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ORIGINAL RESEARCH

The Impact of COVID-19 Vaccines on the Development of Acute Complications in Type 1 and 2 Diabetes Patients: A Cross-Sectional Study in the Eastern Province of Saudi Arabia

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Background: COVID-19 vaccines were developed to control the pandemic spread as they have been proven to be efficient and safe. However, the likelihood of such postvaccination effects as poor glycemic control and adverse events has been noted in several studies.

Objective: To determine the effect of COVID-19 vaccines on the glycemic control and the development of hyperglycemic emergencies among type 1 and 2 diabetes patients.

Methods: A cross-sectional study was conducted on 409 participants aged 18 years and above with type 1 or 2 diabetes who had received at least a single dose of COVID-19 vaccine.

Results: Among the 409 diabetes patients, a majority reported general mild postvaccination symptoms regardless of diabetes duration or type. After vaccination, severe diabetic emergencies were mostly reported in long-standing diabetes patients. Diabetes-related complications and emergencies were more profound among those who had received the Pfizer vaccine. Nonetheless, occurrence of adverse events could possibly be due to various factors, including the duration of diabetes and COVID-19 infection status.

Conclusion: COVID-19 vaccinations have the potential to influence diabetic patients in regard to acute glycemic complications. However, vaccine efficiency and benefits are superior to the side effects of COVID-19 vaccines, as these adverse events only affect a small number of individuals. A need for postvaccination monitoring of diabetes patients is suggested.

Keywords: diabetes, vaccine, COVID-19, hyperglycemic emergencies, diabetes complications

Introduction

Ever since COVID-19 was announced as a pandemic, many studies have linked it to a wide variety of complications affecting almost all body systems.[1–4] The Centers for Disease Control and Prevention has categorized type 2 diabetes mellitus (T2DM) patients as at increased risk of severe illness and type 1 DM (T1DM) patients as "might be at increased risk" with reference to risk of severity of COVID-19 disease.[5] DM patients are more susceptible to severe COVID-19 due to impaired glycemic control and DM-related complications.[6] Several studies have reported that diabetic individuals have greater morbidity and mortality rates, worse disease progression, and overall poor prognosis in comparison to nondiabetic people with COVID-19.[7,8] DM has been noted as a comorbidity in 8.2% of hospitalized COVID-19 patients, the absolute risk of mortality from COVID-19 was raised to 14% for DM, and the percentage of mortality was 8%, pointing to an urgent need for a vaccination strategy.[9,10]

Multiple highly effective vaccines were manufactured to limit the spread of the virus. The effectiveness of some of the common vaccines — Pfizer–BioNTech, Moderna, and CoronaVac — has been observed to be 91.2%, 98.1%, and 65.7%, respectively.[11] The vaccines were allocated to the general population in several phases based on priority. As

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a result, several uncertainties regarding vaccine safety among diabetic patients have raised concerns.[12,13] However, as the rate of COVID-19 vaccine administration has risen, the postvaccination likelihood of deteriorating glycemic control and developing other adverse events (AEs) has also been reported.[14,15] Multiple studies have suggested that the immunodysregulation triggered by the SARS-CoV-2 vaccine might be a reason for this temporary worsening of hyperglycemia and hyperglycemic emergencies.[16,17] However, the mechanism behind this phenomenon and the frequency of postvaccination diabetic complications are still unclear.[13] Furthermore, acute hyperglycemia, hyperglycemic emergencies such as diabetic ketoacidosis (DKA), hyperosmolar hyperglycemic syndrome (HHS), and variation in glucose levels post–COVID-19 vaccination have been reported in different case series.[16,18–20] It has been believed that these AEs are mainly linked to the stimulation of systemic and/or local inflammation that may possibly impair glucose control in diabetic patients.

