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The Relation of Hba1c Levels with Mortality Rates in Hospitalized COVID-19 Diabetic Patients: A Retrospective Cohort Study Conducted in Egypt

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ABSTRACT

Background: Identifying mortality factors in type 2 diabetic patients with COVID-19 is crucial. **Objectives**: To investigate the association between HbA1c levels and mortality rates in hospitalized COVID-19 diabetic patients. **Methods:** A 5-month retrospective cohort study at Al-Agouza hospital in Egypt included 167 adult COVID-19 diabetic patients. Patients were categorized by HbA1c levels at admission (≤ 7%, 7.1% to 8.9%, and ≥ 9%). Hospital mortality was the primary outcome. **Results:** The mean age was 66±10.2 years and the majority (56.3%) of patients were males. Out of 167 patients, 51 (30.5%) had HbA1c ≤ 7%, 77 (46.1%) had HbA1c between 7.1% and 8.9%, and 39 (23.4%) had HbA1c ≥ 9%.The average hospital stay was 12 days. Approximately 35.3% of patients required ICU admission and 35.9% died. The lowest HbA1c levels (≤ 7%) were associated with highest mortality rates (43.1%), however the difference did not reach statistical significance (p=0.385). The multivariate Cox regression analysis demonstrated a significant association between age ≥ 70 years (HR 1.85, 95% CI 1.04 -3.28), severe and critically ill cases (HR 9.88, 95% CI 1.19-82.18), ICU admission (HR 7.66, 95% CI 2.94-19.97), and the administration of insulin sliding scale as hospital glycemic management medication (HR 0.45, 95% CI 0.21-0.96) with mortality in COVID-19 diabetic patients. **Conclusions:** This study challenges the conventional belief regarding the association between HbA1c levels and mortality in COVID-19 diabetic patients. Nevertheless, age, COVID severity, ICU admission, and the use of insulin sliding scale emerged as significant risk factors for mortality in this population.

INTRODUCTION

The global community bore witness to the devastating emergence of the Coronavirus Infectious Disease (COVID) in December 2019, initially identified in Wuhan, China.[1] Subsequently, in 2020, the World Health Organization (WHO) declared COVID-19 a pandemic,[2] with reported global deaths reaching 6,562,281 by October 25, 2022.[3] Egypt documented 24,798 deaths between January 3, 2020, and October 25, 2022, representing approximately 5% of confirmed cases.[4]

Factors affecting mortality in COVID-19 infected patients were studied in many literatures. Diabetes

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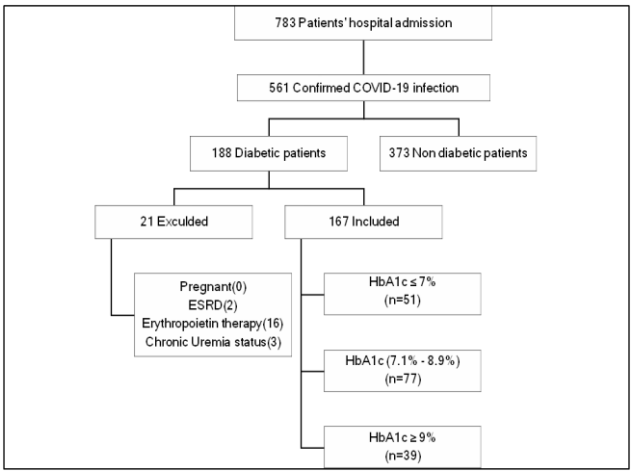

Figure 1: Flow diagram of selected type 2 diabetic patients infected with COVID-19

mellitus (DM) was reported to be one of the comorbidities that increase the mortality of COVID-19 patients. A cross sectional study conducted in South Korea showed an increased mortality rate in diabetic patients versus non diabetics (20.0% versus 4.8%).[1] Additionally, a retrospective, multicenter study conducted in Egyptian hospitals illustrated a mortality rate of 22.8% among COVID-19 infected diabetic patients. Many other studies have declared that DM is considered one of the most dramatic comorbidities contributing to mortality in COVID-19 patients.[5–8]

