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# Effects of COVID-19 on Glycemic Control in Type 2 Diabetes Patients at the Medical Preventive Hospital, Imitiga, Tripoli, Libya

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## Abstract

**Introduction:** The World Health Organization (WHO) warns that viral diseases like COVID-19 pose a serious public health problem. The virus has caused millions of infections and deaths worldwide, including in Libya. The clinical features are similar to those of SARS and MERS, with varying degrees of severity depending on age, comorbid conditions, and basal metabolic index. Patients suffering from chronic health conditions are more likely to suffer further complications and the risk of death. The majority of deaths occur in the elderly as well as any age group with the presence of chronic diseases such as Diabetes Mellitus (DM), hypertension, chronic lung conditions, chronic kidney disease, cardiovascular disease, and other immunocompromised individuals. Hispanic ethnic minority groups and those with diabetes have a high risk of infection and high mortality rates. The history of diabetes and hyperglycemia are independent predictors of mortality and morbidity, and controlling diabetes can lead to good regulation of blood sugar to strengthen the immune system and reduce the severity of the disease. The aim of this study is to assess the effect of COVID-19 on glycemic control and identify the changes in biochemical and hematological parameters in subjects with type 2 diabetes at Imitiga Medical Isolation Center.

**Materials and methods:** The study is a cross-sectional observational study on 135 COVID-19 patients with T2DM and 31 non-diabetics recruited from the Medical Preventive Hospital, Imitiga. The study was conducted from December 2021 to April 2022, and patients were randomly sampled using a nonprobability convenience sampling method. Data was collected through questionnaires containing personal and medical information, symptoms, duration of diabetes, drug history, past medical history, and vaccinations. Laboratory tests were conducted within 24 hours of hospital admission, including SARS-CoV-2 RNA isolation and amplification using qRT-PCR kits. Blood samples were collected from participants after fasting for 12 hours and analyzed for CBC, HBA1c, FBS, and FBS tubes. The samples were labeled by serial number and name of patients, and arterial blood gases were measured by an ABL800 BASIC ABG Machine Blood Gas Analyzer. All data was checked by a team of trained physicians. Ethical approval and informal consent were taken from patients regarding research. Results: showed a total of 135 participants (104 diabetics, 31 non-diabetics), (71 female, 64 male) were registered. The average age of participants was 64.2Â ± 5.3 (1.35). The prevalence of females was 55(52.9%), 16(51.6%), and the prevalence of males was 49(47.1%), and 15(48.4%) among diabetic and non-diabetics respectively, where patients infected by COVID-19 complained of mild symptoms was 17(16.3%), moderate symptoms were 34(32.7%), and sever symptoms was 53(51.0%) among diabetic patients. The prevalence of diabetic patients with no history of other chronic was 34(26.7%) and prevalence with other diseases was 19(18.3%), the prevalence of vaccinated patients was 16(15.3%), and the prevalence of non-vaccinated was 88 (84.7%) among diabetics. The prevalence of oral agents was 21(20.1%), Insulin was 62(59.6%), off-treatment was 2(1.9%), and patients with no treatments was 19(18.3%), the prevalence of diabetics with duration less than 5 years was 7(6.7%), and patients with duration of diabetics 5 to 10 years was 3(2.9%), and patients with more than 10 years was 75(72.1%), and patients whom the new diagnosis was 19(18.3%). Statistically significant differences between FBS, RBS, HgA1c between diabetics and non-diabetic patients, and among differences in duration of diabetes Miletus only in FBS, there were no significant differences between FBS, RBS, HgA1c between the type of management diabetic patients, in relation gender, the severity of symptoms, other comorbidities, and vaccination. The number and percentage of infected patients induced hyperglycemia were 97 (93.3%), and 19(61.3%) among diabetic and non-diabetic respectively, The normal Hemoglobin A1C levels were 11(1.6%), controlled were 48(46.1%) and uncontrolled were 45(43.3%) in diabetic cases, and in non-diabetic patients classified normal HBA1C were 11(1.6%) and pre-diabetic patients as HBA1C were 12(38.7%), there was no significant difference in ABG, LFT, RFT, CBC, and lipid profile function between diabetics and non-diabetic patients.

**Conclusion:** This study showed COVID-19-induced hyperglycemia among diabetic patients, whereas there were changes in arterial blood gases, liver function, renal disturbances, electrolytes, and hematological changes. These findings emphasize the need for close follow-up and management of diabetic patients when they catch the infection.

**Keywords:** COVID-19; Glycemic control; Type 2 diabetes; Imitiga; Tripoli; Libya

## Introduction

According to the World Health Organization (WHO), viral diseases continue to emerge and represent a serious public health problem, in the past twenty years many epidemics of viral diseases such as the Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV) from 2002 to 2003, and H1N1 influenza in 2009 have been recorded and lastly the Middle East Respiratory Syndrome Coronavirus (MERS-CoV) was first identified in Saudi Arabia in 2012 [1]. On December 31, 2019, an outbreak of pneumonia associated with a novel coronavirus,