People who have recovered from the COVID-19 infection are reported to have a higher chance of new-onset cardiometabolic diseases, including DM, hypertension, and dyslipidemia.[21–23] Studies have also indicated that long COVID-19 syndrome is multifaceted and DM is to be considered a prominent facet, as individuals who have recovered from COVID-19 are at an elevated risk of DM onset. A study conducted on over 2.5 million children concluded that patients who had COVID-19 showed a higher chance of new-onset DM than controls, but the proportions of T1DM and T2DM were not specified.[24] Similarly, studies among adults have also shown increased risk of T1DM within the first 30 days and T2DM after 1 year of infection with SARS-CoV-2.[25,26] Presently, there are multiple cases of COVID-19 vaccine–triggered new-onset T1DM following Pfizer–BioNTech and Moderna vaccinations.[13,27–29]

As DM patients are at greater risk of complications post–COVID-19 vaccination, our study aimed to identify the influence of COVID-19 vaccines on glycemic control in patients with T1DM and T2DM by estimating the incidence of acute glycemic complications post–COVID-19 vaccination. AEs in DM patients after COVID-19 vaccination and the effects of COVID-19 vaccines on the hospitalization rate among DM patients were also estimated.

Methods

This cross-sectional study was conducted in the Eastern Province of Saudi Arabia. The study was conducted according to the ethical principles of the Declaration of Helsinki. The ethical approval was obtained from the Institutional Research Review and Ethics Committee of Imam Abdulrahman bin Faisal University (IRB-UGS-2022-01-445). An online bilingual (Arabic and English) questionnaire was prepared using Google Forms and was randomly distributed through social media (WhatsApp, Twitter, and Telegram) for almost 3 months from December 4, 2022 till March 9, 2023. Informed consent was obtained on the online information page explaining the purpose of the study before participants proceeded to the survey. Personal data were kept anonymous and used for research purposes only.

The study questionnaire was divided into four main sections. The first section was structured to collect sociodemographic data about the participants: nationality, age, sex, marital status, education, occupation, contact number, and place of follow-up for diabetes. The second section included vaccination details, such as number of doses, type of vaccine, date of the second dose, and COVID-19 infection status. The third part contained the medical history, including chronic diseases. Lastly, the fourth section included diabetes history, such as type and duration, whether the patient had diabetes before or after the COVID-19 vaccine, HbA_{1c} reading, diabetes-related complications (DKA, HHS, hyperglycemia, and hypoglycemia), symptoms, and need for hospitalization. Another subsection was included to allow the participants to report other unlisted side effects that they may have experienced.

Subjects

The minimum mandatory sample size was calculated to be 377 at a 95% confidence interval and 5% margin of error using the online sample-size calculator Raosoft (http://www.raosoft.com/samplesize.html). A total of 435 people participated in the survey, among which 26 invalid responses were excluded. The valid response number was 409. T1DM and T2DM patients aged >18 years who had received at least one dose of a COVID-19 vaccine and being followed-up at a primary health-care center or hospital in the Eastern Province were included for the study.

Data Analysis

Data analysis was done using SPSS for Windows version 26.0. Frequencies and percentages are used to describe the categorical data and medians (IQR) to describe continuous variables, such as age and severity score. Frequencies for categorical data among T1DM and T2DM patients was compared using χ^2 tests. These variables included nationality, sex, marital status, occupation, and education. Nonparametric tests were used to compare severity scores across different variables. $P<0.05$ was considered statistically significant.

Diabetes-related symptoms were graded 1–3 based on severity: 1 denoted mild, 2 moderate, and 3 severe symptoms. Mild symptoms included extreme thirst, increased frequency of urination, abdominal pain, weakness or fatigue, shortness of breath, blurry vision, pallor, sweating, tremor, headache, palpitation, and nocturia. Moderate symptoms included dizziness, numbness, and dehydration. Severe symptoms included nausea, vomiting, confusion, fruity-smelling breath, elevated random blood sugar >300 mg/dL, drowsiness, unilateral weakness or paralysis, hallucinations, loss of consciousness, and slurred speech. The total severity score was calculated and categorized: 1–15 for mild, 16–30 for moderate, and 31–40 for severe. Diabetic emergencies, such as, DKA, HHS, hypoglycemia, postvaccination, hospitalization, and presence of comorbidities, were scored 3 for each.

Results

A total of 409 diabetic patients who had been vaccinated against COVID-19 were included in the study, of which 190 (46.5%) had T1DM and 219 (53.5%) had T2DM. The median age was 41 years. The median age of the T1DM group and T2DM was 25 years and 56 years, respectively. There were 134 (70.53%) women in the T1DM group compared to 97 (44.29%) in the T2DM group. Most of the patients were Saudi (93.9%) and only 6.1% were non-Saudis. No significant difference between the T1DM and T2DM groups regarding occupation or education was noted (Table 1).

