



PHARMACEUTICAL BIOSENSOR DEVICES USING ARTIFICIAL INTELLIGENCE TECHNOLOGY AND ITS IMPACT ON HEALTHCARE SYSTEM IN COVID-19 AND RELATED PANDEMICS

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ABSTRACT The world today is in a state of crisis, we are amidst the Covid-19 pandemic, that is caused by a new virus belonging to the family of coronaviruses. It is presumed to have taken its origin from a cross species transmission in the Hubei province of the capital city of Wuhan, China. It started as an epidemic to later engulf the entire globe in its purview as a pandemic, causing disastrous consequences on the human race, claiming innumerable lives and causing crippling effects on the global economy. The hardest hit is on the healthcare system, which is overburdened with the responsibility of screening, diagnosis, monitoring, isolation, quarantine and other measures to tackle the menace of this pandemic. The healthcare and allied professionals are on the frontline battling this situation and saving human lives. Risk of exposure among these professionals is high, it is added up by the demands of wide spread screening campaigns that involves aerosol generating procedures for the diagnosis. These procedures increase the risk of spread, by indirectly increasing the viral load. Managing the overall burden of the pandemic, requires large number of people to be in the frontline, which demands for continuous and proper supply of high quality Personal Protective Equipments (PPEs) for their protection. Unfortunately there is a global shortage of supplies of these equipments and frontline workers are forced to work without adequate security and supply of PPEs. In such a scenario, technological advancement in the form of wearable Pharmaceutical devices like the biosensor patches, based on the principles of artificial intelligence comes to our rescue. These devices will enable one to remotely monitor the vital parameters like, heart rate, blood pressure, respiratory rate, temperature, blood oxygen saturation, ECG, etc. By using apps in the mobile phones constructed on the principles of embedded technology, this will indirectly reduce the frequent interactions of doctors with their patients, enable them to monitor the vital parameters of the admitted Covid-19 patients and home quarantines suspects. Such interventions would lessen the burden of excess bed utilisation and enable us to promptly intervene on a necessity basis. Different kinds of wearable biosensor devices are available in the market based on similar principle of input and output data generation, accelerometers and motion sensor, that can be utilised for carrying out this job. The government should divert its funds and encourage the research and development of such devices and implement policies feasible for large scale indigenous production. This could cut through the barriers of accessibility, affordability and availability. Frequent awareness, education campaigns regarding wearable biosensor devices among the general public, would enable easy usage in the coming future. As time is the deciding factor in a pandemic like Covid-19, quick decision, robust action and effective utilisation of the technological advancement is the key deciding factor.

KEYWORDS : Covid-19; Pharmaceutical Biosensor Devices; Wearable Biosensor Devices; Artificial Intelligence; Healthcare Impact.

INTRODUCTION TO PANDEMICS AND COVID-19 A BRIEF SNAPSHOT

We are amidst a pandemic, which essentially means a global outbreak of disease, the world has witnessed crippling pandemics in the recent past, which has taken a huge toll on the globe, claiming innumerable lives, hitting hard on the social behaviors, mental health and negative impact on the global economy. This directly reflects on the infectivity, virulence and the mode of transmission of agent in question. Every pandemic first starts as an epidemic which means a rapid spread of the disease across a particular region. It is important to note that, not all epidemics become a pandemic, examples can be traced back from the history like the Zika virus outbreak of 2014 and the Ebola outbreak which were epidemics. History records some of the most dreaded pandemics in the past like the Spanish flu of 1918 causing 20-50 million deaths worldwide. Asian flu pandemic in the years 1957-1958, was triggered by a new strain of influenza A virus (H2N2) that was supposed to be originating from East Asia, claiming life of over 1.1 million people worldwide. 1968, witnessed the Hong Kong flu pandemic caused by new strain of (H3N2) virus claiming an estimated 1 million people worldwide. The (H1N1) Swine flu pandemic in the year 2009-10, caused by new strain of the same virus thought to cause the Spanish flu, which infected around 700 million to 1.4 billion worldwide, although the mortality was comparatively lesser.¹

On March 12, 2020, the World Health Organisation declared COVID-19 as a pandemic, which began as an epidemic in China, lately in the year 2019 presumably in the Hubei province of China, in the capital city of Wuhan. This later swept the entire globe causing a major health

crisis and impacting the mankind in various dimensions, it has caused restlessness in the globe, owing to the profound infectivity and mortality in the present times. The Covid-19 virus belongs to a large family of viruses called as the Coronaviruses, which is an unusually virulent strain that is supposed to appear from a cross-species transmission, which has the capacity to cause viral pneumonia, and in severe cases respiratory distress syndrome and death.²