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Severe Acute Respiratory Syndrome (SARS-CoV-2) Coronavirus-2 was first detected in Wuhan, Hubei Province, China, infections spread across China and affecting other countries around the world and declared as a public health emergency of international concern on January 30, 2020, it has caused millions of infections and millions of deaths worldwide including Libya. Since the first case of COVID-19 was recorded in Libya on 24 March 2020, a recent epidemiological update by WHO, reported that more than two hundreds countries around the world have reported SARS-CoV-2 Variants Of Concern (VOC) of which the newer VOC, including Libya where were the fatality rate for COVID-19 is 2.2% [2]. However, the case fatality rate is affected by factors that include age, underlying chronic conditions as diabetes mellitus, and severity of illness and significantly varies between countries [3]. The clinical features are very similar to (SARS) and (MERS). The spectrum of clinical presentation of COVID-19 ranges from the asymptomatic to symptomatic, with varying degree of severity depending on age, comorbid conditions, and basal metabolic index, transmitted mainly through droplets or direct contact, feces and infected through the respiratory tract, patients suffering from chronic health conditions as high blood pressure and diabetes, people of older age, and delayed referral to a hospital are all contributing to the severity of the symptoms and more likely to suffer further complications and the risk of death [4-8]. According to the Center for Disease Control (CDC), the majority of deaths occur in the elderly as well as any age group with the presence of chronic diseases such as Diabetes Mellitus (DM), hypertension, chronic lung conditions, obesity (BMI ≥ 40 kg/m2), chronic kidney disease, cardiovascular disease, and other immunocompromised individuals, the percentage of COVID-19 patients requiring hospitalization was higher in those with chronic medical conditions than those without medical conditions based on an analysis by many studies of confirmed cases reported to the CDC. Where the data regarding the gender-based differences suggests that male patients are at risk of developing severe illness and high mortality due to COVID-19 compared to female patients. According to the results of studies conducted by United States and United Kingdom researchers, persons of Black, Hispanic, and Asian ethnic minority groups are more likely to infect and dying from COVID-19 infection. Hispanics had the greatest COVID-19-related mortality rates [9]. DM is responsible for a significant increase in COVID-19 related mortality associated with acute respiratory distress syndrome and (controlling of DM) can lead to good regulation of blood sugar to strengthen the immune system and reduce the severity of the disease [10]. Individuals with diabetes and or obesity generally have impaired innate and adaptive immune response which characterized by a state of chronic low-grade inflammation Interestingly, previous studies have shown that individuals with diabetes have a high risk of infection similar to SARS and MERS [11]. Among patients infected with the SARS virus, and showing that the history of diabetes and hyperglycemia are independent predictors of mortality and morbidity and that metabolic control might improve their prognosis [12]. Furthermore, hyperglycemia is a strong predictor of outcome in hospitalized patients with COVID-19. Previous studies showed that hyperglycemic patients with COVID-19 showed a higher cumulative rate of severe disease compared to the normoglycemic controls [13]. Possible mechanisms for this increased mortality include hyperglycemia-induced Changes in the immune system and increases in inflammatory cytokines [14]. Moreover, among elderly individuals who were at higher risk of death from COVID-19 had diabetes [15]. It's known that people with diabetes have an increased risk of various acute and chronic infections compared with non-diabetic individuals, viral infection may cause serum glucose elevation in people who already have diabetes, or it may cause new onset diabetes in people who have never had diabetes before. The rate of admission to Intensive Care Unit (ICU), need for mechanical ventilation, and mortality of diabetic patients was 3.1 fold greater than that of non-diabetic patients during the SARS pandemics [16]. It was reported that diabetes triples the risk of Hospitalization after Influenza A (H1N1) and quadruples the risk of ICU admission Allard R, et al. where during the COVID-19 outbreak a large number of individuals with diabetes were also observed [17].

## Materials And Methods

The study is a cross-sectional observational study on 135 COVID-19 patients with T2DM and 31 non-diabetics recruited from the Medical preventive Hospital, Imitiga. The study was conducted on December 2021 to April 2022, and patients were randomly sampled using a nonprobability convenience sampling method. Data was collected through questionnaires containing personal and medical information, symptoms, duration of diabetes, drug history, past medical history, and vaccinations. Laboratory tests were conducted within 24 hours of hospital admission, including SARS-CoV-2 RNA isolation and amplification using qRT-PCR kits. Blood samples were collected from participants after fasting for 12 hours and analyzed for CBC, HBA1c, FBS, and FBS tubes. The samples were labeled by serial number and name of patients, and arterial blood gases were measured by an ABL800 BASIC ABG Machine Blood Gas Analyzer. All data was checked by a team of trained physicians. Ethical approval and informal consent were taken from patients regarding research.

## Results

### Demographic characteristics of COVID-19 patients

**Age of patients in study:** This study included total number of 135 of COVID-19 patients. There were 77% (n=104) diabetic subjects and 23% (n=31) non-diabetic subjects (Table 1). Where mean of age among diabetic patients was 67.6 ± 5.1 (1.28) years and 52.8 ± 13.4 (3.29) years in non-diabetic patients and 64.2 ± 5.3 (1.35) years among all cases. Figure 1 showed the distribution of cases involved in the study according to diabetic status and age category, where the highest percentage (36.5%) ranged between 66-80 years among diabetics, and (29.0%) in non-diabetics were between 36-50 years, and among all cases (33.3%) ranged between 51-65 years.

| **Age, years** | **Diabetic (N=104) 77%** | **Non-diabetic (N=31) 23%** | **All patients (N=135) 100%** |
|---|---|---|---|
| | Mean ± CI (SE) 67.6 ± 5.1(1.28) | Mean ± CI (SE) 52.8 ± 13.4(3.29) | Mean ± CI (SE) 64.2 ± 5.3(1.35) |
| **Age range, years** | | | |
| 19-35 | 0(0%) | 6(19.3%) | 6 (4.4%) |
| 36-50 | 10 (9.6%) | 9 (29.0%) | 19 (14.0%) |
| 51-65 | 37 (35.5%) | 8 (25.8%) | 45 (33.3%) |
| 66-80 | 38 (36.5%) | 6 (19.3%) | 44 (32.5%) |
| 81-95 | 19 (18.2%) | 2 (6.4%) | 21 (15.5%) |
| **Sex** | | | |
| Female | 55 (52.9%) | 16 (51.6%) | 71 (52.6)% |
| Male | 49 (47.1%) | 15 (48.4%) | 64 (47.4%) |
| **Symptoms of COVID-19** | | | |
| mild | 17(16.3%) | 8 (25.8%) | 25(18.5%) |
| Moderate | 34(32.7%) | 16(51.6%) | 50(37.0%) |
| sever | 53(51.0%) | 7(22.6%) | 60(44.4%) |

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| | | | |
|---|---|---|---|
| Chronic medical illness | 70(67.3%) | 17(54.8%) | 87(64%) |
| No other Disease | 34(26.7%) | 14(45.2%) | 48(35.6%) |
| Chronic cardiac disease | 19(18.3%) | 3(9.7%) | 22(16.3%) |
| Chronic pulmonary disease | 9(8.7%) | 3(9.7%) | 12(8.9%) |
| Chronic liver disease | 2(1.9%) | 1(3.2%) | 3(2.2% |
| Cerebrovascular disease | 14(13.5%) | 1(3.2%) | 15(11.1%) |
| Hypertension | 53(50.9%) | 8(25.8%) | 61(45.2%) |
| Chronic kidney disease | 9(8.7%) | 0(0%) | 9(6.6%) |
| Malignancy | 8(7.7%) | 2(6.5%) | 10(7.4%) |
| Chronic infection | 2(1.9%) | 4(12.9%) | 6(4.4%) |
| Thyroid disease | 4(3.8%) | 0(0%) | 4(2.9%) |
| **Vaccination** | | | |
| Non-vaccination | 88 (74.6%) | 30 (25.4%) | 118(87.4%) |
| Vaccinated | 16(94.1%) | 1(5.9%) | 17(12.6%) |
| One dose | 2 (100%) | 0 (0%) | 2 (1.5%) |
| Two doses | 14(93.3%) | 1(6.6%) | 15(11.1%) |
| **Note:** N: Number, CI: Confidence Intervals, SE: standard Error. | | | |

**Table 1:** Demographics and baseline characteristics of patients with COVID-19.

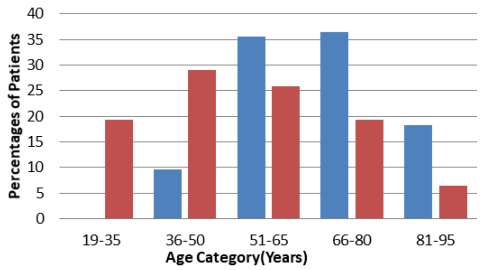


**Figure 1:** Distribution of cases involved in the study according to diabetic status and age category. **Note:** (■) Diabetic %; (■) Patients age.