A total of 267 (65.3%) patients had been administered Pfizer vaccine, followed by Pfizer–AstraZeneca (16.9%) and AstraZeneca (7.3%). Postvaccination complication-related hospital admissions were reported by 52 (12.7%) patients. About 15% of patients who had received the Pfizer vaccine, including 23 with T1DM and 17 with T2DM, had been hospitalized following various AEs. This was followed by Pfizer–AstraZeneca and AstraZeneca, mainly among T1DM patients. In contrast, the lowest hospitalization rate was observed with the Moderna vaccine. T1DM patients had a higher

Table 1 Basic demographic characteristics

	Total	T1DM	T2DM
	(n=409)	(n=190, 46.5%)	(n=219, 53.5%)
Age (years), median (IQR)	41 (25.5–57)	25 (22–32)	56 (45–64)
Nationality			
Non-Saudi, n (%)	25 (6.11)	8 (4.21)	17 (7.76)
Saudi, n (%)	384 (93.89)	182 (95.79)	202 (92.24)
Sex			
Female, n (%)	231 (56.48)	134 (70.53)	97 (44.29)
Male, n (%)	178 (43.52)	56 (29.47)	122 (55.71)
Marital status			
Divorced, n (%)	11 (2.69)	3 (1.58)	8 (3.65)
Married, n (%)	228 (55.75)	57 (30)	171 (78.08)
Single, n (%)	150 (36.67)	130 (68.42)	20 (9.13)
Widowed, n (%)	20 (4.89)	0	20 (9.13)

(*Continued*)

Table 1 (Continued).

	Total	T1DM	T2DM
	(n=409)	(n=190, 46.5%)	(n=219, 53.5%)
Education			
Bachelor's, n (%)	193 (47.19)	122 (64.21)	71 (32.42)
Diploma, n (%)	43 (10.51)	17 (8.95)	26 (11.87)
Elementary, n (%)	29 (7.09)	2 (1.05)	27 (12.33)
High school, n (%)	73 (17.85)	38 (20)	35 (15.98)
Illiterate, n (%)	10 (2.44)	0	10 (4.57)
Middle school, n (%)	33 (8.07)	3 (1.58)	30 (13.7)
Postgraduate, n (%)	28 (6.85)	8 (4.21)	20 (9.13)
Occupation			
Business owner, n (%)	1 (0.24)	0	1 (0.46)
Freelancer, n (%)	1 (0.24)	0	1 (0.46)
Government, n (%)	90 (22)	30 (15.79)	60 (27.4)
Housewife, n (%)	7 (1.71)	2 (1.05)	5 (2.28)
Own business, n (%)	1 (0.24)	0	1 (0.46)
Private, n (%)	101 (24.69)	58 (30.53)	43 (19.63)
Retired, n (%)	33 (8.07)	2 (1.05)	31 (14.16)
Student, n (%)	51 (12.47)	47 (24.74)	4 (1.83)
Unemployed, n (%)	124 (30.32)	51 (26.84)	73 (33.33)

number of ICU admissions than T2DM patients, regardless of the vaccine type. Duration of hospitalization in a majority of the cases was 0–7 days (Table 2).

Symptoms were categorized based on severity score into mild, moderate, and severe. The data revealed that 75% of patients experienced mild and 9% moderate symptoms. However, severe symptoms were noted in 16% of the cases. There was a significant severity-score difference between T1DM and T2DM for the group that took the Pfizer vaccination (P=0.022). Similarly, diabetic emergencies (DKA, HHS, hypoglycemia, hospitalization) postvaccination were scored from 3 to 12 based on the presence of one or all diabetic emergencies. A score of 3 was observed in 41%, followed by 6 in 11.5%, 9 in 4%, and 12 in 1%. Diabetic emergencies were observed more in T2DM patients postvaccination with Pfizer (P=0.001) than T1DM patients (Table 2).

Vaccine efficacy based on postvaccination COVID-19 infection occurrence, duration, and hospitalization are summarized in Table 2. No infection was seen in 58.4% of the total cohort. However, 25.2% of cases had COVID-19 postvaccination. Among the postvaccination infections, a majority of patients (60.2%) were infected after the Pfizer vaccine, followed by 21.3% with the Pfizer–AstraZeneca combination dose. A majority of the patients were infected with COVID-19 4–8 weeks and >8 weeks postvaccination. A majority of the patients infected with COVID-19 pre- or postvaccination did not require hospitalization except for 13% of cases (Table 2).

