Digital and Medical Technologies used for the Diagnosis and Treatment of Covid-19

Syed Sadaf Javid[1], Syed Sharafat U Nisa[2]

[1] UG – Biomedical Engineering, Hindusthan College of Engineering and Technology, Coimbatore, Tamil Nadu
[2] UG - Bachelor of Science, Sheikh-ul-Alam Memorial Degree College, Budgam, Jammu & Kashmir

ABSTRACT

- **Introduction:**

Corona disease (COVID-19) is a contagious disease caused by the SARS-CoV-2 (Severe Acute Respiratory Syndrome-2)– belonging from the family coronaviridae . This strain of coronavirus mainly originated in bats or pangolins and then transferred first to humans in Wuhan, a city in the Hubei province of China in December 2019.This outbreak hit more than 210 countries and territories all across the world which lead to prodigious dilemma in health, economic and educational fields worldwide. Groundbreaking solutions are crucially given to the instant requirement for the medical supplies, healthcare and treatments.

- **Aim:**

The main motive of this review is to encapsulate and enforce the evolving digital and medical technologies used for the diagnosis and treatment of Covid-19.

- **Results:**

The foundation of this review include the applications of digital and medical technologies viz, IoT(Internet of Things), IoMT(Internet of Medical Things), Drones for contactless delivery of medicines, GPS(Global Positioning System), Bluetooth, Telemedicine, UVs, use of artificial intelligence for the treatment ,enforcement of 3D-printing and ability and capacity of robotics.

- **Conclusion:**

The review concludes by focusing the requirement of emerging technologies in the healthcare and medical sectors.

Keywords-Covid-19, technologies, diagnosis, treatment, IoMT, Robots, Drones, Artificial Intelligence, Bluetooth & GPS, Telemedicine, 3D Printing

1. INTRODUCTION

Coronavirus strain (SARS-CoV-2) belonging to the large family of viruses called "Coronaviridae" causing the endemic disease known as coronavirus disease(covid-19).This pandemic disease was first spotted in the City of Wuhan in Hubei province, China in December 2019.It was found that the virus is most likely of zoonotic origin, i.e. it originated first from bats or pangolins. This outbreak struck more than 210 countries and territories all across the world and lead to anomalous crisis in the health, economic and educational sectors. Therefore, WHO laid stress upon the governments worldwide to guarantee the scrutiny and identification of infected individuals to control covid-19 pandemic effects. Various emerging technologies have been proposed to mitigate the impact of covid-19 outbreak. Latest technologies such as IoT & IoMT, drones, robots, Bluetooth, GPS, UVs, use of artificial intelligence, 3D Printing , telemedicine. Thus, technological solutions have proven to be of great help in controlling the spread of disease and facing challenges caused by it.

2. IoT & IoMT

IoT (Internet of Things) is the system of interconnected computing devices, that transmits data over a network without human interference. The common platform is given by the IoT for all the devices

to store their information and a common language for all the devices to interface with one another. From the daily functioning; smart home appliances, smart lighting controlled through smart phones.

IoMT (Internet of Medical Things) is the healthcare version of IoT, which can be implemented to provide aid to medical field. It is making its place in society at a fast pace and the various global healthcare organizations are already making use of it. It combines medical devices and appliances to convert the information technology systems of healthcare by using various networking technologies. Data collection is done with help of sensors integrated in various devices like drones, mobile phones, robots, patient monitors, self-examining covid-19 tests in order to analyse the biomedical signals and subsequently diagnose the diseases of patients without much human involvement. The data is collected through these methods and analysed by the cloud server. This analysis would enable the healthcare providers to respond to the covid-19 emergency.

IoMT would not only help to combat the current covid-19 crisis but also could prove helpful to prevent future outbreaks as well. It has wide range of applications; data transmission monitored by the wearables to the concerned healthcare providers, tracking orders for medications, remote monitoring of patients. It has proved extremely serviceable during an anomalous outbreak of the novel coronavirus also known as covid-19 which poses a major global challenge. As the treatments for the disease are still ongoing, the scientists are finding the efficient way for diagnosing and controlling the disease. Healthcare and medical systems are taking the advantage of IoT to achieve the goal.