**Gender of patients in study:** In patients with diabetes 55(52.9%) were females and 49(47.1%) were males, and in non-diabetic patients 16(51.6%) were females and 15(48.4%) were males. where among all cases of study represented females 71(52.6%) and 64(47.4) were males as showed in Figure 2.

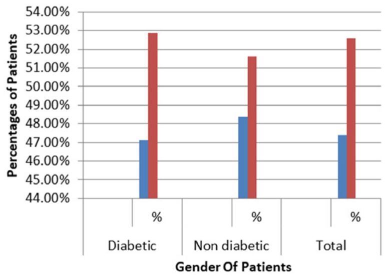


**Figure 2:** Distribution of study cases according gender. **Note:** (■) Male; (■) Female.

**Classification of patients according to severity of symptoms:** During the study patients complained different in symptoms, where classified into mild, moderate and sever, where the percentage in diabetic patients complained symptoms were 17(16.3%), 34(32.7%) and 53(51.0%) as mild, moderate and sever respectively and in non-diabetic patients 8(25.8%), 16(51.6%) and 7(22.6%) as mild, moderate and severe symptoms respectively, and among all cases 25(18.5%), 50(37.0%) and 60(44.4%). The high percentage of severe symptoms among diabetic and total cases, where the high percentage in non-diabetic complained moderate symptoms as showed in Figure 3.

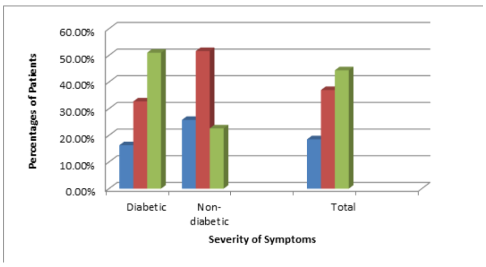


**Figure 3:** Characteristics of participants according to diabetic status by severity degree of symptoms' COVID-19. **Note:** (■) Mild; (■) Moderate; (■) Severe.

**Chronic medical illness of patients:** Patients with other chronic diseases were represent as (64%) among all cases where were most of them diabetics (67.3%) and in non-diabetics (54.8%), in contrast with no history of past medical diseases (26.7%), (45.2%) in diabetic and non-diabetic respectively. Where the highest percentage of hypertension (50.9%), cardiac disease (18.3%), and Cerebrovascular disease (13.5%), similar percentage in Chronic pulmonary disease and Chronic kidney disease (8.7%), where were malignancy (7.7%), thyroid disease (3.8%), also Chronic infection and Chronic liver disease similar percentage were (1.9%). In compare with non-diabetics showed the high percentage hypertension (25.8%), where similar percentages in chronic cardiac disease, chronic pulmonary disease (9.7%), also similar percentage in chronic liver disease and cerebrovascular disease (3.2%), and last chronic infection (12.9%). Where all patients with chronic kidney disease and thyroid disease in diabetic patients only as showed in Table 1.

**Vaccination of patients:** In general there were different in percentages of vaccination were high in non-vaccinated group (87.4%) in compare with vaccinated group (12.6%) among all cases of study, where were most of non-vaccinated were diabetics (74.6%) and (25.4%) in non-diabetics, also the most of vaccinated groups were diabetics (94.1%), and in non-diabetics were (5.9%) as showed in Figure 4.

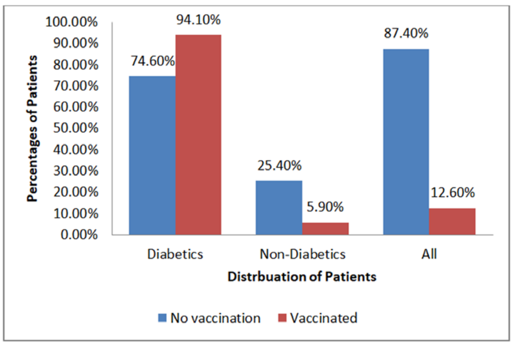


**Figure 4:** COVID-19 and vaccinated patients. **Note:** (■) No vaccination; (■) Moderate.

## The effect of COVID-19 on DM

**Duration and managements of diabetic patients:** Diabetic patients on oral hypoglycemic agents were 2(20.1%) and on insulin was 62(59.6%), and only two patients with off treatment (1.9%), whereas newly discovered with type 2 diabetes were 19 cases (18.3%). The managements of DM and were illustrated in Figure 5. In addition, Figure 6 showed the duration of DM of patients according to gender.

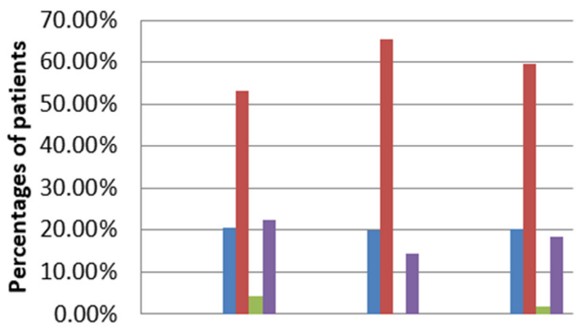


**Figure 5:** Management of diabetic patients according to gender male (N=49); female (N=55); diabetic patients (N=104). **Note:** (■) Oral; (■) Insulin; (■) Off treatment (■) No treatment.

