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Review

COVID-19 among people with diabetes mellitus in Saudi Arabia: Current situation and new perspectives

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A B S T R A C T

Background and aim: This review aims to report the current status of COVID-19 among people with diabetes, newly diagnosed diabetes, diabetic ketoacidosis, and programmatic efforts including vaccinations.
Methods: We conducted a literature search using PubMed, Google, and Scopus until July 15, 2021.
Results: In Saudi Arabia, most studies have reported diabetes as one of the highly prevalent comorbidities among patients with COVID-19. Currently, there are limited studies from Saudi Arabia on the newly diagnosed diabetes and diabetic ketoacidosis caused by COVID-19. The Saudi ministry has taken several measures to control the impact of COVID-19 among people with diabetes, including comprehensive guidelines and prioritized vaccinations. During the COVID-19 pandemic, the use of telehealth services dramatically increased in diabetes clinics in Saudi Arabia.
Conclusions: Focused and evidence-based interventions are essential to control the impact of COVID-19 among people with diabetes.

1. Introduction

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is a novel type of Coronavirus that causes Coronavirus Disease 2019 (COVID-19), which has been the most challenging ongoing pandemic in this 21st century [1,2]. As of July 15, 2021, the World Health Organization (WHO) stated that there were approximately 188,128,952 confirmed cases, 4,059, 339 deaths, and a total of 3,402,275,866 vaccine doses have been administered worldwide [2]. Currently, the WHO is bringing the global health professionals and scientists together to speed up the research and development procedure and develop new standards and norms to contain the spread of the Coronavirus and help care for affected people [3].

It is evident that COVID-19 and diabetes mellitus (DM) significantly impact global health worldwide, including Saudi Arabia [4,5]. From the initial period of the COVID-19 pandemic, patients with diabetes have been documented as having a higher susceptibility to the infection and carrying a higher mortality risk from this disease [6,7]. Furthermore, in previous infectious disease epidemics (SARS and MERS), a high glucose concentration was shown to be an independent predictor of mortality and morbidity; this is also likely to be the case for COVID-19 [8,9].

In Saudi Arabia, given the high nationwide prevalence of diabetes, these individuals represent a large vulnerable segment of the COVID-19. As of July 15, 2021, Saudi Arabia has seen 506,125 cases (486,918 recovered), with 8035 confirmed deaths [10]. The increased rate of patients who have diabetes combined with COVID-19 in Saudi Arabia recommends that the care for patients with diabetes must be increased to reduce any further complications and the risk of death [4,5]. In this current review, we explain the current status of COVID-19 among people with diabetes, newly diagnosed diabetes, diabetic ketoacidosis, and programmatic efforts including vaccinations.

1.1. Search strategy

Data were collected using PubMed, Google, and Scopus with specific keywords until July 15, 2021. No criteria for publication data were set, and all relevant articles published in the English language were retrieved and reviewed. The keywords like

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epidemiology, COVID-19, SARS-CoV-2, Coronavirus, diabetes mellitus, comorbidities, clinical characteristics, pandemic, type 2 diabetes (T2D), type 1 diabetes (T1D), and Saudi Arabia were used to find the relevant articles. We used these words either individually or in combination in order to reach a comprehensive literature search.