A total of 103 (25.2%) cases reported being infected with COVID-19 after their first (n=33) or second dose (n=70). For both T1DM and T2DM combined, 62 of 267 Pfizer-vaccinated individuals (23.2%), nine (30%) of 30 AstraZeneca-vaccinated, and 29 (29.6%) of 98 who had had Pfizer combinations with AstraZeneca or Moderna reported COVID-19 infection postvaccination (Figure 1). Hospitalization for DM complications was seen in 18% of T1DM and 9.8% of

Table 2 Overall vaccine safety and efficacy

Type of vaccine	Type of DM	Admitted to		Severity score			Diabetic emergencies				COVID infection status			Period following vaccine when infection occurred			Hospitalization required	
		General Ward	ICU	0–15	16–30	31–45	3	6	9	12	No infections	After vaccination	Before Vaccination	Within 1st 4 Weeks	4–8 Weeks	More than 8 Weeks	No	Yes
AstraZeneca	T1	3	0	13	2	1	4	1	1	0	6	7	3	0	0	1	5	0
	T2	1	0	11	0	3	8	1	1	0	8	2	4	0	0	0	8	1
	P	0.351		0.218			0.285				0.214			0.341			0.679	
AstraZeneca, Moderna	T1	0	0	2	1	0	0	0	0	0	1	2	0	0	0	0	1	0
	T2	0	0	0	1	2	2	1	0	0	2	0	1	0	0	0	1	0
	P	0		0.135			0.05				0.189			NA			0.54	
Moderna	T1	0	0	3	0	0	0	0	0	0	1	1	1	0	0	0	0	0
	T2	0	0	4	0	1	1	0	0	0	4	0	1	0	0	0	0	0
	P	NA		0.408			0.408				0.293			NA			NA	
Pfizer	T1	15	8	102	6	11	40	14	2	2	72	32	15	1	5	1	49	4
	T2	8	9	106	14	28	82	15	8	2	92	30	26	0	3	7	47	11
	P	0.142		0.022			0.001				0.312			0.131			0.18	
Pfizer, AstraZeneca	T1	1	2	24	5	4	7	6	0	0	17	11	5	0	0	2	18	1
	T2	1	0	23	5	8	15	7	2	0	20	11	5	0	0	2	8	3
	P	0.323		0.542			0.076				0.945			0.929			0.182	
Pfizer, AstraZeneca, Moderna	T1	0	1	4	2	0	3	0	0	0	3	2	1	0	0	0	1	1
	T2	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2	0
	P	0.659		0.495			0.35				0.459			NA			0.459	
Pfizer, Moderna	T1	0	1	7	1	2	2	2	1	0	7	2	1	0	0	1	3	0
	T2	1	1	7	0	5	3	0	2	0	6	2	4	0	0	0	5	1
	P	0.645		0.346			0.439				0.425			0.262			0.741	

Abbreviation: NA, not applicable.

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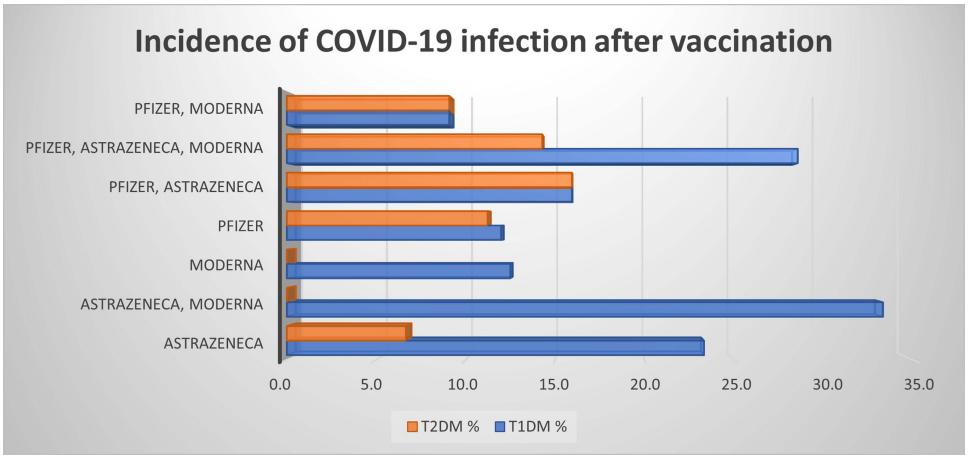

Figure 1 Comparison of COVID-19 infection incidence after vaccination in T1DM and T2DM patients.