In the current pandemic situation, the number of covid-19 cases are surging at an alarming rate, which requires the systematic monitoring and scrutiny for patient tracing. This IoT can play a beneficial role during the pandemic situation in contact tracing, tracking the crowds, tracking orders for medication, identification of infected individuals which is done mostly by using Infrared thermometers. This method does not seem much effective, as it is very difficult to cover all the people in the crowd and it has the close body proximity which can lead to spread of covid-19. The health officer examining the crowd with thermometer can get infected by anyone among them. Hence, the best alternative technology which overcomes these problems is IoT which seems favourable in this regard. Moreover, the various useful IoT technologies used for identification of patients are; Smart Thermometers are the medical thermometers which are linked to some mobile applications and can transmit their readings to be collected, stored and monitored .IoT buttons, which are battery operated can minimize the hospital acquired infections(HAI's).These IoT buttons function to signal quick alerts to the supervisors to make them aware about cleaning and hygiene related issues which can be a risk for the public safety.

Thus, IoMT platform has various advantages. It allows the patients to monitor the diseases easily and receive the medical requirements without spreading the disease to others. This platform is less expensive and proves efficient for monitoring of virus spread.
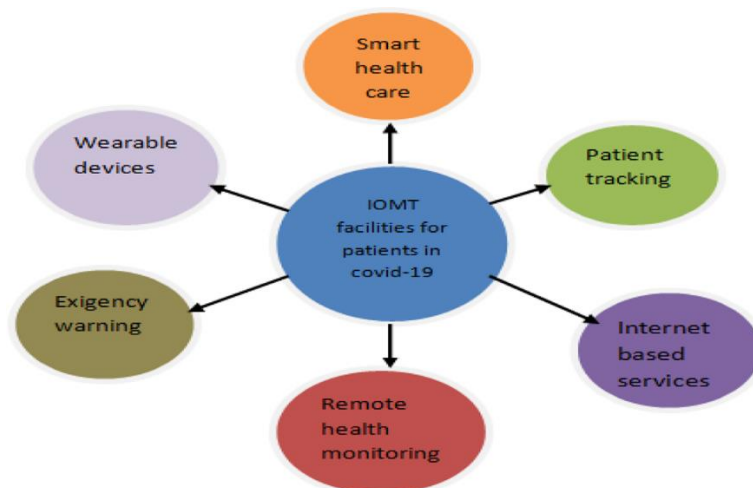
3. ROBOTICS

Robotics is an interdisciplinary field that design construction, operation and use of robots. Robots are most smart machines which proved helpful during covid-19 havoc. They can be utilized as frontline warriors to reduce the risk of infectious disease spread in medical units during pandemic. Robotics can be used to reduce both patient and health provider covid-19 risk. Moreover, ultraviolet (UV) disinfection method for disinfecting the areas from transmissible disease is easily achieved with robots. This method restricts the spread of disease through contaminated surfaces in the hospitals. The automatic disinfecting robots with less or no human interference are more preferred as compared to the manual decontamination methods such as cleaning workers.

Robotic surgery provides secure substitute in terms of covid-19 exposure for procedures compared to other methods like laparoscopy, open surgery etc. Robotics is widely used to perform various procedures and reduces the medical staff exposure from covid-19 infection. Robots can independently collect daily temperature measurements in the covid-19 patients and can independently perform nasopharyngeal swab testing. The use of robots for these purposes has reduced the staff contact with the covid-19 patients. Many countries in the world took benefit from robot technology for not only mitigating the spread of covid-19 disease but also for the sake of social and emotional well-being of patients in quarantine.

Robots are utilized during covid-19 pandemic for the distribution of medicines, medical equipment and to provide the food supply in medical units to avoid the proximity with patients directly. In India, Autonomous Robot, invented by Asimov Robotics in Kerela that can be used for the patients in isolation wards. This humanoid robot can also be used for serving food and medicines to the covid-19 patients that are quarantined. Robots incorporated with cameras are used to keep check of crowds, examining if social distancing is being followed or not. Robots act as the safe medium for disinfecting the medical units, equipment and the places prone to covid-19. These robots support the emotional well-being of patients in isolation and can be virtually controlled by doctors to keep check of patients health condition.