The symptomatology of Covid-19 can range from fever, tiredness and dry cough, it varies from person to person depending upon their immunity and the viral load. Some people may present body aches and pains, nasal congestion, runny nose, headaches, breathlessness, sore throat, difficulty in swallowing, anosmia, dysgeusia or diarrhoea. There are carrier states in this disease, wherein an individual may get infected with the virus and remain asymptomatic or have mild flu like symptoms, but has the capacity to be a potential source to spread the infection among its contacts, these are the group of people responsible for increase in the number of cases. It is presumed that almost 80 % of the people recover from the illness without needing special treatment. Whereas 1 out of every 6 people getting the disease is supposed to land up in complications, needing intubation and ventilatory support with high mortality rates. It is also presumed that elderly people, people with chest and cardiac co-morbidities like cardiac disease, high blood pressure, diabetes and immunocompromised states are more likely to succumb to the illness and mortality among these people are generally higher.³

Global Challenges With Regards Covid-19 Pandemic And Its Toll On Healthcare Workers In A Ppe Deficient Scenario

In the recent headlines across the globe, we are witnessing the hazards

of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontlines despite the usage of Personal Protective Equipment (PPE) which are recommended by their respective ministry of health and family welfare. Throughout the globe the healthcare workers on frontline fighting against Covid-19 has a grim story to tell, that exhibits stories of death and scarcity of life saving medical supplies including PPEs. Traditional news outlets and social media across the globe are showing casing physician and other medical personnel opting for of the book tips and creative solution for making homemade gear for their usage which could prove risky in the real scenario.²

The countries of Asia and Europe offers a sneak peek into how Covid-19 pandemic is taking a devastating toll on healthcare workers, it is estimated that 3000 physicians in China, approx. 6000 physicians in Italy and roughly 14% of infection in Spain accounting to around 5400 health professionals are due to Covid-19. Although America is in the similar path, the statistics of healthcare professionals infected with Covid-19 is obscure, because the United states lacks key data to clarify the exact numbers at the moment.³

India a country of 1.3 billion people living in different states and belonging to varied socioeconomic strata, despite the quick disaster mitigation plan of early lockdown and non-pharmaceutical interventions that includes social distancing and hygiene, wearing of mask, quarantine and isolation plan is still seen a steady increase in the number Covid-19 positive cases, including infection among healthcare professionals with full or minimum protective equipment at their disbursement. This helps us to understand that the virus is highly contagious and the mechanism of spread from one-person to another person or through fomites to a living creature is not clearly delineated. More work needs to be done in understanding thoroughly the precise mechanism of viral transmission.⁴

In such a situation despite social distancing, minimising the viral load in the healthcare setup or a doctor patient interface scenario without compromising the quality of care, should be the key strategy that would help us in reducing the transmission to health care professionals and minimising the workload on health care system.

REMOTE BIOSENSING PHARMACEUTICAL DEVICES "NEED OF THE HOUR"

In the state of health crisis, amidst the burden of Covid-19 pandemic, Wearable Pharmaceutical Biosensing Devices in the form of biosensor patches or wearables, could help us to minimise frequent doctor-patient interaction, help us to track the precise vitals from remote areas of the hospital and with reduced staff and minimal errors with usage of tracking apps in the mobile phone developed using embedded technology. This would help in minimising the risk of contracting Covid-19 by decreasing the viral load as a result of curtailing needs of frequent visits by the doctor to these wards. Secondly it helps us to save unnecessary usage of Personal Protective Equipment's (PPEs) and preventing overcrowding within the wards.

