

Telemedicine and Biosensors, A Boon in COVID Era: An Update

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ABSTRACT

Telemedicine means delivery of medical care and provision of general health services from a distance. Telemedicine tools have been evolved for at home COVID-19 diagnosis, screening, monitoring and treatment. Telemedicine has been practiced for decades with increasing evidence proving its potential for enhanced quality of care for patients, reduction in hospital admission and increase in savings for both patients and health care providers. The COVID-19 pandemic has resulted in a significant increase in the reliance on telemedicine and telehealth for provision of health care services. Development in telemedicine should be structured as complement to current healthcare procedures, not with the goal of completely digitizing the entire healthcare system but rather to use the power of technology to enhance areas that may not be working at their full potential. At the same time, it is also clear that further research is required on the efficacy of telemedicine in terms of both financial and patient benefits. We are hereby discussing the current and rapidly increasing knowledge about the use of telemedicine and identify the gaps in knowledge and opportunity for further research. Beginning with telemedicine's origin to its widespread use during the COVID-19 pandemic, we highlight the use of biosensors and use of telemedicine in this article.

Keywords: Telemedicine, Biosensors, COVID-19, Wearable telemedicine gadgets

INTRODUCTION

The first case of Corona virus disease (COVID-19) was reported in Wuhan, China

in December 2019. Outbreaks have affected most countries in the world with rapid dissemination via unprecedented propagation. The WHO declared COVID-19 as being pandemic on March 11, 2020. Although the mortality rate of COVID-19 is 2-5% which is not very high, casualty among the geriatric population aged over 60 years is greater than 10%. The mortality rate is even higher for individuals in the 70s and 80s.[1]

Corona disease (COVID-19) an infectious disease caused by SARS-CoV-2 virus. While coughing, sneezing, speaking, singing-the virus can spread easily from infected person's mouth and nose through minute liquid particles. So, respiratory etiquettes, hand washing practice is equally important.[2]

In COVID-19 the main problem is how to sustain the capacity to provide services not only for those affected with COVID-19 but also for trauma patients and those suffering from other acute and chronic diseases. While protecting the Doctors, pharmacists, nurses and other allied health professionals and also for the patient located in regions far away from the city by means of telemedicine.[3]

Many research studies have reported that the COVID-19 pandemic causes psychiatric problems, such as anxiety and depression. As such the geriatric population needs psychiatric counselling or treatment, but it is difficult for geriatric patients to visit the hospitals or clinics because of the risk of

COVID-19infection. Furthermore, with the COVID-19 crisis showing signs of being prolonged, measures that address these problems are urgently needed.

Use of telemedicine was done in the late 1950s and early 1960s when a closed-circuit television link was established between the Nebraska Psychiatric Institute at the University of Nebraska USA and Norfolk State Hospital USA for psychiatric consultations.

During the calamity of pandemic, telemedicine provide viaduct to care, providing new possibilities to alter virtual and hybrid/virtual/in person care models, with the intention to ameliorate healthcare approach, consequences and affordability. [4]

Telemedicine is the remote diagnosis and treatment of patient by means of telecommunication technology. Telemedicine is also referred as telehealth or e-medicine is the remote delivery of healthcare services, including examination and consultations, over the telecommunication infrastructure. Telemedicine allows healthcare providers to evaluate, diagnose and treat patients without the need for an in-patient visit. It is helping to shift healthcare from hospital to remote location, as that of net banking. [5]

Telemedicine incorporates enormous number of technologies to safely convey remote health care involving the video conferencing (contemporaneous), typically a two-way audiovisual link in between medical professional and care seeker. At remote locations, care seeker monitoring tools, audio conversation-via patient portals and texting technologies, data collection and transmission in image or text form as store and forward technologies as per requirement.[6]

Present and Future of Telemedicine

Telemedicine provides virtual consultation between healthcare providers and patients. It became very useful during COVID-19 pandemic as it provides persistent connection between organization and gives

chance to connect with experts for guidance and consulting medical help.[7-8]

According to the Centres for Disease Control and Prevention (CDCP), telehealth utilization spiked by more than 154% in late March of 2020 compare to the March 2019. The global telehealth market size was reached at USD 40.3 billion in 2020. Additionally, the market is expected to rise to over \$ 397 billion USD by 2027 following current predictions made by Fortune business insight.[9]

According to Precedence Research, the global telehealth market size is projected to be worth around USD 224.8 billion by 2030, growing at a CAGR of 18.8 % from 2021 to 2030(GLOBE NEWSWIRE). It is short sighted to consider the utility of telemedicine as being limited to handling the current crisis whose utility will dissipate when the pandemic crisis ends. It was estimated that up to \$250 billion of US healthcare spend could potentially be shifted to virtual or virtually enabled care.