In the current era, robotic surgeries are successfully done in different medical fields and were already being successfully done before the pandemic. These robotic surgeries proved more efficient during covid-19 crisis as it reduces the risk of disease spread to medical experts. Robotic technology is evolving day by day and large number of medical and healthcare centres in developed countries have rapidly adopted the technology. Its rising demand signify that soon they will be found in abundance. Robots are efficient and extraordinary and have the capability to perform the work three times more efficiently than the human capability. Hence, robots have replaced humans in unexpected ways.
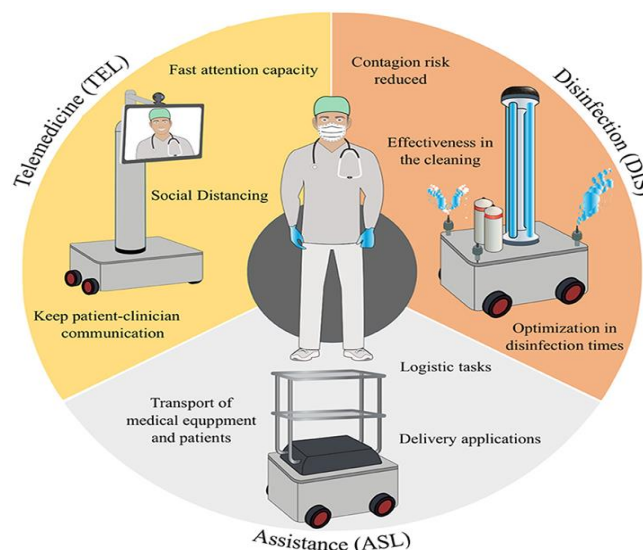
4. DRONE TECHNOLOGY

A drone is an aircraft without human pilot that can be controlled remotely using software controller in its embedded systems. It is a type of unmanned aerial vehicle (UAV). There are different ways to control UAV flights; they can be either remotely controlled by the human operator or piloted by an independent robot. Unmanned Aerial Vehicles(UAV's) are autonomous but still depend on human operators or some other controllers. Autonomous drones are itself UAV's but can operate without human interference.

UAV's and drones were originally used during dangerous and perilous conditions for the human safety. Drones can take off, fly, reach the specific target and land on its own. They are classified into various types depending upon various factors like structure, size, weight, range or altitude, autonomous and so on.

Drones are involved in various application worldwide like military for rescue operations during natural disasters or calamities. Moreover, used by number of countries during covid-19 crisis to mitigate the disease spread.
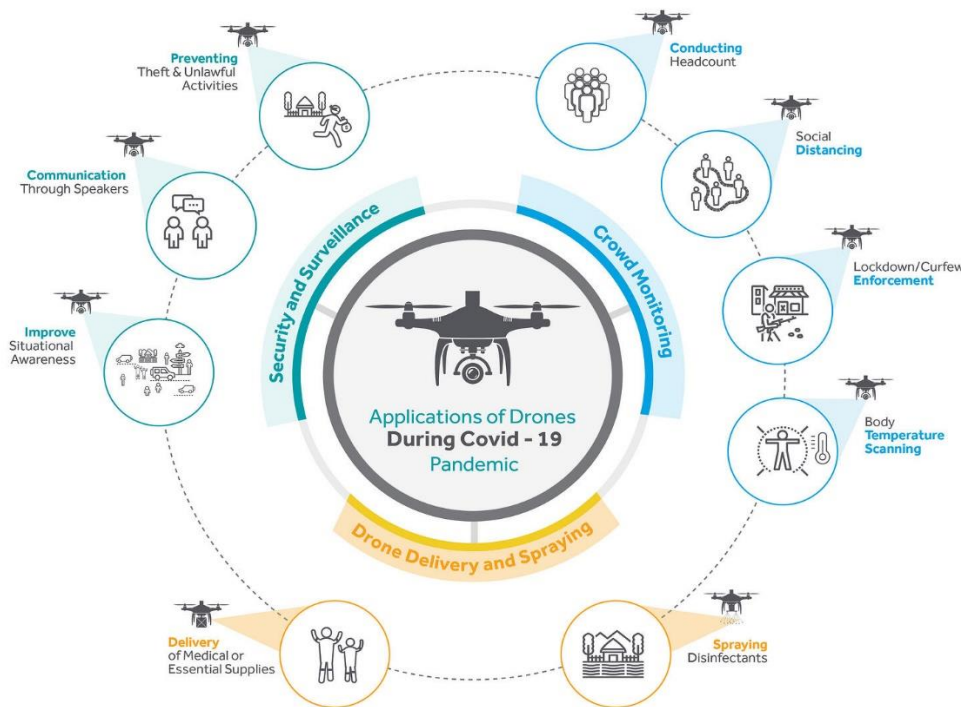
Drones for contactless delivery of medicines:
Drones are widely used during covid-19 for delivery of necessary health supplies and services in a time effective manner. They have capability of travelling faster than any manned vehicle and prove helpful in delivering the medical care to the remote areas which lack infrastructure and proper transportation. With the use of drones covid-19 self-test kits and other essential goods can be transported without human interference. The person with covid-19 is contagious and is kept in isolation. Food and medicines are provided to the person in quarantine. Large number of countries are using drone technology to deliver the medical care and vaccines to different areas. For example; India is using developed drones to deliver covid-19 vaccines to facilitate the proper vaccine delivery in the compromised areas.