Different rationales explained the increased mortality risk in this patient population. First, diabetic patients exhibit elevated expression of angiotensin converting enzyme 2 (ACE2) receptors, the primary binding sites of the spike protein of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), resulting in the production of inflammatory cytokines impacting organ function adversely.[9] Moreover, ACE2 shedding dynamics in diabetes facilitate viral dissemination throughout the body, potentially increasing mortality rates.[10] Second, endothelial dysfunction in diabetic patients exacerbated by COVID-19 infection renders them more prone to thrombosis and microvascular complications.[11] Hyperglycemia further exacerbates viral tissue tropism, disrupts chemotaxis, and impairs leukocyte function like phagocytosis.[10]

Hemoglobin A1c (HbA1c) serves as a vital surrogate biomarker for diagnosing and monitoring diabetic patients. Unlike random blood sugar (RBS) values susceptible to fluctuations due to stress or acute conditions,[12] HbA1c offers insights into long-term glycemic control over three months.

The correlation between HbA1c levels and mortality in COVID-19 patients has been investigated with conflicting findings; some studies report no correlation,[1,13] while others suggest a direct proportionality between HbA1c levels and mortality in diabetic patients infected with COVID-19.[14] Our study aims to highlight the impact of blood glucose control on the prognosis of Egyptian diabetic COVID-19 patients by examining the potential correlation between HbA1c levels at admission and mortality rates within this specific patient population.

METHODS

A retrospective observational cohort study was carried out at Al-Agouza Hospital, a prominent quarantine facility in Egypt, with 60 ICU beds and 130 ward beds, during the pandemic era.

Confirmed COVID-19 diabetic patients admitted from February 2021 to June 2021. Due to non-identifiable data collection and the retrospective study design, informed consent was waived.

The study included adult patients with type 2 diabetes aged 18 and above who tested positive for COVID-19 through real-time reverse transcriptase polymerase chain reaction (RT-PCR) testing.[15] Diabetes diagnosis was confirmed based on HbA1c levels ≥ 6.5% and RBS levels ≥ 200 mg/dl, in accordance with the American Diabetes Association guidelines.[16]

We precluded pregnant diabetic COVID-19 patients due to the likely decrease in erythrocyte lifespan during pregnancy, leading to an increase in young erythrocytes that can lower HbA1c levels.[17] Besides, we excluded end stage renal disease (ESRD) diabetic patients as they had reduced production of erythropoietin, resulting in a false decrease in HbA1c.[17] Patients on erythropoiesis-stimulating agents were excluded as these agents may artificially lower HbA1c by boosting the circulation of immature erythrocytes in the peripheral blood stream, which are less exposed to glucose.[18] Furthermore, chronic uremic patients were excluded as chronic uremia leads to the formation of carbaminohemoglobin, causing false increase in HbA1c.[17]

Data Collection: Investigators extracted data from eligible patients' medical records, encompassing demographics, clinical manifestations, comorbidities, vital signs, current medications, and outcomes. Further, laboratory findings included on admission measured HbA1c values, RT-PCR results, RBS,

Table 1. Demographics and clinical characteristics of COVID-19 diabetic patients in the 3 groups