2. Why diabetes is important?

According to the ninth edition (2019) of the International Diabetes Federation (IDF) Diabetes Atlas, point out that 463 million adults are currently living with diabetes around the world, and in Saudi Arabia, 18.3 % (4,275,200) of the adult population are living with diabetes, and many more are being identified as pre-diabetic [11]. As diabetes ranks high on the list of significant health problems in Saudi Arabia, it is crucial to focus on the COVID-19 occurrence among people with diabetes [12,13]. Earlier studies stated that diabetes is interrelated with low-grade chronic inflammation stimulated by excessive visceral adipose tissue. This condition of inflammatory interrupts the regulation of homeostatic glucose and peripheral insulin sensitivity. An abnormal and ineffective immune response can determine chronic hyperglycemia and inflammation [14,15]. Besides, recent studies have shown that patients with diabetes and severe COVID-19 showed a severe inflammatory response and were more likely to get mechanical ventilation and have higher mortality compared to non-diabetics [16−19]. Indeed, the mortality rate of 81 % reported by an earlier study in patients with diabetes with severe COVID-19 disease (48 % in those without diabetes) is distressing the people with diabetes [16]. Further, studies reported that patients with T1D and T2D possess similar adjusted odds ratios for hospitalization (3.9 for T1D vs. 3.36 for T2D), the severity of illness (3.35 vs. 3.42), and in-hospital mortality (3.51 vs. 2.02) [17−19]. A large number of scientific evidence about COVID-19 showed that 11−58 % of all COVID-19 patients have the co-morbidity of diabetes, and 8 % COVID-19 mortality rate has been observed among patients with diabetes [20−26]. The risk for intensive care unit (ICU) admissions in COVID-19 patients with diabetic comorbidity is 14.2 %, higher than those without diabetes [24]. A Saudi study also stated that the death rate was significantly higher in patients with diabetes than in the non-diabetes group, with diabetes patients generally having worse clinical symptoms and metabolic profiles than their non-diabetes counterparts [27]. These studies clearly indicated that people with diabetes are more likely to have severe complications from COVID-19 and required careful nursing. Compared to people without diabetes, a higher vulnerability of severe illness from SARS-CoV-2 detected among diabetes due to several reasons, significantly, the immune system is compromised, which makes it resistant to fight the virus and likely leading to a lengthier recovery period, and the virus may thrive in an environment of raised blood glucose. It should be noted that patients with diabetes had a higher level of white cell count, neutrophil count, C-reactive protein, lactic dehydrogenase, Interleukin (IL) 2R, IL-6, IL-8, D-dimer, N-terminal pro-B-type natriuretic peptide (NT-proBNP), and a lower lymphocyte count. These findings suggest a higher proinflammatory cytokine response among diabetes than non-diabetics [16,28].

2.1. Current situation in Saudi Arabia

From a few research works done in Saudi Arabia, diabetes has been identified as one of the predominant risk factors for COVID-19 (Table 1). The results from a multi-center, retrospective, cross-sectional study, performed from March 1, 2020, to March 31, 2020, across all parts of the country, revealed a high percentage of diabetes among the COVID-19 positive patients (from the 220

reported comorbidities, 83 had diabetes) [29]. From a retrospective study in March 2020 done on 648 COVID-19 patients in healthcare facilities across all parts of Saudi Arabia, 73 (11.3 %) COVID-19 patients were found to have diabetes [30]. In another retrospective, a single-center study was performed at Al Noor Specialist Hospital, Mecca, using 150 COVID-19 patients (from March 12 to 31 of 2020). 26 % of the patients were reported to have diabetes, among the cases hospitalized [31]. In yet another study, done from March 1, 2020, to April 5, 2020, on 82 adult COVID-19 patients in total, 26 % of them were identified as having diabetes [32]. One of the studies performed at King Saud University Medical City in Riyadh from March 22, 2020, to May 31, 2020, using 99 COVID-19 patients undergoing hospitalization, found diabetes to be the most frequent (31.3 %) comorbidities in this group [33]. At the Prince Mohammed bin Abdul Aziz Hospital in Riyadh, a descriptive, cross-sectional study was performed from March 1, 2020, to May 20, 2020, using 458 COVID-19 patients, where 62 (13.6 %) patients were found to have diabetes [34]. At King Abdullah Hospital in Bisha Province, Saudi Arabia, another retrospective study was done from March 20 to June 30, 2020, where 37 (27 %) of the 137 patients revealed diabetes [35]. In King Saud Medical City, Riyadh, Saudi Arabia, 768 COVID-19 patients were used in a record-based, case-series study, from March 23, 2020, to June 15, 2020, where 96.3 % were identified with the presence of more than one comorbidity of which the most frequent was diabetes mellitus (46.4 %) [36]. Another study from King Saud Medical City, Riyadh, Saudi Arabia, conducted from March 1, 2020, to June 30, 2020, found diabetes to be the most frequent (37.3 %) comorbidities among COVID-19 patients [37].