Drones for screening and monitoring:
Drones with cameras are being used mainly for supervision and scrutiny of crowd due to their feature to provide current location bird eye or aerial view within no time. This is the main reason that many

countries across the world are utilizing drones for crowd monitoring especially during covid-19 crisis. The drones incorporated with surveillance cameras can easily monitor the crowd in the areas and help police to manipulate any unauthorized situation. Surveillance drones with temperature sensor incorporated within them can monitor the body temperature of people in any area. Countries like India and China have also adopted the drone technology for crowd monitoring.

Drones for fumigation:
Drones are useful to people to avoid direct contact with viruses and bacteria. They can be used to spray disinfectants in the contaminated areas. The covid-19 red zoned areas can be sprayed with drone technology without the risk of disease spread.

The demand of drones is increasing in agricultural sector as well. Spraying drones can disinfect the damaged crops and agricultural lands.

5. TELEMEDICINE

The newly developed technology that is expanding in the medical field is telemedicine. Telemedicine is widely described as the use of software and electronic communications to examine and serve patients instead of an inpatient visit. It simply refers to the practice of distant patient care when the healthcare provider and patient are not physically present with each other. Telemedicine enables healthcare providers to care for patients while obeying the social distancing and shelter in place. The novel coronavirus has drawn the healthcare systems to the fringe. COVID-19 might be getting all the headlines but patients are still getting sick from other diseases and injuries.

• Over the past decade, telemedicine is broadly used to define all medical services and health education delivered digitally. Throughout the pandemic, online healthcare services have been used to provide care for patients at home with mild covid-19 and provide information about the symptoms and prevention of disease to all the patients. The field of telemedicine has diversified recently in developed countries for the management of mild covid-19 related problems. Its use has increased from 10% to 64% during the pandemic and of those 46% people who used telemedicine prefer to keep using it even after the pandemic. The use of telemedicine provides various benefits;

• The patients can consult the doctors anywhere on the globe with the help of telemedicine.

• Telemedicine services decrease the number of hospital visits and increase hospital resources including hospital staff time.

• It helps in minimizing the workload of overburdened hospital staff especially during healthcare crisis which enables them to focus on critical and severe cases.

• During disease outbreaks especially covid-19 crisis, telemedicine minimizes the chances of disease spread from patient to healthcare provider.

• The people in rural areas of the country with inadequate medical services get quick and easy access to healthcare.

• It helps the patients in faster recovery, saves the visiting time to hospitals and patients don't need to wait for longer duration in queues outside the OPDs or wards.

• Telemedicine can prove to be a lifeguard in emergency situations requiring immediate critical care.

