Column: Socioeconomic Impact

Smart Healthcare for Diabetes During COVID-19

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***Abstract*—Diabetic patients are at higher risk from novel coronavirus disease 2019 (COVID-19) that spreads through Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). There are around 20% to 50% of COVID-19 cases who had diabetes across the different regions of the world. This article discusses recommendations and associated risks for diabetic patients to balance glycemic profiles during the COVID-19 outbreak. It also discusses the case study of various countries with impact of COVID-19 for diabetic patients. It presents emerging smart healthcare that can potentially safeguard against COVID-19.**

Diabetes is a condition where a person's body is unable to balance glucose–insulin levels after various prandial modes. Diabetic patients have increased exponentially over the past few years due to their unbalanced diet and unhealthy lifestyle. There are around 463 million diabetic people around the world who can be benefited by smart healthcare technologies to improve their quality of life.[1,2] Diabetes may lead to heart disease, kidney infection, blindness, and nerve damage. It has been observed that Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) has infected diabetic patients largely among the others (see Figure 1). People with diabetes were also more susceptible to the previous pandemic known as Middle East Respiratory Syndrome (MERS) and SARS type of coronavirus along with the H1N1 type of severe influenza during 2009.[3] SARS-CoV-2 has affected mainly elderly people and persons having underlying health conditions .

The various case studies reported diabetes as the major pre-existing comorbidity among COVID-19 patients. The challenges for diabetes patients to control their the blood glucose levels after the infection are due to the following.[4]

1) The fluctuation of blood sugar affects the immunity of a person which exposes him

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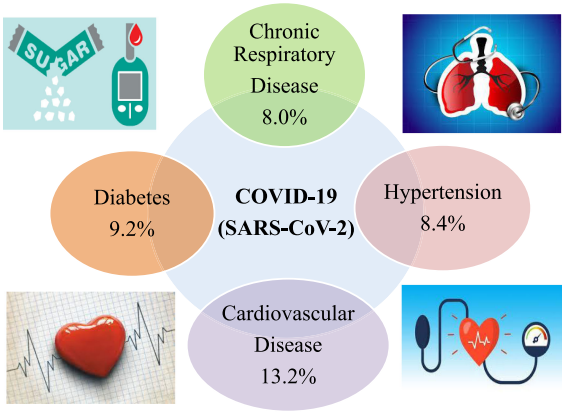

Figure 1. Comorbidities for COVID-19 patients.

against COVID-19, and an unbalanced glycemic profile may lead to longer time of recovery for the patient.

2) The high blood glucose allows the virus to infect the human body easily.

DIABETES PATIENTS: WHY AT HIGH RISK

Elevated glucose levels put diabetic patients at higher risk (see Figure 2). The insulin generation is difficult during infection and high fever also inhabits the control of the glucose level in the blood. This would lead to a severe problem known as Diabetic Ketoacidosis where the body is not generating enough insulin to burn excess amount of generated ketones in the body.[5]

It has been observed that the cellular receptor also known as Angiotensin-Converting Enzyme 2 (ACE2) binds easily with the virus in comparison to earlier SARS-CoV. ACE2 leads to the damage of pancreas islets to have a hyperglycemia state which results in insufficient insulin secretion for blood glucose control.[6] In general, the overall immune system is affected and the body is exposed to fight against COVID-19. Hence, it is the necessary to continuously monitor the glucose level for the diabetic person to avoid COVID-19 infection.[7]

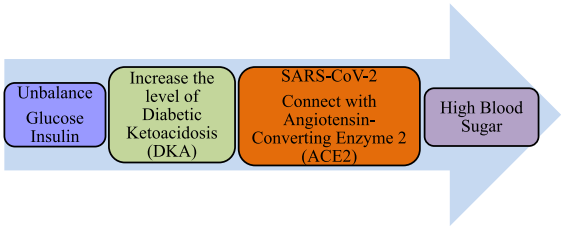

Figure 2. Unbalanced glycemic profile with COVID-19 infection for diabetes patients.

CHALLENGES OF DIABETIC PATIENTS DURING COVID-19

The COVID-19 outbreak has immensely affected the mental health of the people around the globe.[8,9] This has lead to anxiety from the virus infection, concern of losing the jobs as well as the consciousness of being away from loved ones for a longer time. Subsequently, the depression built among the diabetic patients would lead to an unbalanced diet.[10] Therefore, it may be beneficial to take certain self-measures by remotely consulting with nutritionists, endocrinologists, physician, diabetes educators, and psychiatrists at the time of COVID-19. The lock down and imposed restrictions on the movement by higher authorities has made it difficult for diabetic patients to control their glycemic profile.

There are several challenges for self-management of diabetes during COVID-19 including the following.