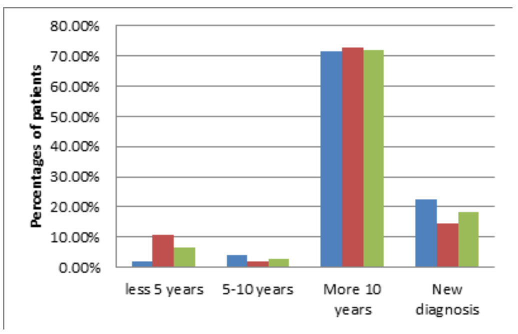


**Figure 6:** Duration of diabetes mellitus of patients according to gender. **Note:** (■) No vaccination; (■) Moderate.

There clearly various in means of FBS among patients according to their managements were 235 ± 57.2 (27.4), 251.2 ± 25.8 (12.9), and 191.9 ± 48 (23) with p=0.097, and means of RBS were 303.1 ± 47.7 (22.8), 327.6 ± 34.9 (17.4), and 253.4 ± 42.8 (20.5) with p=0.063 and means of HgA1C were similar as 8.3 ± 0.9 (0.4), 8 ± 0.5 (0.3), and 7.9 ± 0.4 (0.2) with p=0.806 as in patients with oral agents , insulin and patients with off treatments respectively, as showed in Table 2.

| Management parameters | Oral mean ± CI (SE) | Insulin mean ± CI (SE) | NO treatment mean ± CI (SE) | p-Value |
|---|---|---|---|---|
| FBS | 235 ± 57.2(27.4) | 251.2 ± 25.8(12.9) | 191.9 ± 48(23) | 0.097 |
| RBS | 303.1 ± 47.7(22.8) | 327.6 ± 34.9(17.4) | 253.4 ± 42.8(20.5) | 0.063 |
| HgA1C | 8.3 ± 0.9(0.4) | 8 ± 0.5(0.3) | 7.9 ± 0.4(0.2) | 0.806 |

**Table 2:** Sugars parameters changes of diabetic patients according to their management.

According to duration of DM revealed means of FBS were 183.7 ± 56.1 (22.9), 260 ± 317.3 (73.7), 257.1 ± 26.2 (13.1), among patients of their duration as less than five years, five to ten years, and more than ten years respectively, where the new diagnostic diabetics were mean 165.8 ± 33.8 (16), p=0.011, and means of RBS were 302.6 ± 111.8 (45.7), 315 ± 535 (124.3), 323.9 ± 29.8 (14.9), among patients with duration of DM as less than five years, five to ten years and more than ten years, where were 243 ± 42.8 (20.4) in new diagnostic diabetics with p=0.175. Also there were various in means of HgA1C according to duration of DM were 9.4 ± 3.6(1.5), 8.1 ± 8.3 (1.9), 8 ± 0.4 (0.2), and 7.9 ± 0.4 (0.2) with p=0.500 as showed in Table 3.

| Duration DM | less than 5 years mean ± CI (SE) | 5-10 years mean ± CI (SE) | More 10 years mean ± CI (SE) | New diagnosis mean ± CI (SE) | p-Value |
|---|---|---|---|---|---|
| FBS | 183.7 ± 56.1(22.9) | 260 ± 317.3(73.7) | 257.1 ± 26.2(13.1) | 165.8 ± 33.8(16) | 0.011 |
| RBS | 302.6 ± 111.8(45.7) | 315 ± 535(124.3) | 323.9 ± 29.8(14.9) | 243 ± 42.8(20.4) | 0.175 |
| HgA1C | 9.4 ± 3.6(1.5) | 8.1 ± 8.3(1.9) | 8 ± 0.4(0.2) | 7.9 ± 0.4(0.2) | 0.5 |

**Table 3:** Sugars parameters and duration of diabetes mellitus.

## Relation between sugar parameters and gender in diabetic and non-diabetic finding

In relation of sugar parameters with gender, where were various among fasting blood sugar between males and females were means 228.9 ± 29.4 (14.5), 242.2 ± 31.1 (15.5) p=0.539, and no difference in random blood sugars were 308.2 ± 33.6 (16.6), 307 ± 35.8 (18.1) p=0.961, and hemoglobin A1C were 8.1 ± 0.4 (0.3), 7.9 ± 0.6 (0.3) p=0.683 among diabetics males and females respectively. Where the non-diabetics means of FBS high in males 155.1 ± 32.8 (153) than females were 128.5 ± 24.9 (11.6), and RBS means were high in females 195.6 ± 37.8 (17.7) than males 146.7 ± 19 (8.8), and the HgA1C were 4.4 ± 0.4 (0.2), 5.3 ± 0.4 (0.2) among males and females respectively, as showed in Table 4.

| Gender | Diabetic | | Non-diabetic | | p-Value |
|---|---|---|---|---|---|
| | Males mean ± CI (SE) | Females mean ± CI (SE) | Males Mean ± CI (SE) | Females mean ± CI (SE) | |
| FBS | 228.9 ± 29.4(14.5) | 242.2 ± 31.1(15.5) | 155.1 ± 32.8(153) | 128.5 ± 24.9(11.6) | 0.539 |
| RBS | 308.2 ± 33.6(16.6) | 307 ± 35.8(18.1) | 146.7 ± 19(8.8) | 195.6 ± 37.8(17.7) | 0.961 |
| HgA1C | 8.1 ± 0.4(0.3) | 7.9 ± 0.6(0.3) | 4.4 ± 0.4(0.2) | 5.3 ± 0.4(0.2) | 0.683 |

**Table 4:** Relation between sugar parameters and gender in diabetic and non-diabetic finding.

## COVID-19 induced hyperglycemia in study cases

Clearly that the parameters for assessments hyperglycemia were significant higher in diabetic group than non-diabetic group. The average of Hemoglobin A1c was 8.03 ± 0.38 (0.19) in first group compared with 5.38 ± 0.60 (0.14) in second group. whereas the fasting blood sugar significant higher in diabetic than non-diabetic 235.9 ± 42.3 (10.6), 141.39 ± 39.5 (9.68) and mean of random blood sugar were 307.65 ± 48.9 (12.3), 171.9 ± 44.5 (10.9) consequently, p(0.000, 0.000,0.000) as showed in Table 5.

| Indicators | Diabetic mean ± CI (SE) | Non-diabetic mean ± CI (SE) | p-Value |
|---|---|---|---|
| HemoglobinA1c | 8.03 ± 0.38(0.19) | 5.38 ± 0.60(0.14) | 0 |
| Fasting Blood Sugar(FBS) | 235.9 ± 42.3(10.6) | 141.39 ± 39.5(9.68) | 0 |
| Random Blood Sugar(RBS) | 307.65 ± 48.9(12.3) | 171.9 ± 44.5(10.9) | 0 |

**Table 5:** Effect of COVID-19 on sugar parameters in studies cases.

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Generally the number and percentage of infected patients induced hyperglycemia were 97 (93.3%), 19(61.3%) among diabetic and non-diabetic respectively, also showed high 116 (85.95%) among all cases of study as showed in Figure 7 and depending on American Diabetes Association criteria (ADA), data classified the diabetic patients to normal, control and uncontrolled HBA1C. The normal Hemoglobin A1C level were 11 (1.6%), controlled were 48 (46.1%) and uncontrolled were 45 (43.3%) in diabetic cases as showed in Figure 8, and in non-diabetic patients classified normal HBA1C were 11 (1.6%) and pre-diabetic patients as HBA1C were 12 (38.7%) as showed in Figure 9.