According to the recent estimation it has been found that about 60% of US hospitals have embraced the telemedicine. In Massachusetts, Minnesota, Wisconsin, New Hampshire, New York, the number of hospitals adopting telemedicine has increased up to 80%. Most importantly during covid-19 crisis telemedicine has been casted as a tool to protect medical professionals from exposure of covid-19, to reduce the use of personal protective equipment and to maintain the healthy environment. Coronavirus has boosted telehealth interactions to one billion by the end of 2020. A huge spike in the users has been observed by telemedicine companies such as Teladoc and American Well during the coronavirus widespread. This telemedicine can also be used to train the staff in remote and rural areas to counter the health crisis. It will lead to adequate healthcare of affected patients in rural areas and can be used to support countries lacking trained medical personnel.
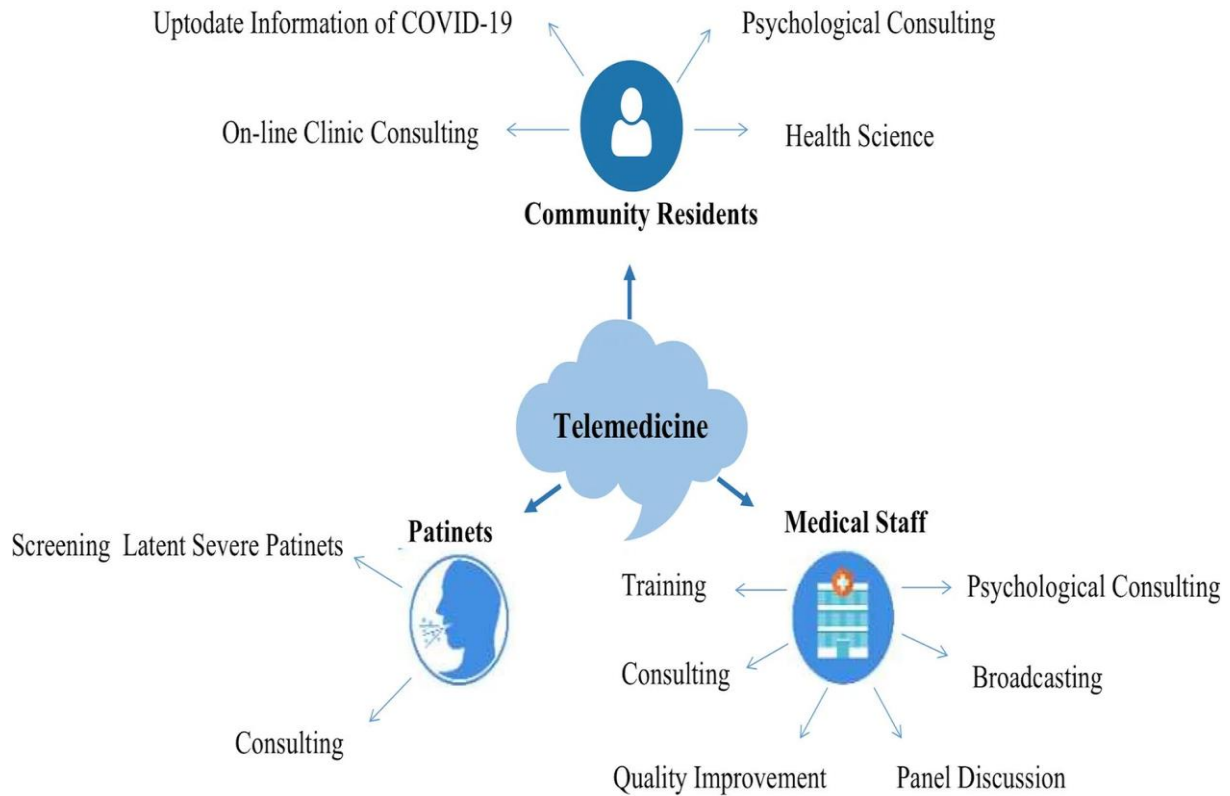
6. BLUETOOTH AND GPS TECHNOLOGY:

Bluetooth is a technology that enables devices to connect with each other without the use of wires and cables. Bluetooth depends on short range radio frequency. This technology works in UHF radio waves spectrum (ultra-high frequency in the range 300MHz-3GHz) and is used mostly to establish low-priced, low-power and short-time wireless connections between laptops, desktops and Bluetooth devices such as mobiles, digital cameras, keyboards, printers, headsets and computer mouse. Thus, the technology uses globally available radio-frequency range between 2.402 and 2.480GHz which is assigned for specific industrial and medical use. In short, Bluetooth reduces the use of wires and cables and connect the devices digitally. Thus, the Bluetooth technology is helpful in various applications including medical field. Public Exposure Notification Systems (ENS) use Bluetooth technology which is already encapsulated in smartphones to alert people about their proximity to the covid-19 patients or other contagious diseases.

GPS is a space-based navigation system which consists of constellation of satellites to provide positioning, navigation and timing (PNT) services of users. This technology has been widely used during the covid-19 pandemic in order to track the movements and interaction of infected people to identify the risk. Nowadays, numerous companies are developing smartphone-based contact tracing apps. During the covid-19 pandemic, various countries have developed various mobile applications based on GPS in order to identify the covid-19 patients and help control the spread of disease. These applications will classify the users as safe or unsafe based on various criterion like presence of virus symptoms or travel history. The GPS location of the mobile phone users will be saved in the database and later the information can be used for various purposes such as ,to warn the user if he gets in contact with the suspected virus victim, can be also used to provide GPS location of the victim to the healthcare providers if any urgent help is required. Various countries are using the GPS technology in smart helmets which consist of GPS modules, optical camera and infrared thermal camera for the detection of covid-19.Infrared thermal camera examines any high temperature of the

given area. When an individual with high temperature is detected, the face of the suspected individual is captured by the optical camera. The position data is then determined by the GPS module and the notification is sent to the allocated smart mobile via GSM.

