption BMEI intervention has been cardinal in the drive for the containment of the pandemic spread of COVID-19 around the globe. Figure 1 presented a contiguous representation of the key BMEI-based technologies along with three examples (for each technology). Wherein it is shown that websites and dashboards, mobile applications, robotics and drones, artificial intelligence (AI) or machine learning (ML), data analytic, wearable or sensor technology, social media and learning tools and interactive voice response (IVR) are primarily used around the world as ICT intervention to combat the pandemic spread of

COVID-19 and to provide health services during this vulnerable period (CIPESA, 2020)

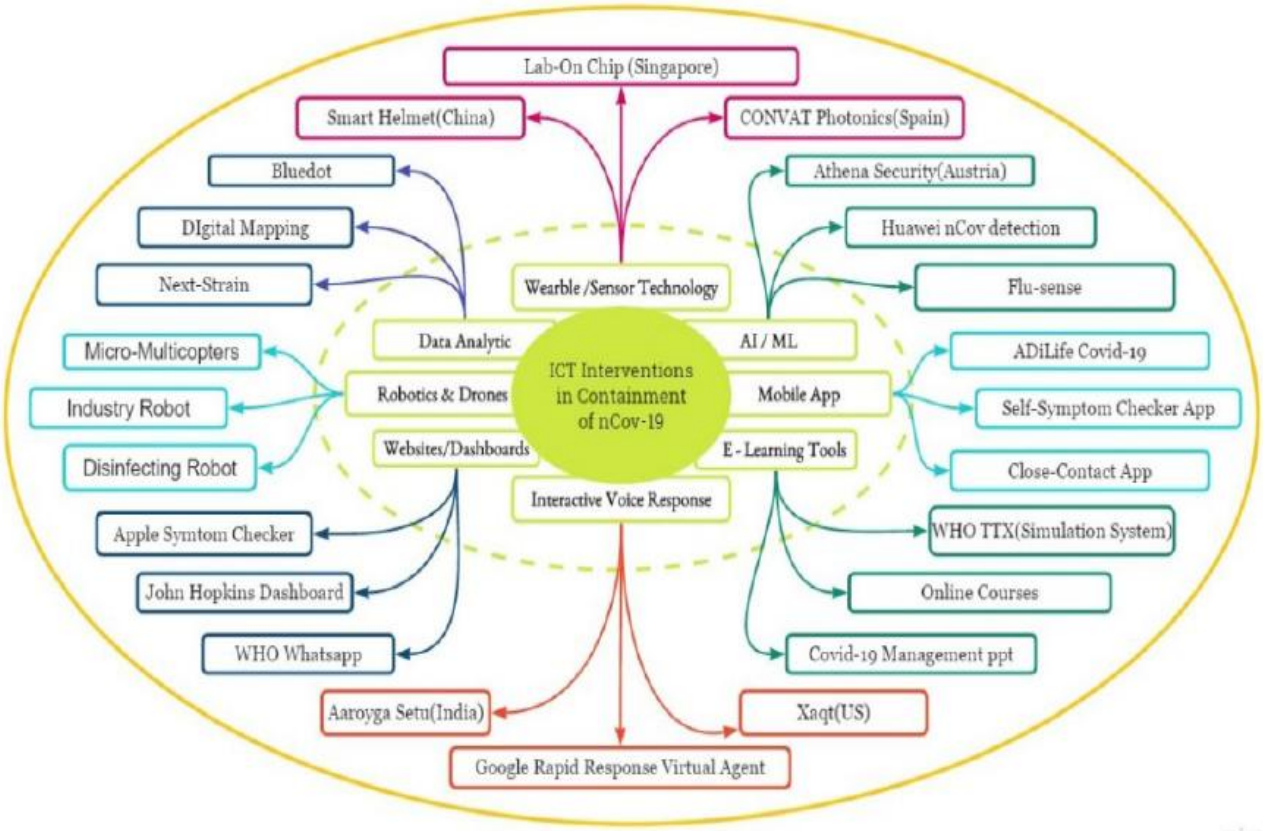

Figure 1: BMEI-Based Technologies used in combating Covid-*19* (Zaman, Muhammad, Zaki, & Hossain, 2020)

Websites and Dashboards - Most countries have created websites, dashboards, and national portals to fight within a local sphere mainly to provide updated Corona statistics, preventive and controlling information, government and medical declarations, awareness and mental health related information, emergency contact information, hospital map, and facilitate for self-assessment and symptom reporting for the risk of COVID-19. For example, WHO collaborated with WhatsApp (WHO, 2020)and CDC collaborated with Apple Symptom Checker (APPLE, 2020)are striving to raise awareness and provide updated statistics of COVID-19. A dashboard developed and maintained by John Hopkins University (Engineering, 2020) has used data visualization technique to provide the latest scenario of the pandemic.