A descriptive, cross-sectional study performed at five tertiary care hospitals in Riyadh, Saudi Arabia, from April 22, 2020, to May 21, 2020, using 401 COVID-19 patients, 41 (10 %) were reported to have diabetes [38]. Later, at Prince Sultan Military Medical City, Riyadh, a large, retrospective, three-month study was done on a total of 7260 COVID-19 patients from May 2020 to July 2020. The results reported 920 (12.6 %; including patients isolated at home) as having T2D [6]. Further, it was clear that the older individuals with diabetes, and those showing higher HbA1c levels, as well as patients with comorbidities like hypertension, cardiovascular disease, cerebrovascular disease, chronic pulmonary disease, chronic kidney disease, malignancy, and those requiring insulin treatments, had a greater likelihood of requiring hospitalization [6]. At King Saud University Medical City and King Khaled University Hospital, Riyadh, Saudi Arabia, a retrospective study performed on 439 patients showed the DM prevalence was 68.3 %, a result drawn from available records and newly diagnosed cases. The study also revealed that individuals with diabetes showed a much higher death rate (20.5 % versus 12.3 %) and lower survival time than patients without diabetes [27]. Further, another study done with 300 adult patients carrying confirmed SARS-CoV2 infection and hospitalized at King Salman Hospital from May 1 to July 31, 2020, showed T2D as the most typical comorbidity in 45.7 % of those affected with COVID-19 disease [15]. A study conducted among 566 patients at Security Forces Hospital in Riyadh, Saudi Arabia, between March 15 and June 30, 2020, showed that the most common comorbidity was diabetes (21.8 %; 123/566) [39]. It is noteworthy that the Ministry of Health (MOH) in Saudi Arabia confirmed that approximately 50 % of the COVID-related deaths among the critical cases present in an ICU were from among patients experiencing chronic diseases such as diabetes [40]. A recently published study stated that DM significantly more prevalent in hospitalized patients than in non-hospitalized patients, and patients with diabetes had a 52.1 % higher risk of hospitalization than patients without diabetes (OR = 1.52) [41].

Concerning T1D, a study from Saudi Arabia done in recent times revealed that only a few numbers (32, 0.44% T1D compared to 920,

Table 1
Prevalence of COVID-19 among patients with diabetes in Saudi Arabia.

Publications	Duration	Study design	Study setting	Prevalence
Alsofayan et al., 2020 [29]	March 2020 to March 31, 2020	Retrospective cross-sectional study	Multi-Center	7.6 % (85/1519)
Khan et al., 2020 [30]	March 2020	Retrospective cohort study	All regions of Saudi Arabia	11.3 % (73/648)
Shabrawishi et al., 2020 [31]	March 12, 2020 to March 31, 2020	Retrospective case series study	Al-Noor Specialist Hospital, Makkah, Saudi Arabia	26 % (38/150)
AlJishi et al., 2020 [32]	March 1, 2020 to,April 5, 2020	Observational descriptive study	Qatif Central Hospital, Eastern province, Saudi Arabia	26.8 % (22/82)
Barry et al., 2020 [33]	March 22, 2020 to 31st May 2020	Retrospective study	King Saud University Medical City, Riyadh, Saudi Arabia	31.3 % (31/99)
Alqahtani et al., 2020 [34]	March 1, 2020 to May 20, 2020	Descriptive, cross-sectional study	Prince Mohammed bin Abdul Aziz Hospital, Riyadh, Saudi Arabia	13.6 % (62/458)
Ibrahim et al., 2020 [35]	March 20, 2020 to June 30, 2020.	Retrospective study	King Abdullah Hospital in Bisha Province, Saudi Arabia	27 % (37/137)
Abohamr et al., 2020 [36]	March 23, 2020 to15th June 2020	A record-based case-series study	King Saud Medical City, Riyadh, Saudi Arabia.	46.4 % (356/768)
Al-Omari et al., 2020 [38]	April 22, 2020 to May 21, 2020	Descriptive, cross-sectional study non-intensive care unit only)	Dr. Sulaiman Al-Habib Medical Group's hospitals, As-Suwaidi, Rayan, Al-Takhassusi, Olaya and Al-Hammadi hospital, Riyadh, Saudi Arabia	10 % (41/401)
Al Hayek et al., 2020b [6]	May 2020 to July 2020	Retrospective study	Prince Sultan Military Medical City, Riyadh, Saudi Arabia	12.6 % (920/7260)
Alguwaihes et al., 2020 [27]	May 2020 to July 2020	Retrospective study	King Saud University Medical City -King Khaled University Hospital, Riyadh, Saudi Arabia	68.3 % (300/439)
Sheshah et al., 2021 [43]	May 1, 2020 to July 31, 2020	Retrospective study	King Salman Hospital, Riyadh, Saudi Arabia.	45.7 % (137/300)
Ghoraba et al., 2021 [39]	15th March to June 30, 2020.	Descriptive, cross-sectional study	Security Forces Hospital, Riyadh, Saudi Arabia	21.8 % (123/566)
Talib et al., 2021 [37]	March 1, 2020 to June 30, 2020.	Retrospective study	King Saud Medical City (KSMC), Riyadh, Saudi Arabia	37.3 % (257/689)
Type 1 diabetes				
Al Hayek et al., 2020a [42]	May 2020 to July 2020	Retrospective study	Prince Sultan Military Medical City, Riyadh, Saudi Arabia	0.44 % (32/7260)
Sheshah et al., 2021 [43]	May 1, 2020 to 31st July 2020	Retrospective study	King Salman Hospital, Riyadh, Saudi Arabia.	1.7 % (5/300)