7. COMMUNITY SCREENING

The rapid global spread of coronavirus disease(covid-19) has created prodigious need for contact tracing and case detection. With the tremendous rise in the active cases in various countries, the health laboratories experienced a huge demand for covid-19 screening. The confirmation of covid-19 positive cases has been entirely based on the identification of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) using real time reverse transcription polymerase chain reaction (qRT-PCR). For case detection there have been two methods of population screening, massive random screening and targeted screening. Moreover, it consists of three compatible testing procedures so as to boost the number of infected people detected. The first procedure is to eliminate the cost barrier and physician referral for testing patients with covid-19 symptoms. The second procedure is to choose and test the people in the areas with high covid-19 risk. The third procedure is to preserve the small number of tests for the random screening at the specific sites in order to detect the infected people. Hence, both population screening procedures have to be followed by contact tracing and isolation of people who test positive. These strategies can minimize the covid-19 spread to the certain extent.

8. ARTIFICIAL INTELLIGENCE

Artificial Intelligence is the intelligence indicated by machines. "Artificial Intelligence" is a term used when a machine imitates intellectual functions that humans relate with other human minds, such as "learning" and "problem solving".

AI has a broad range of applications and characteristics that can be executed to support our response to covid-19. Researchers have used both deep learning and machine learning prototypes to study, diagnose and treat COVID-19. Machine learning tools allow the study of database of virtual genomes and therefore help to increase our fundamental knowledge of covid-19.

AI in prediction and tracking:

AI can be utilized for predicting the spread of virus and evolving early warning systems by deriving information from social media platforms, news sites, calls and yields useful information about the unsafe areas and for the forecast of mortality and morbidity. For example; HealthMap fetches the available public data on covid-19 and makes it readily accessible to enable the effective tracking of the covid-19 spread. Bluedot recognized a bundle of pneumonia cases and predicted the upsurge and geographical location of the covid-19 upsurge based on the data available by using machine learning.

Recently, the part of AI in tracking and forecasting of covid-19 upsurge by implementing multi-model data was highlighted.

AI in contact tracing:

AI can upgrade mobile health applications where smart gadgets like mobile phones, cameras, watches and the variety of variable devices can be implemented for diagnosis, contact tracing and effective monitoring in covid-19. Applications like AI4COVID-19 that depends on audio recording samples of 2S cough can be utilized in telemedicine.

AI in surveillance of covid-19 cases:

AI methodologies are practised for examining patients in clinics or medical units and forecast of course of treatment. Based on the data obtained from the clinical specifications, AI may provide critical information for resource distribution and decision making by prioritizing the requirement of ventilators and respiratory supports in the Intensive Care Unit. AI can also be helpful for estimating the chances of mortality or recovery in covid-19 and for providing the daily updates about the course of treatment .AI was also used for early diagnosis and quantification of covid-19 cases from chest x-ray and CT scan images.

AI in development of vaccines:

Mankind has never witnessed such competition for the development of a vaccine against a pathogen. The rate of discovery can be hastened by exploiting the power of AI. Ong.et.al. forecasted possible vaccine candidates for covid-19 using Vaxign reverse vaccinology machine learning plan that was dependent on supervised classification models.

Ongoing efforts have been made to execute AI in the development of useful therapeutic procedures against covid-19. Machine learning principles can also be employed to predict whether commercially approved medications can be used for the treatment of disease. Despite the capability of AI to be employed in the fight against covid-19, AI systems are still at the initial stage. The diligent quality control for testing the validity and for ensuring patient benefit and safety is guaranteed.
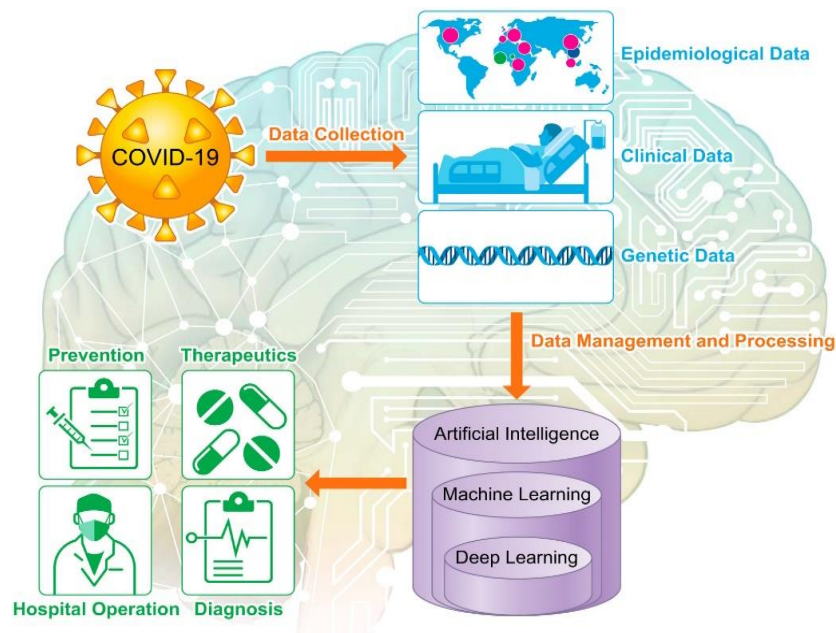
9. 3D-PRINTING