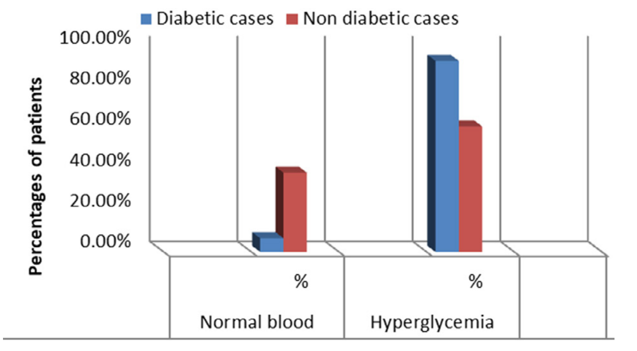


**Figure 7:** Induced COVID-19 hyperglycemia in studies cases. **Note:** (■) Diabetic cases; (■) Non-diabetic cases.

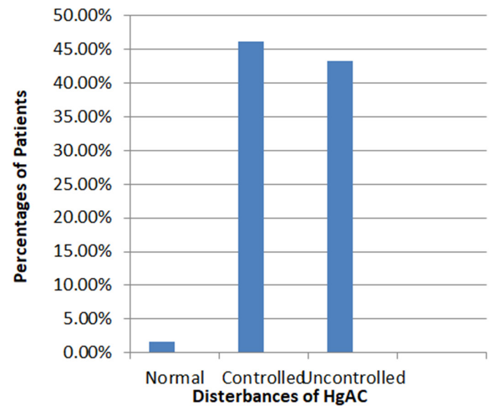


**Figure 8:** Effect of COVID-19 on HBA1C in diabetic cases. **Note:** (■) Diabetic cases.

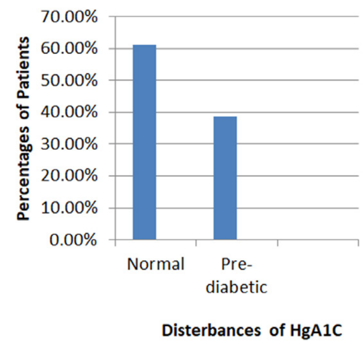


**Figure 9:** Effect of COVID-19 on HBA1C in non-diabetic cases. **Note:** (■) Non-diabetic cases.

## Relation between blood sugar results and severity of COVID-19 symptoms in diabetic and non-diabetic finding

The relation between severity of COVID-19 symptoms and sugars parameters revealed various in mean of FBS were 243.5 ± 7.2 (34.1), 251.4 ± 44.9 (22.1), and 223.7 ± 22.4 (11.2) in diabetics, and in non-diabetics were means 155.9 ± 59.2 (25), 140.2 ± 27.3 (12.8), and 127.6 ± 37.2 (15.2), p=0.490 as mild, moderate, and sever symptoms respectively. While RBS showed high among patients with moderate symptoms were 336.9 ± 41.6 (20.5), and 299.7 ± 46.7 (22.0), 291.1 ± 37.99 (18.9) with mild and sever symptoms respectively. Where among non-diabetic showed high mean of RBS 220.7 ± 65.9 (26.9) in severe symptoms , where means were 156.5 ± 40.2 (17), 158.4 ± 28.4 (13.2) in mild and moderate cases p=0.250, and HA1C presented high mean were 8.6 ± 0.7 (0.3) in moderate cases, where among mild and moderate were 7.6 ± 0.6 (0.3), 7.8 ± 0.6 (0.3) consequently. Although HA1C means were similar 5.7 ± 0.4 (0.2), 5.1 ± 0.4 (0.2) and 5.6 ± 0.8 (0.3) in mild, moderate and severe respectively among non-diabetics patients p=0.141 as showed in Table 6.

## Relation between blood sugar results and other comorbidities in diabetic and non-diabetic finding

The relation between blood sugar of diabetic patients and other comorbidities showed hyperglycemia more with patients had other chronic diseases 66( 63.7%) than patients with no diseases 31(29.8%), and controlled HBA1C were 35(33.7%) and uncontrolled hemoglobin HBA1C 30 (28.9%) with chronic diseases. where normal HBA1C 7(6.73%) in patients with chronic diseases as showed in Figure 10.

| Parameters | Diabetics cases mean ± CI(SE) | | | Non-diabetics cases mean ± CI(SE) | | | P-value |
|---|---|---|---|---|---|---|---|
| | Mild | Moderate | severe | Mild | Moderate | Severe | |
| FBS | 243.5 ± 72.2(34.1) | 251.4 ± 44.9(22.1) | 223.7 ± 22.4(11.2) | 155.9 ± 59.2(25) | 140.2 ± 27.3(12.8) | 127.6 ± 37.2(15.2) | 0.49 |
| RBS | 299.7 ± 46.7(22.0) | 336.9 ± 41.6(20.5) | 291.1 ± 37.9(18.9) | 156.5 ± 40.2(17) | 158.4 ± 28.4(13.2) | 220.7 ± 65.9(26.9 | 0.25 |
| HA1C | 7.6 ± 0.6(0.3) | 8.6 ± 0.7(0.3) | 7.8 ± 0.6(0.3) | 5.7 ± 0.4(0.2) | 5.1 ± 0.4(0.2) | 5.6 ± 0.8(0.3) | 0.141 |