	Total (n=167)	HBA1c Level			*P*-value
		≤7% (n=51)	7.1%-8.9% (n=77)	≥ 9% (n=39)	
Age(years): mean ± SD	66 ± 10.2	69 ± 11.6	66 ± 9.5	61 ± 9.4	**0.001***
Gender:					
Male	94 (56.3)	29 (56.9)	44 (57.1)	21 (53.8)	0.940
female	73 (43.7)	22 (43.1)	33 (42.9)	18 (46.2)	
length of stay(days): mean ± SD minimum-maximum (1-31 days)	12± 5.7	11±5.5	12±5.5	12±5.5	0.656
ICU admission	59 (35.3)	21 (41.2)	22 (28.6)	16 (41.0)	0.240
Comorbidity					
Hypertension	123 (73.7)	38 (74.5)	60 (77.9)	25 (64.1)	0.276
Cardiac diseases	55 (32.9)	14 (27.5)	27 (35.1)	14 (35.9)	0.604
Chest diseases	21 (12.6)	5 (9.8)	11 (14.3)	5 (12.8)	0.755
Chronic kidney disease	8 (4.8)	3 (5.9)	3 (3.9)	2 (5.1)	0.870
Cerebrovascular disease	7 (4.2)	3 (5.9)	2 (2.6)	2 (5.1)	0.626
Laboratory findings: mean ± SD					
White blood cells ($\times 10^3$/ul)	9±4.9	8 ± 3.9	9 ± 5.3	10 ±5.5	0.431
ALC (×103/ul)	1±0.8	1 ± 0.6	1 ± 0.7	1 ± 1.0	0.076
Random blood sugar	225±82.4	171 ± 58.7	233 ± 72.5	281 ± 86.3	**<0.001***
Serum Creatinine (mg/dl)	1±0.8	0.9 ± 0.4	1.2 ± 0.9	1.0 ± 0.7	0.143
D-dimer (ug/ml)	1±2.5	1.5 ± 2.1	1.3 ± 3.1	0.8 ± 0.9	0.414
CRP (mg/L)	73±80.2	60 ± 73.7	78 ± 77.2	73 ± 80.2	0.417
SpO_2	94±3.9	94 ± 2.8	94 ± 4.8	94 ± 3.1	0.584
Covid treatment					
Remdesivir	5 (3.0)	0 (0.0)	3 (3.9)	2 (5.3)	
Steroids	5 (3.0)	2 (3.9)	0 (0.0)	3 (7.9)	0.088
Multiple drugs ‡‡	156 (93.4)	49 (96.1)	74 (96.1)	33 (86.8)	
Hospital glycemic management					
SSIT	91 (54.5)	38 (74.5)	41 (53.2)	12 (30.8)	
SSIT +insulin infusion	12 (7.2)	2 (3.9)	6 (7.8)	4 (10.3)	**0.002***
SSIT + other drugs ‡	64 (38.3)	11 (21.6)	30 (39.0)	23 (59.0)	
Oral antihyperglycemic medications					
Metformin or Sulfonylurea or both	27 (16.2)	9 (17.6)	11 (14.3)	7 (17.9)	
DPP-4** or SGLT2***	6 (3.6)	2 (3.9)	4 (5.2)	0 (0.0)	0.617
DPP-4 plus metformin and sulfonylurea	10 (6.0)	5 (9.8)	3 (3.9)	2 (5.1)	
SEVERITY					
Mild	3 (1.8)	2 (3.9)	1 (1.3)	0 (0.0)	
Moderate	66 (39.5)	17 (33.3)	34 (44.2)	15 (38.5)	0.682
Severe	38 (22.8)	14 (27.5)	15 (19.5)	9 (23.1)	
Critically ill	60 (35.9)	18 (35.3)	27 (35.1)	15 (38.5)	
MORTALITY	60 (35.9)	22 (43.1)	24 (31.2)	14 (35.9)	0.385

*Data were presented as number and percentage unless mentioned otherwise. ‡Other drugs are long acting insulin or oral hypoglycemic drugs; ‡‡Multiple drugs administered during hospitalization including Remdesivir; Ivermectin, steroids, and Tocilizumab; ALC, absolute lymphocyte count; SSIT, Sliding Scale Insulin Therapy; **DPP-4, Dipeptidyl peptidase-4, ***SGLT2, Sodium-glucose transportprotein 2; *Statistically significant at P ≤ 0.05.*

hemoglobin (Hb), white blood cells (WBC), absolute lymphocyte count (ALC), D-Dimer (DD), platelet count (PLT), C-reactive protein (CRP), serum creatinine (sCr), alanine transaminase (ALT) and aspartate transaminase (AST).

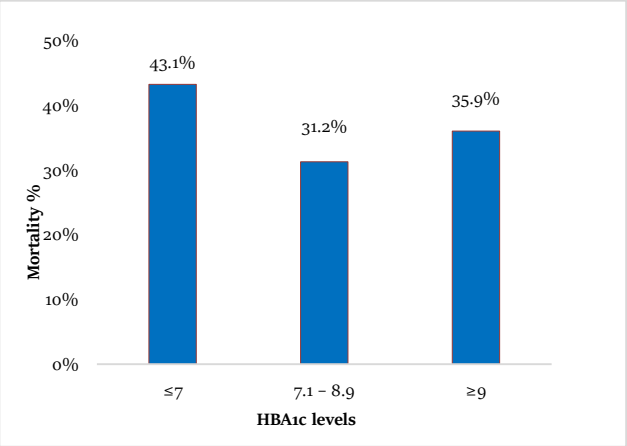

Figure 2: All-cause mortality in patients with different HbA1C levels (≤7, 7.1- 8.9, ≥9)