T2DM cases (*P*=0.039). Diabetic emergencies post–Pfizer vaccination in non–COVID-19 cases with T2DM were higher (65%) than with T1DM (44%; *P*=0.031). Similarly, in COVID-19 cases before vaccination, recipients of the Pfizer vaccination, 84.6% of T2DM cases, encountered more diabetic emergencies than T1DM cases (46.6%, *P*=0.036; Supplementary Tables S1–S3).

New onset of DM postvaccination was diagnosed 4 weeks after vaccination. It was noted in 24 cases, among which eight cases were diagnosed with T1DM and 16 cases with T2DM. Two doses of the Pfizer vaccine had been administered to 18 new-onset DM cases, and five had combination doses with other vaccines, such as AstraZeneca or Moderna (Table 3). The effects of long-standing DM on vaccine efficacy and AEs are summarized in Table 4. Among 18 T1DM patients who had had severe AEs, nine (50%) had had DM >10 years. Similarly, all T1DM cases who experienced severe diabetic emergencies with a severity score of 12 had had DM >10 years (Table 4).

Likewise, among 219 T2DM patients, a majority (n=20) who had severe AEs after vaccination with a severity score >30 had had DM >10 years. Concerning diabetic emergencies postvaccination, only patients with DM >10 years reported the most severe diabetic emergencies (2.17%) with a diabetic emergency severity score of 12. Most patients, whether T1DM or T2DM, had had mild postvaccination symptoms (severity score of 0–15), regardless of DM duration.

The most common diabetic emergency among T1DM patients was DKA and HHS in T2DM, while hypoglycemia and hospitalization were similar between both groups, regardless of diabetes duration. The overall diabetes diagnosis duration (<1 year to >10 years) did not have a statistically significant correlation with severity score, AEs, or diabetic emergencies (Table 4). Regarding postvaccination COVID-19 infection, the rate of infection postvaccination among T1DM (n=38) and T2DM (n=18) patients was higher in those having the disease >10 years.

Table 3 Distribution of new-onset DM after COVID vaccination

Vaccine	Total new-onset DM cases	Infection with coronavirus							
		No infection		After first vaccination		After second vaccination		Before vaccination	
		T1DM	T2DM	T1DM	T2DM	T1DM	T2DM	T1DM	T2DM
AstraZeneca	1	0	0	1	0	0	0	0	0
Pfizer	18	5	0	0	5	2	6	0	0
Pfizer, AstraZeneca	4	0	2	0	1	0	1	0	0
Pfizer, Moderna	1	0	0	0	0	0	0	0	1

Table 4 Long-standing DM, vaccine efficacy, and adverse events

Type of DM	DM duration	COVID infection			Severity score			Diabetic emergencies				
		No infection	After vaccination	Before vaccination	0–15	16–30	31–45	0	3	6	9	12
T1	Less than 1 year	11	1	1	9	3	1	6	6	1	0	0
	1–5 years	11	11	3	17	2	6	17	6	1	1	0
	6–10 years	20	7	5	29	1	2	16	12	4	0	0
	More than 10 years	65	38	17	100	11	9	66	32	17	3	2
	P	NA			NA			NA				
T2	Less than 1 year	4	1	1	5	1	0	3	3	0	0	0
	1–5 years	33	13	14	38	5	17	22	28	8	2	0
	6–10 years	39	14	8	43	8	10	19	31	4	7	0
	More than 10 years	56	18	18	66	6	20	25	49	12	4	2
	P	NA			NA			NA				

Abbreviation: NA, not applicable.

In the present study, the response to COVID vaccination among T1DM and T2DM had some differences, eg, the most common diabetic emergency among T1DM patients was DKA compared to HHS in T2DM and T1DM patients had a higher number of ICU admissions. However, hypoglycemia, overall hospitalization for adverse effects, and rate of COVID infection postvaccination in those with DM >10 years were similar between the groups.