**Table 6:** Relation between blood sugar parameters and severity of symptoms in diabetic and non-diabetic finding.

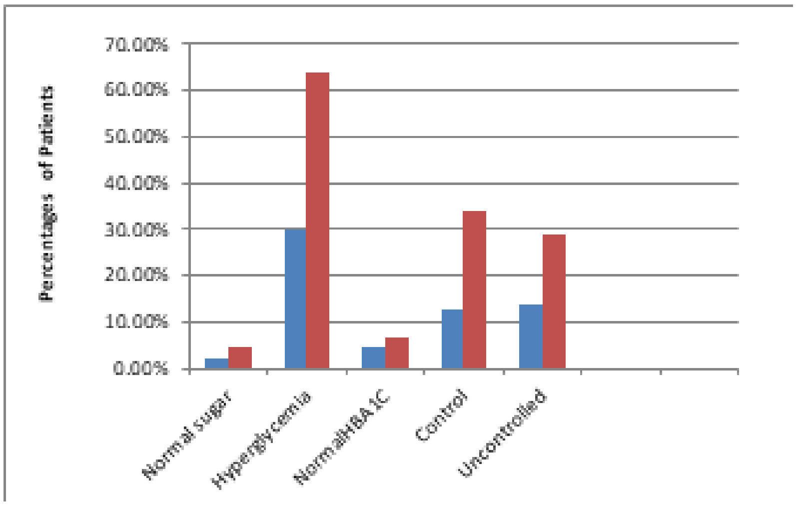


**Figure 7:** Induced COVID-19 hyperglycemia in studies cases. **Note:** (■) Diabetic cases; (■) Non-diabetic cases..

Generally the means of FBS were high in diabetic patients had not other chronic diseases were 243.6 ± 37.5 (18.4) in compare with non-diabetics were 137.8 ± 31.8 (14.7) with p=0.613. In contrary diabetics had other diseases mean of FBS were, 242 ± 26.6(13.2) and in non-diabetic were 144.4 ± 28(14.7), where all cases of cerebrovascular diseases, chronic kidney diseases and thyroid diseases in diabetics group. There were significant high levels of means of FBS, RBS, and HBA1C among diabetics with other chronic diseases specially hypertension in compare with non-diabetics as showed in Table 7.

| Co-morbidities FBS | Diabetic cases Mean ± CI(SE) | Non diabetic Mean ± CI(SE) | p-Value |
|---|---|---|---|
| No other chronic D | 243.6 ±37.5(18.4) | 137.8 ± 31.8(14.7) | 0.613 |
| Other chronic D | 242 ± 26.6(13.2) | 144.4 ± 28(14.7) | |
| Hypertension | 238.3 ± 29.8(14.9) | 140.8 ± 53.8(22.7) | 0.816 |
| CVD | 221.8 ± 56.9(26.8) | 101.0 ± 21.2(4.9) | 0.559 |
| Chronic pulmonary D | 241.3 ± 87.3(38.6) | 103.3 ± 51(11.9) | 0.872 |
| Cerebrovascular D | 290.9 ± 68.7(31.8) | 000 | - |
| Chronic kidney D | 204.4 ± 43.3(19.2) | 000 | - |
| Malignancy | 215.5 ± 105.6(58.6) | 152.5 ±108.1(8.5) | 0.638 |
| Thyroid D | 157.8 ± 157.6(49.5) | 000 | - |
| **RBS** | **Diabetic cases** | **Non diabetic** | **pValue** |
| No other chronic D | 318.3 ± 47.2(23.2) | 179.9 ± 27.9(12.9) | 0.540 |
| Other chronic D | 302.2 ± 28.9(14.5) | 165.4 ± 36.1(17) | |
| Hypertension | 309.1 ± 29.6(14.8) | 147.2 ± 37.9(16) | 0.014 |
| CVD | 291.7 ± 67.2(31.7) | 141.9 ± 94.6(21.9) | 0.571 |
| Chronic pulmonary | 311.7 ± 80.5(35.6) | 193.2 ± 229(53.2) | 0.916 |
| Cerebrovascular D | 334.6 ±70(32.4) | 000 | - |
| Chronic kidney D | 271.3 ± 76.9(34) | 000 | - |
| Malignancy | 231.9 ± 84.9(32.7) | 194.2 ± 220.7(17.4) | 0.130 |
| Thyroid D | 269.6 ± 64.6(20.3) | 00 | - |
| **HA1C** | **Diabetic cases** | **Non diabetic** | **p Value** |
| No other chronic D | 8.1 ± 0.7(0.4) | 5.6 ± 0.8(0.2) | 0.700 |
| Other chronic D | 7.9 ± 0.5(0.2) | 5.2 ± 0.5(0.2) | |
| Hypertension | 8.2 ± 0.5(0.2) | 4.7 ± 0.7(0.3) | 0.489 |
| CVD | 8.2 ± 01(0.5) | 4.2 ±1.9(0.4) | 0.765 |
| Chronic pulmonary | 8.2 ±1.1(0.5) | 5.1 ± 2.3(0.5) | 0.825 |
| Cerebrovascular D | 7.9 ±1.2(0.4) | 000 | - |
| Chronic kidney D | 7.4 ±1.2(0.5) | 000 | - |
| Malignancy | 6.9 ± 0.8(0.3) | 5.9 ± 6.9(0.5) | 0.187 |
| Thyroid D | 7.3 ± 2(0.6) | 000 | - |

**Table 7:** The relation between blood sugar and other tests of diabetic patients and other comorbidities.

## Relation between sugar parameters and vaccination in diabetic and non-diabetic finding

In relation of vaccination and severity of symptoms were showed the high percentage (50%) of non-vaccinated diabetic patients complained severe symptoms of COVID-19 in compare with other groups as (13.6%), (36.4%) were mild and moderate consequently, also there were high percentage (56.3%) in vaccinated group complained with severe symptoms of COVID-19 in compare with patients complained as mild (31.3%), and moderate (12.5%) in diabetics as exhibited in Table 8 and Figure 11.

| Severity of symptoms | Diabetic | | | Total |
|---|---|---|---|---|
| | Mild | Moderate | Severe | |
| Non-vaccination | 12(13.6%) | 32(36.4%) | 44(50%) | 88(100%) |
| vaccination | 5(31.3%) | 2(12.5%) | 9(56.3%) | 16(100%) |

**Table 8:** Distribution of cases involved in the study according to relation between severity of symptoms and vaccination.

**Citation:** Ali FGM, Darif AB, Elmaryu AA, Daeki AO (2023) Effects of COVID-19 on Glycemic Control in Type 2 Diabetes Patients at the Medical Preventive Hospital, Imitiga, Tripoli, Libya. J Infect Dis Ther 11: 572.



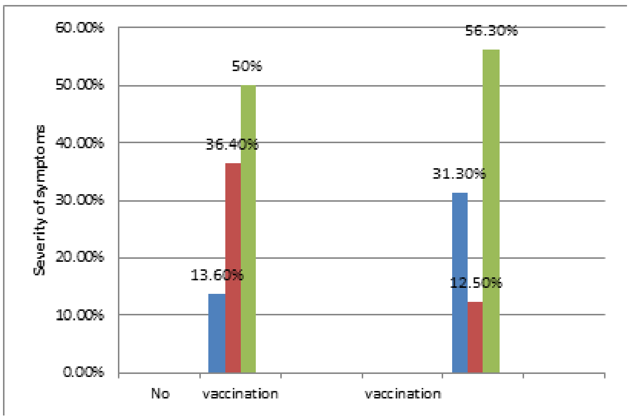


**Figure 11:** Relation between severity of symptoms and vaccination among diabetics patients. **Note:** (■) Mild; (■) Moderate; (■) Severe.