BIOSENSING TECHNOLOGY AND ARTIFICIAL INTELLIGENCE

The term Biosensor refers to powerful and innovative analytical devices involving biologically sensing elements with wide range of applications such as monitoring of vital parameters that includes: pulse, heart rate, blood pressure, respiratory rate, SpO₂ (oxygen saturation), temperature, ECG, discovery of drugs, clinical diagnosis, biomedicine, food safety and processing and a variety of other functions. These devices are based on the principles of Artificial intelligence (AI) that essentially means a technology or an automated process that enable us to arrive at a conclusive diagnosis and treatment protocols for the management patient. In the recent headlines across the globe, we are witnessing the hazards of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontline despite the usage of Personal Protective Equipment (PPE) which are recommended by their respective ministry of health and family welfare. Throughout the globe the healthcare workers on frontline fighting against Covid-19 has a grim story to tell, that exhibits stories of death and scarcity of life saving medical supplies including PPEs. Traditional news outlets and social media across the globe are showing casing physician and other medical personnel opting for of the book tips and creative solution for making homemade gear for their usage which could prove risky in the real scenario.⁵

The application of this technology has enabled us to develop wearable

patches that helps in tracking real-time temperature, heart rate, Oxygen saturation monitoring, respiratory rate, blood pressure and ECG changes, that can be used with ease on thousands of patients at home or hospitals without requiring regular physical checking, these device also help us to continuously monitor fluctuations in the vital parameters with an embedded alarming technology that would caution the healthcare professional to perform immediate intervention and resuscitation. The availability of smartphone and upsurge in embedded technology makes it easy to track the functioning of these devices remotely without involving much technical expertise. In the recent headlines across the globe, we are witnessing the hazards of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontliners, despite the usage of Personal Protective Equipments (PPEs).

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In the present situation of Covid-19 pandemic, where the healthcare setup is facing challenges related to screening, diagnosis, treatment, compliance, quarantine and isolation facilities, shortage of PPEs, shortage of frontline workers, shortage of ventilators and other resources that can jeopardize the disaster management protocols such wearable devices can help us to curtail the demand and supply mismatch of PPEs, requirement of healthcare professionals to monitor the patient, unnecessary utilisation of hospital bed through remote monitoring of people who are home quarantined. This could ultimately minimise the risk of infection and transmission of Covid-19 in the health care setup, serving as the key strategy along with non-pharmaceutical intervention in containing the spread of Covid-19 pandemic.⁷

HOW DOES A WEARABLE BIOSENSOR DEVICE/PATCH WORK?

Wearable biosensor devices are incorporated with input and output data generating technology and variable sensors that helps in sensing changes in the heart rate, respiratory rate, blood pressure, oxygen saturation and temperature which are considered vital in monitoring pts Covid-19 disease. In the recent headlines across the globe, we are witnessing the hazards of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontliners despite the usage of Personal Protective Equipment (PPE) which are recommended by their respective ministry of health and family welfare. Throughout the globe the healthcare workers on frontline fighting against Covid-19 has a grim story to tell, that exhibits stories of death and scarcity of life saving medical supplies including PPEs. Traditional news outlets and social media across the globe are showing casing physician and other medical personnel opting for of the book tips and creative solution for making homemade gear for their usage which could prove risky in the real scenario.⁶

Body Temperature Interpretation

Body temperature (BD) is the outcome of balance between heat production and heat loss in the body. Its measurement is vital to understand temperature fluctuation in different kind of fever and its negative health impact. It is important to note that body temperature is divided into 2 measures: the Core temperature (CT) and Skin temperature (ST) skin temperature varies within a wider range of temperatures than core temperature because the bodies thermoregulatory centres regulate the core temperature. The different wearables system that have been developed to measure both temperatures such as skin like arrays of precision temperature sensor or wearable adhesive devices to continuously measure the temperature. Very recently a reusable wireless epidermal temperature sensor, a battery-less RFID thermometer I showing promising results to estimate CT. Rectal temperature is still gold standard for measurement core temperature but some other technique like telemetric pills are also showing promising results. In the recent headlines across the globe, we are witnessing the hazards of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontliners despite the usage of Personal Protective

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Respiratory Rate interpretation

Respiratory rate (RR) is one of the most critical and fundamental parameter while is kept under observation it serves as an accurate and important health indicator in cases of acidosis, stress and potential hypoxia. It is also important to note that RR abnormality is the best indicator for adverse event like cardiac arrest. Hence, RR ambulatory monitoring using wearable biosensor devices is important in the detection of symptoms of Respiratory disease like ARDS, sleeps apnoea, COPD, asthma which becomes more important in the monitoring of respiratory symptomology of Covid-19 infected individuals.