Discussion

The introduction of COVID-19 vaccinations brought about a drastic reduction in daily COVID-19 incidence by 37.7%, COVID-19–related hospitalizations by 29.9%, and mortality by 18.8% during the COVID-19 pandemic.[30] Earlier studies have confirmed that the risk of DM after COVID-19 infection was higher among the nonimmunized than immunized patients.[31] Therefore, the COVID-19 vaccination drive was a pivotal move in the fight against the global COVID-19 pandemic. However, there were several reports of COVID-19 vaccination-induced hyperglycemia and precipitation of DKA and HHS in both diabetic and nondiabetic subjects. These patients usually presented with typical symptoms, such as nocturia, polyuria, and polydipsia, with some subjects reporting disorientation and lightheadedness.[32]

COVID-19 vaccines were effective in preventing both infection with SARS-CoV-2 and severe COVID-19 complications in adults, but there had been no specific analysis on the diabetic population. Hence, one of the aims of the present study was to assess vaccine safety among the DM population. In general, a majority of side effects reported by 75% of participants were mild, irrespective of the vaccine type. However, about 15% of Pfizer vaccine–administered patients showed a higher number of severe side effects among the DM patients. Pfizer vaccine–administered patients were associated with the highest hospitalization rate and diabetic emergencies, post–COVID-19 vaccination, followed by AstraZeneca. However, severity scores seemed to be higher in T2DM patients across all vaccine types. Earlier studies showed that the Pfizer vaccine was associated with fewer side effects than Moderna and AstraZeneca in the general population.[33,34] A study of seven hyperglycemic emergencies cases following COVID-19 vaccination showed that the AstraZeneca vaccine has the highest number with a total of three cases. However, those patients who had received the

AstraZeneca vaccine had diabetes risk factors, including obesity and dyslipidemia, and two were prediabetic.[13] Also, acute hyperglycemia in one case each of Pfizer and AstraZeneca vaccines has been reported.[35]

It has been observed in previous studies that the immunoresponse in diabetic patients postvaccination was lower than the general population. In a systemic review, it was noted that vaccine effectiveness in DM patients was lower in preventing both SARS-CoV-2 infection and severity of illness.[36] In the present study, most DM patients had had no COVID-19 infection postvaccination. Also, it should be emphasized that among the population who got infected, a major portion of them had received Pfizer or Pfizer–AstraZeneca vaccination. Furthermore, it has been noted that most patients who develop COVID-19 postvaccination acquired it 1–2 months after the vaccination. Except for 13% of the instances, most COVID-19 patients who were infected before or after vaccination did not need hospitalization. However, further laboratory-based studies to check the antibody titers and viral load are required to explore the effectiveness of COVID-19 vaccines in the DM population.

The present study discovered that patients who received the Pfizer vaccine were more likely to develop new-onset DM. Similarly, in a case series four cases reported new-onset T1DM either after a single dose or both doses of the Pfizer vaccine.[27] Another study reported new-onset T1DM manifesting as DKA after the first dose of Pfizer.[28] In addition, two reported cases of new-onset T2DM manifested as HHS following the Pfizer vaccine.[13] One case of T1DM has been reported post–Moderna vaccination.[29] The present study also noted one case of T1DM after the second dose of the Moderna vaccine. A study conducted on T1DM patients who received the Moderna vaccine was reassuring, with no significant change in glycemic control.[37] Another study reported three cases of well-controlled T2DM that experienced transient increases in blood glucose levels after receiving the first dose of Covishield (AstraZeneca) vaccine.[38] Few cases of postvaccination new-onset DM reported hyperglycemic crises being precipitated by the Pfizer and Moderna vaccines. A recent study specifically linked the Pfizer–BioNTech with latent autoimmune diabetes in adults.[30] There are several hypotheses to explain how SARS-CoV-2 can trigger new-onset DM: i) infection-triggered systemic inflammatory response — a "cytokine storm"; ii) disruption of the renin–angiotensin–aldosterone system and angiotensin 1–7 balance leading to detrimental effects on the pancreas; iii) infection stress–induced release of cortisol and catecholamines; iv) destruction of pancreatic β cells by binding to pancreatic ACE2 receptors; and v) polyethylene glycol present in the vaccine acting as an adjuvant and inducing an immunoresponse in predisposed individuals.[30] Aydoğan et al, reported new onset T1DM cases are associated with the mRNA-based SARS-CoV-2 vaccination, BNT162b2 (Pfizer–BioNTech).[27] They concluded that T1DM may occur as a rare phenomenon of autoimmune/inflammatory syndrome induced by adjuvant syndrome, and new-onset DM cases should be evaluated from this perspective.[27]