All vaccinated patients were diabetics, their means of FBS, RBS, HgA1c were 208 ± 45.4 (21.3), 253.7 ± 50.7 (23.7), and 7.6 ± 0.9 (0.4) consequently, they were less than non-vaccinated groups, where means of FBS, RBS, and HgA1c were 241 ± 23.8 (11.9), 317.5 ± 27.3 (13.7), and 8.0 ± 0.5 (0.2) consequently. In compare with non-diabetics were all not vaccinated their means of FBS, RBS, HgA1c were 143 ± 20.2 (9.9), 171.5 ± 23 (11.3), and 5.4 ± 0.3(0.2) subsequently as Table 9.

| Parameters | | Diabetic mean ± CI (SE) | Non-diabetic mean ± CI(SE) | p-Value |
|---|---|---|---|---|
| FBS | Vaccinated | 208 ± 45.4(21.3) | 0 | 0.266 |
| | Non-vaccinated | 241 ± 23.8(11.9) | 143 ± 20.2(9.9) | |
| RBS | Vaccinated | 253.7 ± 50.7(23.7) | 0 | 0.62 |
| | Non-vaccinated | 317.5 ± 27.3(13.7) | 171.5 ± 23(11.3) | |
| HgA1c | Vaccinated | 7.6 ± 0.9(0.4) | 0 | 0.404 |
| | Non-vaccinated | 8.0 ± 0.5(0.2) | 5.4 ± 0.3(0.2) | |

**Table 9:** Relation of Sugar parameters and vaccination in diabetic and non-diabetic finding.

## Effect of COVID-19 on respiratory system

General effect of COVID-19 infection on blood gases, there were clear variations of blood oxygen level grading, Carbone dioxide concentration, PH and bicarbonate level among all infected patients where were the high percentage of respiratory alkalosis were 34(32.7%), and metabolic alkalosis 22(21.2%), metabolic acidosis 20(19.2%), respiratory acidosis 10(9.6%), and mixed of M acidosis and R acidosis were 4(3.8%), where were normal ABG was 9(8.7%), and the not valid ABG was 5(4.8%). And in non-diabetics where were high percentage was metabolic alkalosis 10(32.3%), and similar percentages were respiratory alkalosis and normal results were 5(16.1%), metabolic acidosis was 5(16.1%), respiratory acidosis 4(12.9%), where not valid reading of ABG was 2(6.5%) as showed in Tables 2 and 10. Whereas the correlation of radiological finding with blood oxygenation in COVID-19 infected patients and according to WHO radiological classification as motioned before in method and material. Both diabetic and non-diabetic infected patients were had more CORAD5 79(76%) and 21(67.7%) and among all cases 100(74%) consequently and CORAD4 were 25(24%), 10(32.3%) among diabetic and non-diabetic and 35(26%) among all infected patients as showed in Figure 12.

| ABG interpretations | DM | Non-DM | Total |
|---|---|---|---|
| Not valid | 5(4.8%) | 2(6.5%) | 7 |
| Normal | 9(8.7%) | 5(16.1%) | 14 |
| Respiratory alkalosis | 34(32.7%) | 5(16.1%) | 39 |
| Metabolic alkalosis | 22(21.2%) | 10(32.3%) | 32 |
| M acidosis | 20(19.2%) | 5(16.1%) | 25 |
| R Acidosis | 10(9.6%) | 4(12.9%) | 14 |
| M acidosis, R acidosis | 4(3.8%) | 0(0%) | 4 |
| Total | 104 | 31 | 135 |

**Table 10:** ABG interpretations among diabetics and non-diabetics.

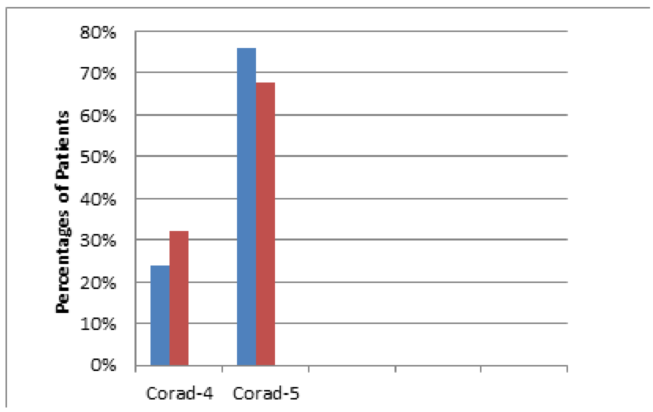


**Figure 12:** Radiological classification difference in diabetic and non-diabetic. **Note:** (■) Diabetic; (■) Non-diabetic

## Effect of COVID-19 on liver function parameters in studies cases

COVID-19 induced hepatitis according diabetic status. As assessment of liver function among all infected patients, there were fluctuation in liver enzymes levels among patients were (56.2%) normal function test, (85.5%) were diabetics and (26.3%) were non-diabetics, in difference the patients had abnormal function tests (43.7%) were (81.3%) diabetics and (18.6%) non-diabetics as showed in Figure 13 and as assessment the effect of COVID19 induced liver injury were percentage of hepatic injury was 23(76.7%) among diabetics and 7(23.3%) among non-diabetics, where were induces cholestasis were 17(81%) among diabetics and 4(19.0%) among non-diabetics, where were induces mixed of both hepatic injury were all among diabetics.

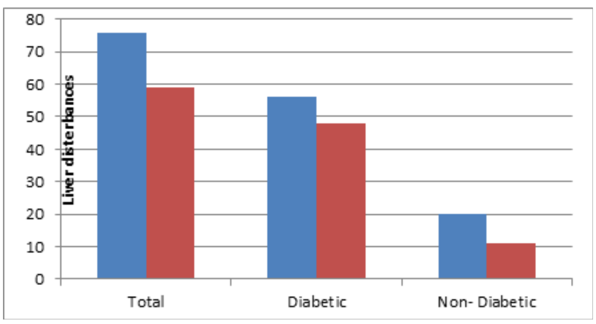


**Figure 13:** Effect of COVID-19 on liver function parameters in studies cases. **Note:** (■) Non-liver enzyme; (■) Patient type.

**Citation:** Ali FGM, Darif AB, Elmaryu AA, Daeki AO (2023) Effects of COVID-19 on Glycemic Control in Type 2 Diabetes Patients at the Medical Preventive Hospital, Imitiga, Tripoli, Libya. J Infect Dis Ther 11: 572.