Moreover, a research shows between 40% and 60% of consumers express interest in a set of broader virtual health solutions, such as “Digital-front-door” or lower cost virtual-first health plan. On the provider side, 58% of physicians continue to view telehealth more favourably now than they did before COVID-19, though perceptions have come down slightly since September 2020 (64% of physicians). As of April 2020, 84% of physicians were offering virtual visits and 57% would prefer to continue offering virtual care.[10]

Drawbacks of Telemedicine:

Telemedicine is a tool to provide nourished care to patients can show various snags as

- Quality telemedicine needs a stable internet connection and access to system (android or computer) technology.
- Basic electronic literacy is also needed to operate, which may lack in lower socioeconomic population.[11]

Applications of Telemedicine

As of new normal, stay-at-home guidelines allowed execution of telemedicine in broad way at various levels of health services, that ultimately provides enormous number of benefits to general public. Studies conducted reveals that as the cases of COVID-19 increased, engrossment of telemedicine raised up. It also shows that telemedicine provides high degree of contentment to users, moreover it make easier for the patients who use to move fair distance for expertise medical help.[12] Telemedicine provides remote access to physician that gives reassurance to both patients and healthcare providers.[13-14] Countries that are less-economically developed using telemedicine for diagnosis and treatment seems to be benefitted as reducing distance travelled and saving time for specialist care also reducing related expenses and stress.[15-18] Wherein developing countries, telemedicine network also offers secondary benefits. By initiating new channels, telemedicine is opening the way of connection among rural and health care providers worldwide.[17,19-20] This lead to raised up collaboration between cross-site and inter country, such networking can help physicians in distance training and learning at remote locations. [14-15,17,21-22]

It is not surprising that health system globally is now shifting to telemedicine to provide care while keeping patients at home. The massive conversion to telemedicine demonstrates its utility as an effective tool for the so called “social distancing” in clinical or other settings. With the onset of COVID-19, it has become clear that a sizeable proportion of outpatient visits can be clinically managed effectively from a distance that is patients can be treated from a distance that is patients with non-emergency conditions can be shifted to telemedicine service without compromising their health.

Telemedicine has evolved, prior as a patient care and comfort but today among world-wide pandemic, is a requisite way delivering

health care in such a system to lower down the risk of transmission of COVID-19 among families, clinicians and patients.[23] Prior it was signified that telehealth can help to overcome pitfalls in health care in remote locations. From the beginning of pandemic era, telemedicine has captured eye on it as biggest partner because of enlarged number of transformations in telehealth delivery, to serve patients in best possible way. Telehealth providers care services at home, making patients safe through social distancing and maintaining isolation.[24]

Wearable Telemedicine Gadgets

Wearable devices that are skin-interfaced and E-health (mobile health) monitors have been extensively used for fitness tracing and record signals to monitor and detect potential patients.[25-32]

Wearable sensors will allow self assessment that simultaneously reduces contact between one another. Devices for continuous sign monitoring- Viral infection instigate immune system to defend against it that hike up temperature and it can be measured using telehealth devices and have been adopted worldwide. As the temperature elevates, caregiver is isolated to protect general public.[33] As viral infection increases stress that directly leads to elevation in heart rate & blood flow shows fluctuation in pulse waveforms. Commercial fitbit and Huami sensor devices helps to diagnose change in heart rate.[34-35] Apple wearable watches also help to diagnose heart rate & other health data.[36-37]

According to reported studies COVID-19 infection is analogous to cardiovascular difficulty like heart failure, venous thromboembolism and Myocarditis.[38] Cardiovascular death is highly reported with COVID-19 infection and came as major issue.[39]

Individuals’ fitness status also reflects through activity patterns. Steps count by fitbit measures activity levels. During stay-at-home guidelines it showed significant deduction in activity potential.[40]

Study conducted for COVID-19 patients using wearable sensors that are skin interfaced to monitor activity patterns.[41-42]

Telemedicine for COVID-19 risk estimation studies disclosed the fact that severity of COVID-19 and death is exceedingly towering among those with various metabolic disorders like fatty liver disease, obesity, alcoholism and diabetes [43-48] and so metabolic biomarkers are proven to be an essential gadget to access the worth of outcome of pathologies.[49]

Affluence of metabolic biomarkers, have been recognized by severe and non-severe COVID-19 pattern serum, uric acid, creatinine, urea, ions (chloride, bicarbonate, iron, potassium), lactic acid and glucose.[50]

Certain biomarkers among these have delivered attention as they are directly correlated with COVID-19 risk assessment. [51-52]

Wearable Chemical Sensors

Scanning of approachable body fluids like sweat, tears, interstitial fluid and saliva in continuous and concurrent manner is

possible during COVID-19 pandemic through these wearable biosensors.[53-55]

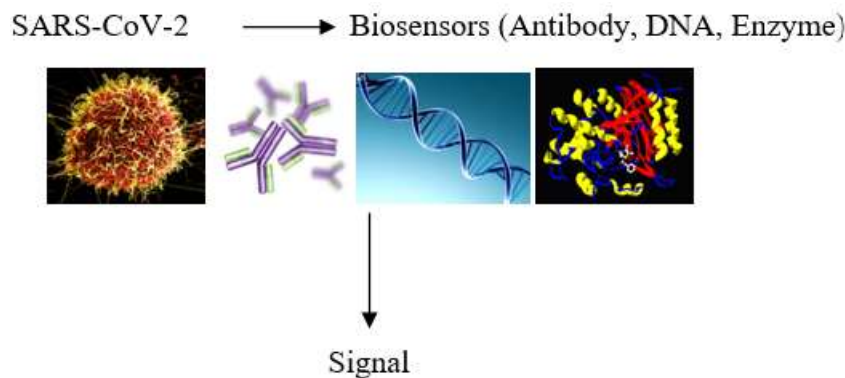
Challenges with traditional methods.