Three-dimensional field is rapidly evolving field that can aid in the design of medical equipment. It can also aid in providing the required materials at less costs. The covid-19 epidemic lead to the global insufficiency of medical supplies as well as personal protective equipment (PPE), mandatory for the

care of covid-19 patients. PPE comprises face shields, face masks, aprons, gloves and goggles. These equipment assist to prevent droplet exposure and further virus spread. The face masks need to be adjusted suitably in order to air and small droplets sufficiently from penetrating around the edges of the mask. 3D laser scanning allows estimation of exact facial parameters and can enable the production of personalized masks. Face shields can also be produced with biodegradable material using open source data which permits the on-demand production at home. Use of 3D-printing technology would grow access to these supplies and will produce more personalized equipment than can better protect medical workers.

Three-dimensional printing technology can aid in the manufacture of oropharyngeal and nasopharyngeal test swabs. The aid of 3D printing in the manufacture of these materials would enable for worldwide population testing. With increased access to testing, tracing and isolation to suppress the spread of virus could be more operative and practical. Countries extremely affected by the covid-19 pandemic have faced scarcity in the key elements of the respiratory support equipment. In such situations, 3D printing has been applied to produce venturi-valves. These valves were hard to produce given their design subject to copyright and patent covers. Furthermore,3D printing can also be used for manufacture of ventilator splitters with adjustable flow control valves. The adjustable flow control valves have better patient access to ventilators by allowing two patients with different oxygen requirements to use the same ventilator.

The use of 3D printing can transform production of equipment in terms of capability, proportion and cost. Large medical facilities and hospitals should associate with 3D printing companies to meet the growing demand of medical supplies. However, safety precautions should be still obeyed during the COVID-19 upsurge to make sure that the medical supplies meet standard regulations and are safe for use.

3D printing applications for COVID-19

Medical devices
- Ventilator valves
- Mask connectors for CPAP and BiPAP
- Emergency respiration device
- Non-invasive PEEP mask

3D-printed Charlotte valve

Testing devices
- Nasopharyngeal (NP) swabs

3D-printed NP swab

Training and visualization aids
- Medical manikins
- Bio-models

3D-printed medical manikin

Personal protective equipment (PPE)
- Face shield
- Respirators
- Metal respirator filters

3D-printed respirator

Personal accessories
- Face masks
- Mask fitters
- Mask adjusters
- Door openers

3D-printed customizable mask

Emergency dwellings
- Isolation wards

3D-printed isolation wards

10.

CONCLUSION
Evolving technologies can be productively used to allow the medical association to rapidly counter to the increased demands and the stress of COVID-19 upsurge. Various advanced technologies have been utilized in the study, diagnosis and the treatment of COVID-19. Latest developments have manifested the cooperation between the engineers and the medical researchers which is necessary for the development of efficient and less expensive methods of tackling the pandemic. In the context of the expeditious and global disease spread, open approach to knowledge, technology and tools are necessary for convenient comeback. Engineers and researchers must keep up to cooperate and share proficiency to continue to provide solutions in the covid upsurge. Although instant development and

implementation of modern technologies is required, safety supervision should not be neglected. The safety standards for the manufacture and the delivery of services, goods and supplies should be examined continuously as new technologies are being utilized. The specific guidelines related to the patient generated data as well as confidentiality must be maintained. Treatments figured out with the help of evolving technologies should go through standard clinical tests. The medical association requires to maintain all the safety standards to assure the best results for patients.