12.6% T2D) of patients visited the hospital for COVID-19 treatment during the three-month study tenure (May to July 2020) [42]. Of these, 21.9 % required hospitalization, with diabetic ketoacidosis (71.4 %) being the most typical reason for the admission. The study concluded that more COVID-19 patients with T1D were able to adopt conservative treatment at home and make a complete recovery [42]. In another study done using 300 adult patients having confirmed SARS-CoV2 infection and hospitalized in King Salman Hospital (KSH) from May 1 to July 31, 2020, low number of T1D (1.7 %) was reported as comorbidities [43]. The MOH report in Saudi Arabia further demonstrated that children constituted the lowest proportion of confirmed COVID-19 cases, with no significant difference being evident in the recovery percentage between the healthy children and those with comorbidities like diabetes [42]. There are several reasons offered for the low incidence of COVID-19 in the patients with T1D, particularly that T1D was noted among the younger age classes and had a lower incidence compared with the number of patients with T2D in general populace. Further, as children possess a less diverse microbiome, the disease severity may be less intense, even if diabetes is one of the comorbidities they possess [44,45].

[46–50]. The proportion of newly diagnosed diabetes widely varying (from 0.6 % to 46.2 %) in COVID-19 patients, the majority of COVID-19 patients had severe or critical illness [51]. A meta-analysis of eight studies with more than 3700 patients displays a pooled percentage of 14.4 % for newly identified diabetes in hospitalized COVID-19 patients [51]. At present, there is a dearth of studies regarding newly diagnosed diabetes among patients with COVID-19 in Saudi Arabia. In a case series from Saudi Arabia stated that out of five reported COVID-19 cases, three were known to have preexisting diabetes and two with newly diagnosed diabetes based on the significantly elevated HbA1c levels during hospital admission [52]. The pathophysiology of the SARS-CoV-2 infection can subjective to hyperglycemia, and the heightened inflammatory cytokine storm can overlap with the metabolic chronic inflammatory condition attributable to the metabolic syndrome, which causes DM [53]. These findings are shown the direct damage to the pancreatic β-cells by the virus that resulted in acute hyperglycemia and transient T2D [54]. Hence, COVID-19 patients with newly diagnosed diabetes should be managed timely, properly, and carefully monitored for the emergence of full-blown diabetes and other related disorders in the long term [51].

2.2. New-onset diabetes in COVID-19

Intriguingly, emerging evidence shows that newly diagnosed diabetes is often detected in severe or critical COVID-19 patients. Reports have revealed that newly identified diabetes may confer a higher risk for poor prognosis of COVID-19 and had the highest risk of mortality than people without diabetes and pre-existing diabetes

2.3. Diabetic ketoacidosis

During the pandemic, the SARS-CoV-2 infection has been reported to cause diabetic ketoacidosis (DKA) and induce DKA in patients with and without diabetes [53,55–57]. In a study done among 658 Chinese hospitalized patients with confirmed SARS-CoV-2 infection, 42 (6.4 %) patients presented with ketosis; 27

out of 42 patients did not have a past history of diabetes [55]. At this time, there is a lack of studies regarding diabetic ketoacidosis among patients with COVID-19 in Saudi Arabia. However, an existing study from Saudi Arabia reported that 83 % were admitted for DKA during the lockdown, which was higher than 2019 (73 %; risk ratio = 1.15), after adjusting for age and sex [58]. Therefore, ketosis and ketoacidosis should be examined in all hospitalized COVID-19 patients to decline the morbidity and mortality risks [53].

2.4. Efforts to control COVID-19

The government of Saudi Arabia had implemented timely measures to decline the virus transmission before COVID-19 being declared as a pandemic [58]. However, in March 2020, after the WHO announces the COVID-19 outbreak a pandemic, and owing to an increase in infected cases, Saudi Arabia executed further defensive measures, comprising a nationwide lockdown, closing of schools, international and national travel restrictions, postponement of elective procedures and non-essential visits to hospitals to combating COVID-19 [58,59].