This vital parameter is normally calculated from the acquired respiratory wave form that reflects the chest volume variation during inspiration and expiration. The thoracic expansion combine with the muscle signs helps us to determine the respirator effort which indicates different physiological and pathological stage. Similarly, to obtain the respiratory function there are three methods commonly employed viz. elastomeric plethysmography (EP), impedance plethysmography (IP) and respiratory inductive plethysmography (RIP).

EP technique converts the current variation of Piezo-electric sensor in voltage using and elastic belt, similarly IP uses impedance changes for the body surface due to the expansion and contraction during breathing. RIP technology incorporates principle of loop wire with current that generates a magnetic field normal to the loop orientation, chest volume variation changes the area enclosed by the loop creating an opposing proportional current. Apart from these 3 methods various other technologies are used to get respiratory wave form like accelerometer, waves are extracted from ECG signals, pulse oximeter derivatives, polymer based transducer sensors, optical fibres etc. The polymer based stretchable strain sensor allows us to acquire electrical charges without the usage of dangerous meta fluids and this technology helps to obtain chest volume variation. In the recent headlines across the globe, we are witnessing the hazards of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontliners despite the usage of Personal Protective Equipment (PPE) which are recommended by their respective ministry of health and family welfare. Throughout the globe the healthcare workers on frontline fighting against Covid-19 has a grim story to tell, that exhibits stories of death and scarcity of life saving medical supplies including PPEs. Traditional news outlets and social media across the globe are show casing physician and other medical personnel opting for of the book tips and creative solution for making homemade gear for their usage which could prove risky in the real scenario.⁶

Blood oxygen saturation interpretation. (SpO₂)

SpO₂ is an extremely important vital parameter and is easy to measure using photoplethysmography (PPG) technology and pulse oximetry principles. The PPG method enables us to acquire wave forms of variation in the blood vessel. When measured with 2 wavelengths normally 660 and 905 nm the makes it possible to estimate the blood oxygen saturation which is due to haemoglobin absorbance spectrum change when it binds with oxygen. In the recent headlines across the globe, we are witnessing the hazards of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontliners despite the usage of Personal Protective Equipment (PPE) which are recommended by their respective ministry of health and family welfare. Throughout the globe the healthcare workers on frontline fighting against Covid-19 has a grim story to tell, that exhibits stories of death and scarcity of life saving medical supplies including PPEs. Traditional news outlets and social media across the globe are show casing physician and other medical personnel opting for of the book tips and creative solution for making homemade gear for their usage which could prove risky in the real scenario.⁶

Heart rate interpretation

Heart rate is a standard vital sign and has become a routine measurement in patients of Covid-19 disease and other health related problems. The monitoring of the signal provides information about physiological status of the individual by indicating the changes in the heart cycle. These devices easily extract the heart rate by extracting the ECG (R peak) or photoplethysmography (PPG signals) some of the other ways to measure heart rate using these devices are inertial sensors or scale which are named as ballistocardiogram (BCG), it is noteworthy that the values obtained from ECG (R peak) and (PPG) are more reliable than that obtained from (BCG). In the recent headlines across the globe, we are witnessing the hazards of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontliners despite the usage of Personal Protective Equipment (PPE) which are recommended by their respective ministry of health and family welfare. Throughout the globe the healthcare workers on frontline fighting against Covid-19 has a grim story to tell, that exhibits stories of death and scarcity of life saving medical supplies including PPEs. Traditional news outlets and social media across the globe are show casing physician and other medical personnel opting for of the book tips and creative solution for making homemade gear for their usage which could prove risky in the real scenario.⁶

Blood pressure interpretation

Ambulatory BP monitoring using wearable patches have been developed which estimates BP based on pulse wave transit time between the pulse wave obtained by photoplethysmography and ECG (R peak) or with PPG acquired on the wrist. It is imperative to note that the pressure sensor near the radial artery use and accurate blood pressure measurement on a personal smartphone in a real-time continuous BP wearable device.