References
1. Abdulrazaq, A. P. D. M., N. Hazairin, S. Al-Zubaidi, S. Karim, S. Mustapha, and E. Yusuf. Toward a novel design for Coronavirus detection and diagnosis system using IoT based drone technology. Int. J. Psychosoc. Rehabil. 24:2287–2295, 2020.
2. Adam, D. Special report: The simulations driving the world's response to COVID-19. Nature 580(7803):316–318, 2020.
3. Alex, Z., A. Vladimir, Z. Alexander, Z. Bogdan, T. Victor, S. B. Dmitry, et al. Potential COVID-2019 3C-like protease inhibitors designed using generative deep learning approaches. ChemRxiv 2020. https://doi.org/10.13140/RG. 2.2.13846.98881.
4. Anggraeni, S., A. Maulidina, M. W. Dewi, S. Rahmadianti, Y. P. C. Rizky, Z. F. Arinalhaq, et al. The deployment of drones in sending drugs and patient blood samples COVID-19. BioRxiv 5(2):8, 2020.
5. Baharudin, H., and L. Wong. Coronavirus: Singapore develops smartphone app for efficient contact tracing. h ttps://www.straitstimes.com/singapore/coronavirus-singap ore-develops-smartphone-app-for-efficient-contact-tracing
6. Barton, C. M., M. Alberti, D. Ames, J. A. Atkinson, J. Bales, E. Burke, et al. Call for transparency of COVID-19 models. Science 368(6490):482–483, 2020.
7. Bekiros, S., and D. Kouloumpou. SBDiEM: a new mathematical model of infectious disease dynamics. Chaos, Solitons Fractals 136:109828, 2020.
8. Bray H. The robot will see you now A Boston hospital is using Spot, the dog-like robot of Internet fame, to screen for coronavirus. https://www.bostonglobe.com/2020/04/23 /business/robot-will-see-you-now/.
9. Callaway, E. The race for coronavirus vaccines: a graphical guide. Nature 580(7805):576–577, 2020.
10. Chauhan, V., S. Galwankar, B. Arquilla, M. Garg, S. D. Somma, A. El-Menyar, et al. Novel coronavirus (COVID19): leveraging telemedicine to optimize care while minimizing exposures and viral transmission. J. Emerg. Trauma Shock. 13(1):20–24, 2020.
11. Chen, F. M., M. C. Feng, T. C. Chen, M. H. Hsieh, S. H. Kuo, H. L. Chang, et al. Big data integration and analytics to prevent a potential hospital outbreak of COVID-19 in Taiwan. J. Microbiol. Immunol. Infect. 2020. https://doi. org/10.1016/j.jmii.2020.04.010.
12. Ciliberto, G., and L. Cardone. Boosting the arsenal against COVID-19 through computational drug repurposing. Drug Discov. Today 2020. https://doi.org/10.1016/j.drudis.2020. 04.005.
13. Dhama, K., K. Sharun, R. Tiwari, M. Dadar, Y. S. Malik, K. P. Singh, et al. COVID-19, an emerging coronavirus infection: advances and prospects in designing and developing vaccines, immunotherapeutics, and therapeutics. Hum. Vaccin. Immunother. 2020. https://doi.org/10.1080/2 1645515.2020.1735227.
14. Dormont, F., R. Brusini, C. Cailleau, F. Reynaud, A. Peramo, A. Gendron, et al. Squalene-based multidrug nanoparticles for improved mitigation of uncontrolled inflammation. Sci Adv. 6(23):eaaz5466, 2020.
15. Edward, H., and H. P. F. Kaplan. Logistics of Aggressive Community Screening for Coronavirus 2019, 2020. https:// jamanetwork.com/channels/health-forum/fullarticle/27656 93?resultClick=1.
16. Gozes, O., M. Frid-Adar, H. Greenspan, P. D. Browning, H. Zhang, W. Ji, et al. Rapid AI development cycle for the coronavirus (COVID-19) pandemic: initial results for automated detection

& Patient Monitoring Using Deep Learning CT image analysis. arXiv e-prints [Internet], 1 March 2020 [arXiv:2003.05037p]. https://ui.adsabs.harvar d.edu/abs/2020arXiv200305037G.

17. Han, Y., and P. Kral. Computational design of ACE2- based peptide inhibitors of SARS-CoV-2. ACS Nano 14(4):5143–5147, 2020.

18. Hong, Y. R., J. Lawrence, D. Williams, Jr., and I. A. Mainous. Population-level interest and Telehealth Capacity of US hospitals in response to COVID-19: cross-sectional analysis of Google Search and National Hospital Survey Data. JMIR Public Health Surveill. 6(2):e18961, 2020.

19. Hosny, A., C. Parmar, J. Quackenbush, L. H. Schwartz, and H. Aerts. Artificial intelligence in radiology. Nat. Rev. Cancer 18(8):500–510, 2018.

20. Hu, Z., Q. Ge, S. Li, L. Jin, and M. Xiong. Artificial intelligence forecasting of Covid-19 in China. arXiv e-prints [Internet], 1 February 2020. [arXiv:2002.07112p]. h ttps://ui.adsabs.harvard.edu/abs/2020arXiv200207112H.

21. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8084752/