Mobile Application - A number of mobile applications are being developed almost in every Corona affected country around the world. The main purpose of using mobile applications includes providing treatment information or services, remote monitoring and assistance to Corona infected patients, provide updated statistics on COVID-19, making people aware about Coronavirus, providing communication service including live video chatting and emergency calls, assisting to improve self-confidence and mental health during the pandemic situation, and providing preventative and controlling information. For example, ADiLife COVID-19 (ADLife, 2020), Health Lynked COVID-19 Tracker (33), COVID Live Tracker - Corona Virus Pocket Guide (Tower, 2020)are providing remote assistance, health awareness and updated statistics about the spread of

COVID-19. Again, China-based apps like "Close contact" (Jakhar, 2020)and "Ali pay Health Code" (Jakhar, 2020) are using data analytic to provide colour codes to every citizen which is actively helping to maintain the social distance and monitor public health.
Various governments have been quick to encourage mobile money use for local transactions and payment for goods and services in lieu of cash, to stem the contagion. In response, mobile network operators have increased daily limits and waived fees on nominal transfers via mobile money. Effective March 17, for 90 days, Kenya's Safaricom increased the daily transaction limit via M-Pesa from Kenya Shillings (KES) 140,000 to KES 300,000 (USD 1,400 to USD 3,000) and waived fees off peer-to-peer transfers up to USD 10. Airtel and MTN have done the same in their major markets including Cameroon, Ghana, Rwanda, Sudan, South Africa, Uganda and Zambia.

Robots and Drones - Several kinds of robots and drones like disinfecting robot, agricultural robot, virtual human, micro-multicopter and industry robot are being used in several countries for multiple purposes that include transporting medical supplies, disinfection process, detection of symptoms, patient monitoring and in few cases providing physical medical support (Jakhar, 2020).

Artificial Intelligence - Artificial Intelligence (AI) is playing numerous roles to limit human interaction and involvement to fight against the COVID-19 pandemic (Mazhukhina, 2020) and also in supporting researchers and healthcare professionals in the diagnosis and screening of patients with severe symptoms, as well as developing appropriate responses based on a thorough analysis of the situation on the COVID-19 spread.

In addition, the famous "Walk-Thru" testing station allows quick collection of samples as subjects walk through the station with minimal contact. Services like disease surveillance, early warnings and alerts, virtual healthcare assistance, diagnosis and prognosis, information verification over social media, controlling social distancing and measuring the lock-down, treatment and cures, processing and analyzing COVID-19 test samples, detecting and tracking individuals even when a person is wearing a face-mask and the likes are received from the AI-based technologies. For example, AI-based system Flu-sense (US) is using machine learning and edge computing to predict the timing of the disease that to be launched within a small scale in university clinics. Another similar project was launched in Austria as Athena-Security using thermal imaging and AI. On a similar note, Huawei has created AI based swift diagnosis tool (Mazhukhina, 2020) for COVID-19 patients and suspected cases.

Data Analytics- Big data, data analytic, predictive analytic or data science is used to provide the data dashboard as well as to track, predict, control, respond to, and combat the pandemic spread of COVID-19 (Naude, 2020). For example, a data analytic platform like Blue-dot (Bowles, 2020)is used to predict the upcoming epidemic using AI and data analysis. On a similar note, next-strain is an open dataset where the genome sequencing of the novel coronavirus was uploaded for data analysis purposes. Digital Mapping was also created in few countries using data mining. Like in Bangladesh, ICT Division and ROBI Axiata Ltd have developed data analytic based digital solutions that allow performing various innovative data visualization exercises to generate insights and as such, the Government can assess the probability of exposure in a given area to determine the next course of action (TheMedicalFuturist, 2020).

Wearable Technology - Wearable computing or sensor technology like Smart Helmet in

China (Jakhar, 2020)and portable lab-on-chip detection kit in Singapore (TheMedicalFuturist, 2020) are being used to detect COVID-19 cases in a mass crowd using thermal imaging, monitor and ensure quarantine of suspected patients, and measure/collect patient's health data remotely (Draper, 2020). In Spain, a scientist team named CONVAT (the Catalan Institute of Nano science and Nanotechnology) has built photonics (WHO, 2020) system with an ultra-sensitive laser sensor that detects Coronavirus at the earliest point of infection from saliva or nasal swab in minutes.