Table 2: Correlation between the laboratory findings of the patients and HBA1c levels

	Pearson's Rho	P value
Alanine transaminase	-0.092	0.238
Aspartate transaminase	-0.132	0.088
Absolute lymphocyte count	0.141	0.069
Platelet count	0.115	0.140
C-reactive protein	-0.028	0.721
D-Dimer	-0.028	0.715
Serum creatinine	0.028	0.715
Hemoglobin	.178*	0.022
Random blood sugar	0.485*	.000
White blood cells	0.09	0.218
SpO_2	0.14	0.860

The severity of COVID-19 cases and their management were classified according to the MoHP protocol into four groups: mild (mild illness symptoms and normal chest CT), moderate (positive chest CT, oxygen saturation (SpO_2) ≥ 92% on room air (RA) accompanied by symptoms or lymphocytopenia or leucopenia), severe (pulmonary infiltrates > 50%, or deteriorating lung lesion within one or two days, or SpO_2 < 92% at RA or respiratory rate (RR) > 30) and critically ill (SpO_2 < 90 at RA, RR > 30, respiratory failure despite oxygen therapy, shock or multiple organ injury).[15]

Additionally, COVID-19 medications followed the MoHP COVID-19 management protocol, involving antiviral agents (Remdesivir, Ivermectin), anti-inflammatory agents (steroids), and immuno-modulatory agents (Tocilizumab).[15] Diabetes control regimens in the hospital included sliding scale insulin, continuous insulin infusion, long-acting insulin, and oral antihyperglycemic medications.

Outcome and exposure groups: Hospital mortality was the primary outcome. The patients were divided into three groups based on HbA1C values; group 1 had HbA1c ≤ 7%, group 2 had HbA1c between7.1% and 8.9%, and group 3 had HbA1c ≥ 9%. This classification is crucial in diabetes management, aiding treatment decisions and complication forecasts. HbA1c thresholds help categorize patients by risk; ≤ 7% for good control, 7.1-8.9% for moderate control, and ≥ 9% for poor control. These values are vital for predicting diabetes-related complications and preventing long-term health issues from uncontrolled blood sugar levels.[19]

Statistical analysis: After data entry, cleaning, and coding into Microsoft Excel version 2007. The data were managed and analyzed using SPSS program version 24. Data normality was assessed through Kolmogorov-Smirnov test and histograms. Quantitative data were described as mean and standard deviation. Categorical data were presented as numbers and appropriate proportions. One-way ANOVA test was used in bivariate analyses to identify differences in demographics and clinical characteristics across three HbA1c level groups and to determine factors associated with COVID-19 mortality. The Chi-square test was used to compare categorical variables. A multivariate COX regression model was applied to assess baseline factors associated with COVID-19 mortality and to calculate adjusted Hazard ratios (HR) and 95% CIs. This model incorporated independent variables associated with mortality from univariate analysis ($p < 0.2$), i.e., age, severity, CT scan, SpO_2, ICU admission, insulin therapy, ALC, and DD. Pearson's correlation test was used to investigate correlations between HbA1c levels and other clinical parameters in COVID-19 patients including; ALT, AST, Hb, WBC, ALC, PLT, CRP, DD, sCr, RBS, and SpO_2. A two-sided p-value of 0.05 or less was considered statistically significant.

RESULTS

During the 5 months of the study, the hospital received 783 COVID-19 infected patients of whom 167 patients were diabetic. The flowchart of detailed numbers of included and excluded patients are shown in Figure 1.

Table 3: Cox regression model for identifying the main risk factors associated with in-hospital COVID-19 mortality.