The Saudi Society of Diabetes (SSD) provided clinical care guidelines for diabetes during the COVID-19 pandemic that covered glycemic target, a management plan for different types of diabetes, the therapeutic principle of glucose management, management plan according to the COVID-19 severity, glucose management of patients treated with glucocorticoids and glucose management of children and adolescents with COVID-19 [4,5,60]. In addition, the MOH of Saudi Arabia has provided a guideline for diabetics to be a reference during the COVID-19 pandemic, which comprises measures to avert the COVID-19 disease. Moreover, the MOH of Saudi Arabia provided a general summary of COVID-19 management and treatment guidelines for patients with different comorbidities, including DM [40]. Furthermore, the Saudi National Diabetes Center (SNDC) in the Saudi health council prepared the guidance aiming the specialists of health care in the management of diabetes during the COVID-19 pandemic, which comprised the recommendations of the emergency room visit, outpatient management of diabetes to control COVID-19, guidelines of admission and inpatient management of COVID-19 for people with diabetes [4,61].

The Saudi MOH has implemented several informatics tools to deliver public health information for individuals and the community. The private sectors and the government of Saudi Arabia developed and launched about 19 apps and platforms that help public health functions and provide health care services [62]. The Saudi Data and Artificial Intelligence Authority (SDAIA) created two Smartphone apps (1) Tawakkalna, a GPS-enabled app to monitor and restrict the people's movement during curfew hours with the capacity to issue permits for exceptions, and (2) Tabaud, whose name means "Distancing", sends the identified information to people who come near by contact with confirmed cases of COVID-19 [63]. The app follows the international Google and Apple guidelines on data privacy. Any residents or citizens who have symptoms or request an examination can use the self-assessment service on 'Mawid' application or can visit one of the 237 (Tetamman) clinics dedicated by the Saudi MOH to helping people who show COVID-19 symptoms [64].

2.5. Possible solutions and recommendations

(a) In Saudi Arabia, the COVID-19 pandemic still exists; therefore, it is suggested that a well-planned and structured educational program should be commenced to upsurge the awareness and contribute to better practice among people with diabetes [22,65].

(b) It is also suggested that patients with diabetes need to adopt the MOH instructions to prevent being infected. However, patients developing symptoms of COVID-19 disease should immediately inform healthcare services to find out the necessities for assessment of severity, diagnostic evaluation, isolation, and hospitalization. For the reason that there is a higher risk of adverse effects, patients with diabetes should be preferentially managed in hospitals or settings where close monitoring of disease progression is possible [22,65].

(c) Patients who are infected by COVID-19 are recommended to follow guidance for homestay procedures for COVID-19, which is available on the Twitter page (@saudiMOH937) and awareness platform of Saudi Arabia. The guidelines provide several tips for home isolation patients, such as stay calm, psychologically stable and to strengthening immunity [66].

(d) For patients who are managed at home, regular telephone contact with healthcare services and follow-up is essential to recognizing deterioration in glycemic control, hyperglycemic emergencies, or clinical status deterioration [65].

(e) During the COVID-19 pandemic, if patients with diabetes maintain good glycaemic control, which will be critical in maintaining low vulnerability and protection from the severe effects of COVID-19.

(f) The most important fundamental principles of care for mild outpatient cases are; regular glucose monitoring, a patient-tailored therapeutic approach, and following the medical recommendations regarding lifestyle measures and drug treatment.

(g) For critically ill hospitalized patients with COVID-19, tight monitoring of glucose, fluids, electrolytes, pH, and blood ketones is paramount to improving the outcomes [67]. Hence, for people with diabetes and COVID-19, regular glucose monitoring, a healthy diet, adequate hydration, and dose titration of glucose-lowering medication in liaison with healthcare providers should be prioritized [22,65].

(h) In patients with T1D with COVID-19 and hyperglycemia, it is essential to monitor the blood glucose and ketone levels, maintain hydration and continue insulin therapy [22,65].

(i) People with diabetes who have not yet been infected with the SARS-CoV-2 should improve their metabolic control as necessary as means of primary prevention of COVID-19 disease. Further, diabetes patients should also be encouraged to follow general advice from the WHO, IDF, Centers for Disease Control and Prevention (CDC), American Diabetes Association (ADA), and Saudi MOH guidelines about handwashing and physical distancing [68].

(j) It is well demonstrated that a large number of patients with T2D have other components of the metabolic syndrome, including but not limited to hypertension and dyslipidemia. Therefore, continuation with an appropriate antihypertensive and lipid-lowering regimen in all patients with diabetes is essential.