### Effect of COVID in renal function test and serum electrolytes among study cases

In general the number and percentage of patients with normal renal function were 41(39.4%) among diabetics and 18(58.1%) in non-diabetics. Where the number and percentage of infected patients induced dehydration were high in diabetics were 28(26.9%) than non-diabetics were only 2(6.5%) in non-diabetics, and the number and percentage of infected patients induced acute kidney injury (AKI) were 26(25%) in diabetics, and 11(35.5%) in non-diabetics, where the all cases of chronic kidney disease 9(8.7%) in diabetics as showed in Figure 14. As assessment of electrolytes, where were normal level of electrolytes (24.0%), (48.4%) among diabetics and non-diabetics, where were the high percentages of abnormal levels of electrolytes were hyponatremia in diabetics as showed in Figure 15, and non- diabetics were (36.5%) in diabetics, and (16.1%) in non-diabetics, and other abnormal levels of other electrolytes showed in Figure 15.

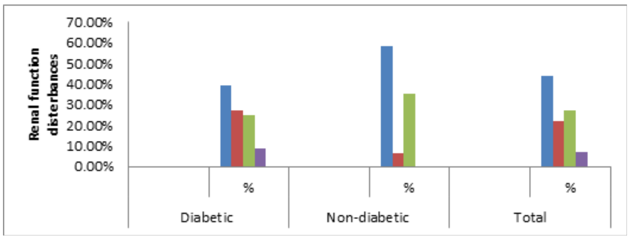


**Figure 14:** COVID-19 induced renal function disturbances. **Note:** (■) Normal; (■) Dehydration;(■) Severe kidney deterioration; (■) CKD.

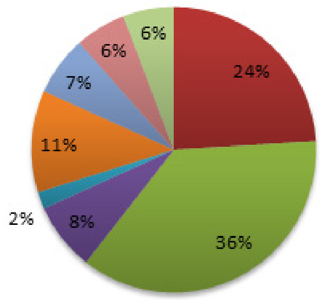


**Figure 15:** COVID-19 induced electrolytes disturbance according diabetic status. **Note:** (■) Normal; (■) Hyponatremia; (■) Hypernatremia; (■) Hypokalemia; (■) Hyperkalemia; (■) Both hypo; (■) Both hyper; (■) Hyponatremia+; (■) Hyperkalemia.

### Effect of COVID on hematological changes and inflammatory parameters according diabetic status

As assessment of complete blood count were presented high percentage of infected patients with anemia (69.2%) and with normal hemoglobin were (30.8%) among diabetics, where (48.3%) with normal hemoglobin and (51.6%)with anemia among non-diabetics. And patients with normal WBC were (48.1%), and percentage of patients were induced Leukocytosis (51.9%) among diabetics , and non-diabetics with normal WBC were (48.4%), (51.6) with induced leukocytosis, and effect on neutrophils were (9.6%), (87.5%), (2.9%) as normal, high, and low percentage respectively among diabetics, where were percentages of neutrophils were (6.5%), (93.5%), (0%) as normal, high , and low correspondingly. Percentages of lymphocytes were (8.7%), (10.6%), and (80.8%) as normal, high, and low percentage among diabetics, and in non-diabetics where were effect of lymphocytes as (12.9%), (3.2%) and (83.9%) as normal, high, and low correspondingly, and effect of platelets among diabetics were (75%), (10.6%), and (14.4%), and amongst non-diabetics were (77.4%), (12.9%), and (9.7%) as normal, thrombocytosis, and thrombocytopenia correspondingly.

### Effect of COVID in lipid profile changes among study cases

Where percentage of patients were (53.8%) with normal lipid profile among diabetics and (70.9%) among non-diabetics, and percentage of hypercholesterolemia as (7.7%) among diabetics only. Where were percentage with high triglycerides were (28.8%), (16.1%) among diabetics and non-diabetics separately, and percentages of increased both cholesterol and triglycerides were (9.6%), and (12.9%) among diabetics and non-diabetics as respectively as showed in Figure 16.

## Discussion

The COVID-19 pandemic has had an indirect effect on glycaemic control in patients with Diabetes Mellitus (DM2). The study included 135 COVID-19 patients, with 77% being diabetic and 23% being non-diabetic. Patients were classified into mild, moderate, and sever symptoms, with severe symptoms being more common in diabetic patients. Patients with chronic diseases were represented in the study, with high percentages of hypertension, cardiac disease, chronic pulmonary disease, and chronic kidney disease. Vaccination rates were high in non-vaccinated patients. Also the study investigated changes in blood sugar levels and other hematological changes of type 2 DM patients affected by the pandemic. The study found a high prevalence of hyperglycemia among patients on insulin and those with long-standing disease, with age groups ranging from elderly to children. HbA1c was considered as the diagnostic standard for diabetes in the study, with 18.3% of newly diagnosed patients being newly diagnosed with diabetes. Previous studies have shown that high glucose levels are associated with inflammation, hypercoagulability, and low oxygen saturation, leading to higher mortality rates. The distribution of patients according to age and gender was, women have a higher prevalence of hypoglycemia than men, with the highest percentage in diabetics aged 65-74 years. Insulin doses were increased among a considerable portion of patients to manage uncontrolled diabetes as part of the integrated care program protocol. Other studies have also shown different patterns of glycemic control among high-risk patients with Chronic Kidney Diseases (ICVD) and Chronic Kidney Failure (ICD-19). Chronic Kidney Disease (CKD) is a chronic kidney disease that is more common in diabetic and non-diabetic patients.

## Conclusion

The study found that even mild SARS-2 patients with mild symptoms have higher fasting blood glucose levels, which is associated with inflammation, hypercoagulability, and low oxygen saturation. The mortality rate is higher in patients with diabetes, and the proportion of severe COVID-19 illness increased progressively in relation to glucose abnormalities at admission. This study also found a high prevalence of hyperglycemia among patients on insulin and a high percentage of non-vaccinated diabetic patients complaining of severe symptoms. The disturbances in arterial blood gases, liver enzymes, renal function, electrolytes, and haemoglobin are significantly lower in diabetic patients, indicating that they are more likely to be undernourished. Elevation in D-dimers is common during convalescence and may be of relevance in long-term COVID pathogenesis. Careful evaluation of laboratory indices can assist in formulating intensive care for those who need it. Lipid-lowering therapies are especially important for those with diabetes-related complications. Patients with disturbed glucose metabolism should be considered for intensive care as they have a higher risk of rapid liver damage and kidney injury.

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