Factors	Mortality		*P* value	Adjusted HR 95% CI	P-value
	Survived (107) N %)	Died (60) N (%)			
Age:					
<70years(r)	77 (70.6)	32 (29.4)	0.015*	1	0.035*
≥ 70 years	30 (51.7)	28 (48.3)		1.85 (1.04-3.28)	
Gender:					
Female (r)	49 (67.1)	24 (32.9)	0.469	-	
Male	58 (61.7)	36 (38.3)			
HbA1c:					
≤7% (r)	29 (56.9)	22 (43.1)	0.385	-	
>7%-8.9%	53 (68.8)	24 (31.2)			
≥9%	25 (64.1)	14 (35.9)			
Severity:					
Mild or Moderate (r)	68 (98.6)	1 (1.4)	**<0.001***	1	0.034*
Severe or critically ill	39 (39.8)	59 (60.2)		9.88 (1.19-82.18)	
ICU admission:					
No (r)	102 (94.4)	6 (5.6)	**<0.001***	1	<0.001*
Yes	5 (8.5)	54 (91.5)		7.66 (2.94-19.97)	
COVID signs by CT Scan					
No/low (r)	52 (78.8)	14 (21.2)	**0.001***	1	0.991
Moderate to high	55 (54.5)	46 (45.5)		0.99 (0.51-1.94)	
COVID therapy:					
Remdesivir (r)	4 (80.0)	1 (20.0)	0.571	-	
Steroid	4 (80.0)	1 (20.0)			
Multiple drugs ‡	99 (63.5)	57 (36.5)			
Hospital glycemic management:					
SSIT (r)	51 (56.0)	40 (44.0)	**<0.001***	1	0.038*
SSIT+ Insulin infusion	2 (16.7)	10 (83.3)		0.68 (0.31-1.47)	
SSIT+ other drugs #	54 (84.4)	10 (15.6)		0.45 (0.21-0.98)	
O_2 saturation:					
Mild or moderate(r)	96 (68.6)	44 (314)	**0.006***	1	0.542
Severe or critically ill (<92)	11 (40.7)	16 (59.3)		1.21 (0.65-2.26)	
D-Dimer:					
Normal range (<0.5 ug/ml, r)	53 (76.8)	16 (23.2)	**0.004***	1	0.910
High level	54 (55.1)	44 (44.9)		0.97 (0.52-1.79)	
Absolute lymphocytic count:					0.935
Normal count (1.5-3.5/cm, r)	37 (86.0)	6 (14.0)	**<0.001***	1	
Abnormal count	70 (56.5)	54 (43.5)		0.96 (0.38-2.45)	

(r): Reference category. SIT, Sliding Scale Insulin Therapy;‡Multiple drugs administered during hospitalization including Remdesivir, Ivermectin, steroids, and Tocilizumab.#Other drugs are long acting insulin or oral hypoglycemic drugs

Patients' demographics: The basic demographic and clinical characteristics of COVID-19-infected diabetic patients were divided into three groups based on their HbA1c levels (Table 1). The mean of their ages was 66±10.2 years, with a majority being male (56.3%). The average length of hospital stay was 12 days,

ranging from 1 to 31 days. About one third of the patients required ICU admission (35.3%). Concerning comorbidities, around half of the patients had either no comorbidities or only one (50.3%). The most comorbidities that the patients suffered from were hypertension (73.7%), cardiac diseases (32.9%), and chest diseases (12.6%). The differences in demographics among the three groups were not statistically significant, except for age, which showed a significant difference (p-value 0.001) . Patients with HbA1c ≤ 7% were the eldest, while those with HbA1c levels ≥ 9% were the youngest, with mean ages of 69 ± 11.6 and 61 ± 9.4, respectively.

Clinical characteristics: In the context of vital signs, the pulse exhibited statistically significant differences among the three groups, notably higher in patients with HbA1c level ≥ 9%
(p-value 0.009). Regarding laboratory parameters, there was a statistically significant difference across the three groups in terms of RBS, notably higher in patients with HbA1c levels (≥ 9%). Concerning hospital glycemic control, the predominant diabetes management strategies utilized were insulin sliding scale alone and in combination with other medications such as oral hypoglycemic drugs or long-acting insulin, accounting for 54.5% and 38.3% of cases, respectively (Table 1). Following correlation analysis conducted between HbA1c levels and some laboratory parameters reflecting hepatic, renal, coagulation and pulmonary functions in COVID-19 patients, it was found that HbA1c levels exhibited statistically significant correlations with only two variables. Specifically, a moderate positive correlation was observed with RBS (r) of 0.458, and a weak positive correlation was noted with hemoglobin level (r) of 0.178 (Table 2).