- RT-PCR is time taking, difficult to reach mass testing, expensive and there are many possible causes of false negative cases.
- CT- Scan is not effective for asymptomatic condition and there are chances for excessive radiation exposure.
- mNSG shows difficulty to differentiate between microbes and host RNA.
- Serological test is ineffective for multiple sample, high in cost and demand trained personnel.[56-62]

Principles of Biosensors

Biosensors reacts with sample present using combination of both biometric system and transducer that represents amount of analyte through a digital signal.[63-64]

Biosensors are of various types depending upon signal discern techniques and concept of transduction adopted.[65]



Advantages of biosensors for SARS-CoV-2

- Cost effective
- Quick response time
- Easy to use
- Highly sensitive
- Highly selective
- Multiple sensing models[66-67]

Types of Biosensors for COVID-19.

1. Optical Biosensors
2. Smart and Wearable Biosensors
3. Electrochemical Biosensors
4. RT-LAMP based Biosensor
5. Piezoelectric Biosensor
6. Other Biosensors[68]

1) Optical Biosensor

Used as detecting gadget for infections caused by virus specially for respiratory tractinfection.[69-70] These are worthy for point of care zone as it is highly sensible, digital output, being-label free, integration capability and gives real-time diagnosis of various targets.[71] So, these biosensors are made for PoC (point of care) zone. Particularly, highly sensible optical biosensor based diagnosis of SARS-CoV-2 reveals with Surface Plasmon Resonance and fluorescence.[68]

2) Electrochemical biosensors

These types of biosensors can measure potential difference, conductivity and electrode material works as transducer.[72] Electrochemical sensor chip has been developed that have many good attributes:

- Easy to operate
- Quantitative results
- Works at good speed (less than 5 minutes)
- Cheap

3) Wearable smart Biosensors

Concept of internet of Bio-Nano Things (IoBNT) was given by Akyildiz et al. for PoC diagnostics that given information regarding patients health to health care providers via internet. Masks are coated with nanoparticles doped metal organic framework that shows interaction with COVID-19 virus as it comes in contact with it and visible changes are observed by visual color change.[73]

For preventing SARS-CoV-2 from spreading Artificial Intelligence (AI) could be used as telemedicine tool.

4) Piezoelectric Biosensors

These are simple, flat-surfacing, label-free testing and real-time response providers, due to these certain reasons Piezoelectric Quartz Crystal Microbalance (QCM) biosensors have attained acceptance for the medical applications. [74-75]

After complex formation between antigen and antibody electronic signal appears.

Piezoelectric immune sensors can be recognized as steady, efficacious and swift detection of SARS-CoV-2.[76]

5) RT-LAMP Based Biosensor

Loop-mediated isothermal amplification (LAMP) is a method which has been conducted for COVID-19 diagnosis. Reverse transcription-loop mediated isothermal amplification nanoparticles based biosensor was evolved using colorimetric sensing nanoparticles that gives visual detection.

RT-LAMP reaction boosts up and recognize two target genes simultaneously, which give more précised results. So this method have been used as detective tool for SARS-CoV-2 as:

- It is highly sensitive
- Précised results are obtained
- Cheap
- Easy to operate.[68]

6) Other Biosensors

CANARY™, a path sensor which is effective and highly sensitive biosensor for SARS-CoV-2 detection.[62]

Abbott ID Now™, diagnostic kit based on loop mediated isothermal amplification technique.

It has ability to detect COVID-19 in 5 minutes. Sample required is taken up from Oral, Nasopharyngeal, Nasal swabs etc.[68]

CONCLUSION

Gleaned from latest global mode, it is comprehensible that fight against COVID-19 is not easy one. While preventing spread of disease stay-at-home guidelines were essential to obey for the population globally. While sheltering in place, following government guidelines, it became a challenge that how we proceed towards COVID-19 screening, diagnosis and treatment. It is vitally important that infected individual is quarantined and restrict the consultation via health and telemedicine. The most challenging part during pandemic has been consulting with doctors. Moving towards biosensors and

inexpensive telemedicine tools may solve this problem.

Future prospective have to include straightforward amelioration or merge different test like use of fast nucleic acid investigation in addition to assert test outcome. Contemporary work has venture to improve the recognition capabilities, explicitness and execution of biosensors.

Declaration by Authors

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