- Lack of awareness of self-care devices to manage diabetes properly.
- Lack of awareness on smart healthcare technologies such as mhealth and telemedicine.
- Lack of a diet plan to avoid the use of saturated fats and high carbohydrates for controlling the glycemic profile.
- Lack of access to have cost-effective solutions for medical emergency.
- Reluctant approach toward telemedicine and remote monitoring from medical fraternity because of the legal barrier.

BRIEF CASE STUDY OF DIABETIC PATIENTS AROUND THE WORLD IN COVID-19

India has a population of 77 million people with diabetes. Long-term complication of this population due to COVID-19 can be avoided by fixing many health conditions including sugar levels, blood pressure, and cholesterol levels. Various

studies conducted in China bestowed higher risk in terms of mortality of diabetic patients as 7.3% in comparison to the overall rate of 2.3%.[11] In Russia, the patients in intensive cars were seen with diabetes along with heart disease and chronic obstructive pulmonary disease.[12]

Australia addressed the threat of COVID-19 pandemic with help of various products like insulin supply and medicines under National Diabetes Services Scheme especially for diabetic people.[13]

There are more than 59 millions diabetic people in Europe with approximately 26% suffering from either type-1 or type-2 diabetes in the total death in the U.K. due to COVID-19.[14] In Italy, the University Hospital of Padova conducted a study on hospitalized patients, where 8.9% were diabetic in nature. In Spain, the reports suggested that the prevalence rate of diabetes cases is around 12%.[15]

In USA, approximately 34.2 million people are diabetic or prediabetic including 14.3 million senior citizens reported in 2018.[16] With 32% patients in intensive care units due to COVID-19 had diabetes, whereas 24% hospitalized patients had diabetes.[17] Only 6% diabetes patients with COVID-19 infection did not seek any medical attention. However, it is not evident whether type-1 or type-2 diabetes patients are at more risk.

There are nearly 71.2% people suffering from hyperglycemia cases of diabetes in Brazil who have been observed bigger threat from COVID-19 infection.[18]

NOVEL SMART HEALTHCARE TECHNOLOGIES FOR DIABETES DURING COVID-19

Self-Glucose Measurement Through Noninvasive Device and Its Automatic Control

Continuous glucose measurement is helpful for diabetic patients. It helps in controlling the glycemic profile after insulin secretion, medication, and physical activity. Our intelligent noninvasive glucometer is suitable for frequent glucose level measurements (see Figure 3).[1,2] Avoiding high blood glucose is key as it results in high ketone. It is important to control these ketone levels down in order to minimize the chances of infection.

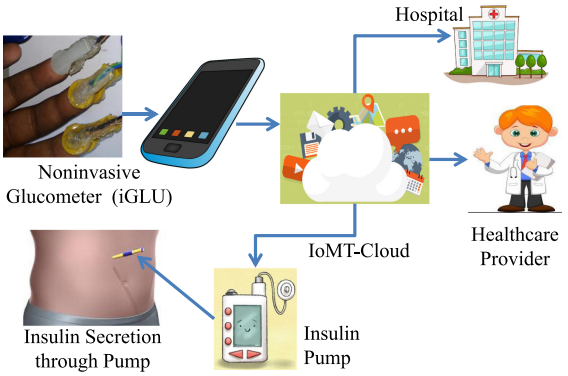

Figure 3. Intelligent noninvasive glucose monitoring and its control by iGLU.[1,2]

iGLU is integrated with the Internet of Medical Things (IoMT) in a Healthcare Cyber Physical System (H-CPS) Framework. H-CPS helps patients to schedule their diet plan and provide them an automatic insulin injection under the observation of a caretaker/diabetologist.

Diabetes Care Through Telemedicine

Telemedicine paved a path for diabetic patients during COVID-19 as social distancing has restricted visits to doctors.[19] Also, it has affected patient's glucose–insulin profile and hyperglycaemic components. The accessibility to telemedicine can be in forms like text e-mails, short messaging services, chats on social media platforms, and by using teleconferencing. The penetration of telemedicine is expected to grow gradually with advances in digital technology. It is also useful for physicians where they can connect with patients for medical diagnosis and provide them guidance to control glucose and blood pressure. This telemedicine platform serves to overcome the geographical barrier and also allows the doctor in the urban territory to consult patients with an appropriate treatment. The revolution in technology would certainly help diabetes patients during such an unparalleled situation to reduce the exposure toward infection.