Apart from these 3 methods various other technologies are used to get respiratory wave form like accelerometer, waves are extracted from ECG signals, pulse oximeter derivatives, polymer based transducer sensors, optical fibres etc. The polymer based stretchable strain sensor allows us to acquire electrical charges without the usage of dangerous metal fluids and this technology helps to obtain chest volume variation. In the recent headlines across the globe, we are witnessing the hazards of COVID-19 pandemic on healthcare professionals and allied professionals who are fighting this as frontliners despite the usage of Personal Protective Equipment (PPE) which are recommended by their respective ministry of health and family welfare. Throughout the globe the healthcare workers on frontline fighting against Covid-19 has a grim story to tell, that exhibits stories of death and scarcity of life saving medical supplies including PPEs. Traditional news outlets and social media across the globe are show casing physician and other medical personnel opting for of the book tips and creative solution for making homemade gear for their usage which could prove risky in the real scenario.⁶

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WHAT ARE THE DIFFERENT BIOSENSING DEVICES AVAILABLE IN THE MARKET

Table 1. Depicts compilation of different biosensing devices available for detection of symptoms related to Covid-19, Other pandemics and health conditions.^(8,9,10)

Devices	Application	Country
VitalPatch	Single-Lead ECG, Heart Rate, Heart Rate Variability, Respiratory Rate, Body Temperature, Blood Pressure, Oxygen Saturation	California
LifeSignals	cardiovascular monitoring platform, SpO ₂ , temperature, respiration rate.	California
AVA	It helps women naturally track their cycles to understand more about their fertility, pregnancy and overall health	San Francisco
KARDIAM OBILE	It tracks heart activity and transmits the activity to a mobile app through chest and finger sensors.	California
MOTIV	Motiv Ring slips onto a user's finger to monitor activity, sleep and heart rate.	California
GARMIN	The partnership will use ActiGraph's platform and Garmin's wearables to aid in clinical trials, academic research and the remote monitoring of patients.	Kansas
TEMPTRAQ	monitoring sensor for babies and children that tracks temperatures during an illness	Ohio
WITHINGS	offer activity tracking and ECGs, as well as heart rate and sleep monitoring	Massachusetts

CONCLUSIONS

In view of the current Covid-19 pandemic that is claiming thousands of life worldwide and counting. The world today is in requirement of technology advanced interventions like the wearable biosensor devices that would not only reduce the demand for PPE but would also prevent its excessive usage. Vis a viz reduce the transmission of infection from patient to healthcare professional in a hospital setting by limiting the frequency of visits for monitoring the vital parameters of patients admitted in the healthcare facility because as these devices help us to monitor the essential vital parameters remotely through apps prepared using embedded technology.

This will also help to limit the viral load and the amount of exposure, a health care professional exposed to his/her routine Covid-19 duties. On the other hand, we can prevent unnecessary admissions, overcrowding, bed utilisation of asymptomatic Covid-19 suspected individuals who can be provided with wearable and monitored remotely while their home quarantined.

More focuses should be directed towards the Research and Development, production, marketing, disbursement of these devices on a large scale that would enable us to cross the barriers of accessibility, affordability and availability. Government of the respective countries should lay emphasis on channeling capital budgets to support and encourage large and medium scale enterprises to undertake production of these devices. The government should also ensure buyback policies of the products that are manufactured by these enterprises.

Government should encourage Public Private Partnership (PPP) for industries that are technologically updated but require investment of capitals.

Indigenous production of these equipment's should be encouraging which may help us to boost of our economy by limiting our imports and financial drain. Educative, training and awareness campaign should be carried out on the basic concepts of artificial intelligence, biosensing technologies and its application in the management of Covid-19 pandemic. Time is the deciding factor in a pandemic situation, so quick decision, robust action and effective utilisation of the technological advancement available to us would go a long way in curbing the menace of Covid-19.

ACKNOWLEDGEMENTS

We would like to thank Dr. Harish H.S, Ophthalmologist Delhi and Dr. M.K. Srinivas, IRMS, Bangalore, for reviewing the article and giving opinions, comments and corrections as appropriate. We extend our thanks to Dr. B. Devanand, Director, VIMS, Ballari, Dr. D.

Krishnaswamy, Principal, VIMS, Ballari, Dr. J. Mariraj, Medical Superintendent, VIMS, Ballari, Dr. K Lakshmi Narayana, HOD, Department of Pharmacology, for creating a desire to explore our capabilities in research to its fullest dimension, Dr. Y. Vishwanath Professor, Department of Pharmacology, for constantly encouraging us to contribute back to medical fraternity and other Faculties of Department of Pharmacology, VIMS, Ballari for their encouragement, our families for their continued support and friends for their appreciation and valuable views.

CONFLICT OF INTERESTS

The authors does not declare any competing conflict of interest.

FUNDING AND SPONSORSHIP

No funds or sponsorship was availed for carrying out this research work.

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