The relationship between the duration of DM and the experience of postvaccination AEs indicated that 50% of T1DM and 42% of T2DM individuals with DM >10 years had severe AEs. Patients with >10 years of T1DM exhibited all severe diabetic emergencies, such as DKA, HHS, hypoglycemia, and postvaccination hospitalization. In the current study, the T2DM patients who exhibited diabetic emergencies with the highest severity scores were those who had had diabetes >10 years. Similarly, COVID-19 vaccine-triggered hyperglycemic emergencies have been reported in patients who had had T2DM for longer than 10 years.[38] A previous study compared postvaccination effects in two T1DM patients with DM for 5 and 15 years. The former had mild symptoms without affecting the consciousness; however, the latter had severe diabetes-related AEs involving impaired consciousness and severe acidosis.[36] Overall, 66.6% of T1DM and 50% of T2DM patients who developed infections after vaccination had had diabetes for more than 10 years. The disease duration plays a vital role in the development of COVID-19 infection after the vaccination. The present study indicates that long-standing diabetes increases the risk of developing diabetes AEs COVID-19 infection after vaccination.

In the present study, COIVD-19 infection postvaccination was lowest with the Moderna vaccine and highest with the AstraZeneca vaccine (30%), both with higher incidence among T1DM cases. The Pfizer vaccine had 23.2% cases with postvaccination infection, and the incidence was almost same with T1DM and T2DM. Though the overall vaccine efficacy was moderate among DM patients, eight patients (7.8%) with Pfizer vaccination needed hospitalization. Seven of these patients had had DM >10 years. Four patients had diabetic emergencies — DKA and HHS. Diabetes symptoms, diabetic emergencies, and hospitalizations in COVID-19 infection before and after vaccination cases did not vary among vaccines, except for Pfizer (P=0.036). A detailed and specific Pfizer-related outcome study was possible, as a higher proportion, 87.5%, of DM individuals who participated in this study had received Pfizer or Pfizer in combination with

AstraZeneca and Moderna vaccines. In general, all COVID-19 vaccines have proven to be relatively safe and to be effective in the fight against COVID-19. Thereby, the overall benefits outweigh the severe risks associated with vaccine side effects, as these are seen in a considerably small proportion of individuals, which may be due to genetic predispositions or presence of comorbid conditions. However, among DM cases, vaccine efficacy and safety differ from normal individuals. Higher incidence of AEs, DM emergencies, and new-onset DM were seen among COVID-vaccinated DM patients. This was mainly noted to be due to long-standing DM and COVID infection before or after vaccination in some patients. Hence, the overall study outcome emphasizes the need for continuous postvaccination monitoring for rare but potential COVID-19 vaccine-related AEs, especially for the Pfizer vaccine, in the DM population.

Limitations

The primary limitation of the study was recall bias, as a majority of patients could not remember such details as date of vaccination and their $Hb1_{Ac}$ levels. Secondly, participants could not be followed up, as they were from various private and public hospitals in the Eastern Province.

Conclusion

The present study further reiterates the utmost need for prompt monitoring of DM patients following administration of COVID-19 vaccines. There have been inadequate studies exploring the link between vaccine effects and DM. To the best of our knowledge, this is the first cross-sectional study conducted exclusively to address the effect of COVID-19 vaccines on DM patients in Saudi Arabia. Thus, to validate this study further, extended studies on larger DM samples and long-term postvaccination follow-up of different ethnic populations can precisely confirm whether postvaccination-related onset of AEs, postvaccination COVID infection, and postvaccination hyperglycemia and DM emergencies are vaccine-related or dose-specific. Further studies are needed to identify definite molecular mechanisms that trigger new-onset DM and its relationship with SARS-CoV-2 infection.

Abbreviations

DM, diabetes mellitus; T1DM, type 1 DM; T2DM, type 2 DM; AEs, adverse events; DKA, diabetic ketoacidosis; HHS, hyperosmolar hyperglycemic syndrome; HbA_{1c}, glycated hemoglobin; ICU, intensive care unit; NA, not applicable.

Data Sharing

All relevant data are within the manuscript.

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