Intelligent Diet Control for Glucose–Insulin Balance

Improper and unhealthy diet results in several health issues. Diabetic patients are required to take care of their diet in order to maintain glycemic profile. An IoMT-based automatic glucose–insulin model helps in observing their diet closely and

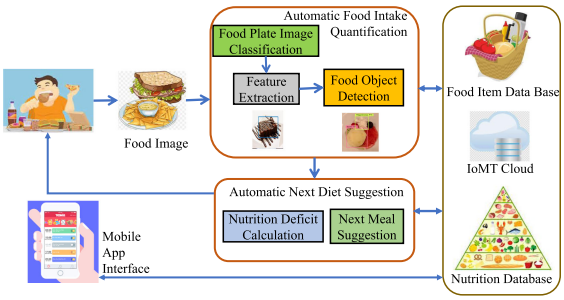

Figure 4. Diet automatic monitoring and control for blood glucose management.[10,20]

plan their food habits on daily bases (see Figure 4). The device known as iLog is useful to educate user for consumption of proper food intake.[10,20] It works on a mobile application where images of foods are taken and it calculates the calories and its nutrition value. It is an automatic platform for maintaining healthy life style through continuous monitoring of daily food intake at the user end.

Wearable Safety-Aware Mobility Tracking Device

The spread of COVID-19 is due to close contact with an infected person. It is necessary to use an IoMT-integrated device for everyone that can alert the existence of any other infected and/or anyone who came in close contact with an infected one within a radius of 6 to 13 feet.[21] The devices can monitor a COVID-19 patient and store the information on a cloud server using an H-CPS framework. This would be useful for diabetic patients to take care of their health during a pandemic situation. Each device is able to accumulate some information like device ID, time stamp, and time period of every device having contacted in the last 14 days within a 6 feet distance. This would trace out for diabetic people to take care of their health during this crisis time.

Rapid Detection of COVID-19

The detection of COVID-19 is necessary to inhabit the prevalence of a virus among people who have underlying diabetes. There is a need of the solution that can provide an accurate, portable, and rapid solution for coronavirus detection. The near-infrared spectroscopy has been applied effectively to detect hepatitis B and C and Zika virus instantly.[22] A similar optical technique can be applied for COVID-19 detection. The light of specific wavelength is used to find the presence of virus in saliva of the person. The proposed system carries emitters and detectors of a specifical wavelength selected juridically along with acquisition and processing using data converters. The logged value from the system is processed subsequently through machine learning models. The system can be integrated with an IoMT-based H-CPS framework to store data of patients at periodical intervals.[23]

CONTEMPORARY SOLUTIONS DURING COVID-19

Role of Industry 4.0

The COVID-19 outbreak has raised the demand in healthcare facility especially for diabetes patients (including insulin pump and glucometer) in self-care management. Industry 4.0 plays a major role in essential services related to medical management using smart manufacturing.[24] These smart solutions for diabetes patients are required in order to provide real-time point-of-care services using Industrial Internet of Things. Industry 4.0 solutions would help to create a connected environment for providing useful information. This information can be used to improve health services, address necessary preventive actions, and help in the process of vaccine development without any human intervention.

Food Supply Chain

Internet-of-Agro-Things along with the blockchain technology has potential for helping the suppliers to ensure safe and confirm food delivery to the consumers.[25,26] Healthy diet is must for the people suffering from chronic diseases such as diabetes to boost their immunity. The adulterated and counterfeit food consumption lead to higher chances of infection. In the present scenario, everyone must ensure food quality using agriculture cyber-physical system. It is need of the hour to develop a cost-effective portable solution to measure the quality of food. It is a must for diabetic people to have healthy diet during the pandemic outburst such as COVID-19.

Robotics-Based Technologies

Robotics can play a significant role during such a pandemic outbreak. They can ensure quality of

service in healthcare, teaching, entertainment, and other useful communal services.[27] They can be effective in other crucial day-to-day services like transportation, hotels, hospital, and similar places of public services where the social distancing is unavoidable. Telerobot can assist in preventive actions with autosensing capabilities and other intelligent techniques. The social robot can help in housekeeping, food delivery, cleaning, and other essential tasks of sustainability with proper safety measures. The usage of robotic applications has shown the exponential growth during this crisis situation, and self-belief of people would help to adapt in daily life.

CONCLUSION

This article intends to create awareness for diabetes patients (may be applicable to all) with contemporary technologies for smart health during the COVID-19 outbreak. The literature study shows that diabetes patients are more vulnerable to SARS-CoV-2. The chances of getting infected prediabetic patients are 2–3 times more than those of nondiabetic patients. The balanced glucose–insulin level would help in the prevalence as well as reducing the morbidity rate of coronavirus. This article briefly discusses stress management, glucose–insulin management, and diet management for diabetes patients. There is a requirement of smart healthcare to tackle the pandemic situation more effectively. However, there are a few substantial technologies available for healthcare, it is a requirement to have an intelligent long-term plan to fight against such a pandemic in future in order to minimize the impact across the globe using an IoMT-based H-CPS framework.

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