Social Media and Learning Tools - Social Media platforms like Facebook, Twitter, Instagram, and Telegram are playing a very effective role to raise awareness and spread preventive measures. Moreover, learning tools like simulation exercises and management presentation (WHO, 2020) are being provided globally to raise resistance against the pandemic. Consequently, technology has found its way in enabling learning to be accessed, without visiting a class, while keeping up with the curriculum. It has made education easily and readily available to millions of people, simultaneously, through e-learning. Through e-learning, you go through a seamless, formal education, once you have an electronic device, (desktop computer, laptop, iPad, or even, your smartphone), Internet connectivity, and electricity or other forms of current to power your device.

The Trepidation of Biomedical Electronics and Informatics Advances

Although BMEI interventions are rippled with numerous appealing opportunities for the ICT, health and technology allied industries Covid-19 has brought enormous strain on infrastructure networks, contractions in consumer spending, disruptions to supply chain, reduced availability of components, and in general, the all-around financial impact of the Coronavirus are taking its toll in all sectors of human endeavour. In this study, the major concerns to the use of BMEI Systems include;

The Trepidation of Privacy

The challenge of privacy is a major threat to the rapid impact of BMEI systems. The study revealed that while the flow of personal health information is very important to control pandemic outbreaks, the alleged threat of continuous online surveillance and proliferation of this data can be disastrous.

The Trepidation of High Infrastructure & Development Cost of BMEI Systems

The online survey conducted underlined the High Infrastructure & Development Cost of BMEI Systems, the consensus opinion is that in many cases, prevailing BMEI facilities are quite costly which makes it extremely difficult for less-developed and underdeveloped countries and the normal masses to afford the system. Thus, considering the cost-benefit ratio of the system, a user may stop using them which will lead to the collapse of BMEI based health systems. Thus, it is indeed a noteworthy threat, and thus a cost-effective with a lower cost-benefit ratio system is always desired (APPLE, 2020).

The Trepidation of inconsistent and unreliable data influx and variation

Investigation for this paper shows that inconsistent variation in the data and huge influx of data is creating confusion, and making it very difficult for general people to crosscheck the information and attain a success state from the utilization of BMEI Systems.

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Additionally, political and religious interference which has been termed as Vicious Social Obtrusion poises very imminent blockades to the free and rapid growth of BMEI Systems. In this vein, capturing authentic data may be hazardous due to the non-cooperative behaviour of such

organizations. It makes the control procedure of the pandemic slower and clumsy.

The Trepidation of Techno-phobia, illiteracy and Political Access Restrictions

The online survey conducted revealed that the effects of BMEI Systems have not been adequately felt amidst the devastation of Covid-19 as a result of digital illiteracy and the techno-phobia that pervades many parts of the world, particularly the under-developed and developing nations.

Some countries have put in place measures that undermine citizens' access to digital communications. These stringent measures creel the use of BMEI in combating the spread of the coronavirus. For instance, Cameroon has in the past initiated two internet shutdowns in the Anglophone region of the country, which together lasted 240 days. Ethiopia still maintains an internet blockade on the Oromia region, denying citizens access to critical information. Uganda's social media tax of USD 0.05 per day of access is an impediment to access to information for many citizens, notably lower-income groups. In most of Africa, internet access remains out of reach for many, with high taxation being a key driver of the high cost of access (CIPESA, 2020).

In a nutshell, Covid-19 has exposed a number of the serious trepidations for BMEI Systems inherent with short term retrenchment outlook and reduced investments in modern technologies as part of the survival instincts. However, the drive to prosperity will bring about the massive rebound of BMEI Systems.

Prospects of Biomedical Electronics and Informatics

COVID-19 pandemic has certainly not triggered the BMEI Industry but it has brought home the reality of the industry. Thus, amidst the current Covid-19 uncertain scenario, many BMEI technological areas continue to emerge and the prospects are ever-widening. Consequently, a number of viable opportunities to strengthen BMEI Systems intervention were found from the study survey.

With countries and organizations promoting working remotely, there is already an exponential rise in video calls/phone calls, as an increasing number of people are organizing meetings via apps or collaboration platforms. Digital media and Over the Top (OTT) content players are benefiting while Virtual Private Networks (VPNs), cybersecurity, and data security are other technologies that will see a surge as most workforces are operating remotely. Cloud services will grow, boosted by higher usage of content, gaming downloads, video conferencing, and the impact of remote access to corporate networks.

Digital workflows, robots, automation are no longer goals; they are requirements. IoT devices have offered organizations a path toward preserving revenue streams during this pandemic.