(k) A higher number of patients with T2D are living with the conditions of overweight or obesity. Several studies stated that obesity is an independent risk factor for the vulnerability of COVID-19, the severity of COVID-19 and substantially increased the risk of hospital admission. In the earlier viral pandemics have also revealed that obesity, especially severe obesity (BMI > 40 kg/m2), is connected with a higher risk of hospitalization, critical care admission, and fatalities [69]. Hence, in the current pandemic, obese people with diabetes should be included as one of the clinically vulnerable groups, particularly patients having morbid obesity (BMI > 40 kg/m2) [70].

(l) During the hospital admission, diabetes patients with COVID-19 have a wavering level of insulin necessities due to factors such as concomitant medications and altering pathophysiologic conditions. Therefore, patients with T1D, T2D managed with insulin, or T2D not managed at home with insulin who have elevated blood sugar in the hospital should have scheduled insulin while inpatients.

(m) Although it is essential to ensure that patients receive regular glucose monitoring while on insulin therapy and control their blood glucose at home to prevent severe COVID-19 infection, medication use is also considered in the outpatient setting [68,71].

(n) A study from Saudi Arabia stated that the pandemic had caused a disruption in the diagnosis of diabetes, which apparently increased the frequency of DKA and severity, which highlights that healthcare access to undiagnosed and diagnosed people with diabetes should continue in the standard level of care during pandemics.

(o) The healthcare workers should be considered and conscious of the application of clinical programs, and clinical education proposed to increase compliance with the ADA 2021 guidelines for standard of care. As per the ADA standard of care, diabetic centers health specialists must be educated to document appropriately clinical practice procedures [72].

2.6. Telemedicine technology

For new or ongoing medical advice, remote consultations can be used wherever possible during the pandemic to reduce the risk of exposure to Coronavirus for patients with diabetes. Telemedicine technology has been an effective method to deliver care for known and new-onset diabetic patients during this current pandemic. Thus, in such situations in the future, technology and telemedicine should be used to fill the gaps when the healthcare system is overloaded [58,73]. A recent study from Saudi Arabia stated a significant progressive effect of telemedicine care on glycaemic control among high-risk patients with diabetes during the COVID-19 pandemic [74]. As of August 2020, a report indicated that almost 60,000 patients with diabetes benefitted from remote consultation in Saudi Arabia [75]. Telehealth mobile applications such as Seha, Mawid, Tabaud, Tawakklna, and Tetamman have found helpful tools to provide healthcare to people with COVID-19 and tracking of COVID-19 patients. Earlier studies specified that telehealth applications have been essential in controlling the spread of COVID-19 and have helped to flatten the growth curve in Saudi Arabia.

2.7. Vaccination

Within less than twelve months after the beginning of the COVID-19 pandemic, numerous research teams rose to the challenge and developed vaccines to protect from COVID-19. In Saudi Arabia, the BNT162b2 mRNA (Pfizer-BioNtech) vaccine was the first vaccine approved for use from the mid of December 2020. The Oxford-AstraZeneca chimpanzee adenovirus vectored vaccine ChAdOx1 nCoV-19 (AZD1222) was the second vaccine approved for use in Saudi Arabia from February 2021 [76,77]. A study from Saudi Arabia stated that the side effects of post Oxford-AstraZeneca and Pfizer-BioNTech vaccines are not different from those reported in earlier clinical trials, specifying the safe profiles for both vaccines [77]. The government of Saudi Arabia has stated the distribution of vaccines at no cost to all citizens and expatriates, prioritizing individuals with a higher risk of infection, like those having diabetes. As of July 15, 2021, Saudi Arabia's Health Ministry stated that at least 21,533,971 COVID vaccines are administered across 587 sites

in Saudi Arabia [78]. As persons with diabetes tend to develop symptom severity if they get infected with Coronavirus, vaccination is an effective and safe method to control COVID-19, especially in vulnerable people [19].

3. Conclusions

In Saudi Arabia, most studies have reported diabetes as one of the highly prevalent comorbidities among patients with COVID-19. Diabetes management in patients with COVID-19 has several clinical challenges, requiring a much integrated team approach, as this is an essential approach to reduce the risk of medical complications and mortality as much as possible. As diabetes ranks high among the major health issues in Saudi Arabia, we emphasize the necessity for comprehensive researches are an urgent need to provide an enhanced understanding of COVID-19 and its relationship with diabetes to develop and implement evidence-based programs policies in the country.

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Authors' contributions

All authors contributed equally to this work.

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None.

Appendix A. Supplementary data

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