There will also be an increased focus on technologies like artificial intelligence, big data, augmented reality, and virtual reality, among others going forward. Equipment maker, Huawei, for example, recently posted a surge in its technological services comprising AI, video conferencing, and wireless network coverage across the Asia Pacific, given the on-ground communication challenges to ensure smooth connectivity (Okereafor, 2020).

Other areas that would get an uptick include e-learning, online education, and e-governance. As shoppers begin to self-isolate and avoid crowded areas, the clear winner is the e-commerce sector, with digital payment taking over a lot faster than the physical payment options.

The media industry (both traditional broadcasters and newer streaming platforms)

is playing a vital role during the pandemic in providing correct and responsible health information to the public with search engines and social media platforms. In terms of the morale of those isolated, access to the wealth of quality content available is important (Tower, 2020).

The current circumstances may also accelerate the adoption of 5G to meet the demands of bandwidth, performance, and network slicing. There will be more focus on the sufficiency of networks to carry the significantly increased traffic as working from home continues to ramp up. Social distancing and self-isolation mean that telecommunication has become an elevated essential service. It will be worthwhile to see how the Communications Service Providers (CSPs) both Mobile Network Operators (MNOs) and cable operators meet the challenge of their new critical role in the changing world.

While people are mostly using home WiFi, they would still use their mobile phones for voice communications, and this is the area that MNOs need to keep a close eye on. With video conference services (Skype, Zoom, and others) traffic is going through the roof right now. The dial-in option is an alternative if video conferencing platforms are overloaded (Bowles, 2020).

Also, with the need for social distancing, people are communicating more, which will drive additional voice traffic, whether it's on a legacy circuit-switched system or the 4G network with Voice over Long-Term Evolution (VoLTE) calls. The strain on voice services, though, will be helped to some extent by the convergence of WhatsApp, Messenger, Skype, Hangouts, and FaceTime calling within the iOS and Android ecosystems. Nevertheless, some CSPs is predicting significantly higher voice traffic growth against the regular year-on-year increase of only 5% (Draper, 2020).

With the potential congestion of fixed broadband service, there is a chance that devices will fall back on mobile networks, and this will cause a significant surge of mobile data traffic. Likewise, in areas where MNOs also provide home broadband connectivity, one would expect a significant increase in data traffic, and in some parts of the world where unlimited data isn't pervasive, an increase in subscriber costs (Kozinet, 2020).

The cable operators, on the other hand, will be more impacted than MNOs due to the increased activity at home – working from home and a greater demand for streaming services. Netflix and Google have already announced that they would be reducing video streaming quality in Europe for a month from high definition (HD) to standard definition (SD) to prevent network overload and collapse (Tower, 2020).

With significant changes in user behaviour, escalating use of telemedicine solutions for remote diagnosis, and the corresponding data traffic shifts, it will be increasingly important for CSPs, whether it's a mobile or cable operator, to keep vigilant and closely monitor their network.

The current crisis is an excellent accelerator of digitalization for both consumers and businesses. Even the most sceptical ones will be prepared to integrate the digital agenda in their organizations and will be in much favour of automating their operations. For many technology firms, data-driven automation will be a strategic focus beyond Robotic Process Automation (RPA). Businesses will need to leverage automation across multiple areas, including customers, employees and network. Marrying AI and analytics to the digital agenda will be vital to building resilience. AI can be an enabler of the digital transformation

covering multiple use-cases such as digital relationship management, adoption of digital channels, digital identity verification, digital onboarding and digital fraud prevention. With more traffic being directed to digital channels, AI-based automated solutions can help quickly detect friction points and their root causes in customer journeys and hence, timely intervention/ resolution to drive more sales and better customer experience.

Conclusion

COVID-19 has globally impacted all industries. Nevertheless, it has brought to the fore the impeccable importance of ICT in confronting dare challenges of society. The interdisciplinary synergy that gave birth to BMEI can be turned into a matchless opportunity for the present situation and for future health uprisings when the best and appropriate cutting-edge approaches are adopted and deployed. Concerted endeavours towards doubling internet speeds for home fibre packages at no extra cost to users for at least a month and the deployment of Google Loon to boost 4G network coverage in remote areas, promotional 'work from home' data bundles and a campaign to educate the public on the pandemic; and zero-rating information from the health ministry website and free text messaging services to 'keep public connected' are some of the many endeavours that are being mobilized towards a wider and more comprehensive adoption of BMEI in many countries of the world.

In retrospect, one thing that COVID-19 has done for BMEI is to create the massive awareness that in today's world, technology is now an extremely important aspect of our existence. It is, therefore, envisaged that post the pandemic, many nations would embrace and integrate impactful policies that will help deepen the adoption of technology, particularly home-grown ICT based solutions into all sectors of national endeavours.

Recommendations

As the situation on COVID-19 and newer pandemics may evolve, governments and telecom companies should refrain from arbitrarily shutting down the internet as a way of containing misinformation and false news, as this would violate citizens' right to express themselves and to access information, and the resulting information void would provide fertile ground for the virus to spread. Meanwhile, taxes on access to vital platforms such as social media should be scrapped to enhance citizens' access to information.

Precise Prediction System of Imminent Epidemic through considerable enhancement of domains like artificial intelligence and data analytic can be the prime opportunity in days to come. It is, therefore, needful to emphasize the importance of identifying underlined reasons of bio-hazard/epidemic with effective identification of harmful sectors which may lead to a pandemic likeCOVID-19.

Medical Robotic Process Automation (RPA) as an opportunity to look forward. RPA can emulate human execution of repetitive processes, saving time and costs and more importantly enabling healthcare professionals to treat patients and can play a very vital role in the containment of pandemics like COVID-19 and others.

Most of theCOVID-19 diagnosis techniques existing now is very sluggish in nature which is prolonging the phase of the pandemic. Thus, Swift Diagnosis Technology has been identified as a vital prospect to be explored in a similar situation like this in future.

Overall, the future for the BMEI industry is here, but only the savviest businesses will bring it to its full potential.

References

ADLife. (2020, April 2). *COVID 19.* Retrieved from https://www.adilife.net/en/covid19/.

APPLE. (2020, March 30). *Covid - 19 Screening Tool.* Retrieved from https://www.apple,com/covid-19

Bowles, J. D. (2020, June 20). *How Canadian AI BlueDot Spotted Corona Virus Before Anyone Had a Clue.* Retrieved from https:./ / diginomica.com/how-canadian-ai-start-bluedot-spotted-coronavirus-anyone-elsehad-clue.

CIPESA. (2020, March 27). *How Technology is Aiding the Covid-19 Fight in Africa.* Retrieved from https://twitter.com/cipesaug/status/1243085354405691393: https://twitter.com/cipesaug/status/1243085354405691393

Draper, S. (2020, March 10). *German Public Health Authority Launches Smart Watch App to Monitor Covid-19 Spread.* Retrieved from www.wearable-technologies.com/2020/04/ germanys-public-health-authority-launchessmartwatch-app-to-monitor-covid-19spread.

Engineering, C. f. (2020, March 30). *Covid - 19 Global Case Dashboard.* Retrieved from John Hopkins University: https://gistanddata.maps.arcgist.com/apps/oppsdashboards/index.html/bda7594740fd40299423467b48e9ec

Jakhar, P. (2020, March 20). *Corona Virus: China's Tech Fights Back.* Retrieved from https://www.bbc.com/net/news/technology 5171764.

Kozinet, R. V. (2020). *Netnography: Doing Ethnography Research On-Line.* Calfornia: Sage Publishers.

Mazhukhina, K. (2020, April 10). *How AI is Helping Scientists in the Fight Against COVID-19.* Retrieved from https://www.geekwire.com/2020/how - ai -is -helpng -scientists- in -the- fight - against- coviid-19/.

Naude, W. (2020). *Artificial Intelligence Against Covid-19.* Retrieved from https://www.towardsdatascience.com/artificial -intelligence- against -Covid-19/92a8360edaba.

Okereafor, K. A. (2020, March). *The Role of ICT in Curtailing the global Spread of the Coroma Virus Disease.* Retrieved from www.researchgate.net/publication/340038819: https://www.researchgate.net/publication/340038819

TheMedicalFuturist. (2020, April 10). *How Medical Health Technology can Help the Corona Outbreak.* Retrieved from https://www.medicalfuturist.com/how - medical-health-technology-can -help-the -coronaoutbreak/.

Tower, S. (2020). *COvid Life Tracker-Corona virus pocket guide* . Retrieved from https://sensortower.com/android/it/giamma-app-

WHO. (2020, April). *Corona Viirus.* Retrieved from https://www.who.int/healthtopics/coronavirus#tab¯tab 1.

WHO. (2020, March 20). *Coronavirus disease (COVID-19) training: Simulation exercise.* Retrieved from

https://www.who.int/emergencies/diseases/novel-coronavirus-2020/training/simulationexercise.

Zaman, A., Muhammad, N., Zaki, T., & Hossain, M. S. (2020, April 23). *The Pandemic Spread of Covid-19 - An Exploratory Study.*

Zobel, R. (2005, January). *Biomedical Infomatics: The Opportuniity and Challenge for Multidisciplinary Research.* Retrieved from www.ercim.org: https://www.ercim,org