*Mortality***:** As shown in Figure 2, the highest mortality rate was detected in the lowest HbA1c levels ≤ 7% (43.1%), while the lowest mortality rate was in the HbA1c levels ranging from 7.1% to 8.9% (31.2%). Despite the difference in mortality rates across different the HbA1c levels, this difference was not statistically significant (p = 0.385, Table 1)

Mortality risk factors: Table 3 shows the main risk factors for mortality among diabetic COVID-19 patients, based on demographic, clinical, and laboratorial characteristics. Significant associations with mortality were found for age *(*p = 0.015), severity of the case (p < 0.001), CT scan report (p = 0.001), SpO_2 (p = 0.006), ALC (p < 0.001), ICU admission (p < 0.001), hospital glycemic management (p < 0.001) and DD level (p = 0.004). However, the multivariate Cox regression model identified several significant predictors of higher mortality among patients, including those aged ≥ 70 years [adjusted HR of 1.85 (95% CI 1.04 - 3.28)], severe and critically ill cases [adjusted HR of 9.88 (95% CI 1.19 - 82.18], ICU admitted patients [adjusted HR of 7.66 (95% CI 2.94 - 19.97)], and those receiving insulin sliding scale alone [adjusted HR of 0.45(95% CI 0.21 - 0.98)].

DISCUSSION

The global impact of COVID-19 has been profound, particularly affecting individuals with comorbidities like DM. Our study hypothesized that higher HbA1c levels in hospitalized COVID-19 diabetic patients were associated with higher mortality. Unexpectedly, our findings indicated that the highest mortality rates (43.1%) were in the lowest level of HbA1c ≤ 7% group, while the lowest mortality rates (31.2%) were in the intermediate level (7.1% - 8.9%) HbA1c group. However, this difference in mortality rates among the three HbA1c groups was not statistically significant (p = 0.385). Consequently, our study reveals that HbA1c can't be considered a predictor for COVID-19 mortality in diabetic patients infected with the virus.

A retrospective, single-center, observational study from New York which aimed to find the correlation between HbA1c and COVID-19 mortality as a primary outcome illustrated that there was no statistically significant association between HbA1c levels and mortality which resembles our results.[13] Also, this study showed that the highest HbA1c levels > 9% had the lowest mortality rate (19%).[13] Another retrospective study conducted in Jeddah, Saudi Arabia revealed that the difference in outcomes based on HbA1c levels did not demonstrate statistical significance.[20] Our study adds strength compared to the aforementioned studies by identifying age, COVID severity, ICU admission, and the use of insulin sliding scale for hospital glycemic control as significant predictors of mortality in COVID-19-infected diabetic patients**.**

Williamson EJ et al. in the OpenSAFELY study, examined the factors associated with COVID-19 death in 17 million patients which showed that COVID-19 mortality was higher in diabetic individuals with

HbA1c ≥ 7.5% versus non-diabetic COVID patients.[21] Our findings differ from those of that study as our study population was confined to diabetic patients**.** A Chinese and English systematic review and meta-analysis which included nine clinical trials reported that when HbA1c was assessed as a continuous variable, its association with poor outcomes of COVID-19 was not significant (OR, 1.02; 95% CI, 0.95 – 1.09). Conversely, considering elevated HbA1c as a dichotomous variable, led to significantly higher COVID-19 fatality rate compared to reduced HbA1c (OR, 2.300; 95% CI, 1.679 – 3.150).[22]

In our research, the highest survival rate observed among patients with HbA1c levels (7.1% and 8.9%) could be attributed to their lowest percentage of ICU admission (28.6%) and lowest percentage multiple comorbidities (42.9%). However, there was no statistically significant difference between the three groups in the preceding two issues. A commentary performed at a Brazilian hospital reported that 548 died from 2501 COVID patients, highlighting a higher mortality rate among ICU admitted patients (15.6%) compared to those who died in the COVID wards (6.3%).[23] Additionally, a retrospective Chinese cohort study conducted to identify predictors for composite endpoints (ICU admission, mechanical ventilation or death) revealed that patients suffering from a minimum of one comorbidity had a HR of 1.79 (95% CI 1.16 –2.77), whereas patients with more than two comorbidities had a HR of 2.59 (95% CI 1.61 – 4.17) compared to patients with no comorbidities.[24] Thus**,** an increase in ICU admissions and the number of comorbidities is directly proportional to an increase in mortality.

However, the assumed reason behind higher mortality in the lowest level HbA1c group ≤ 7% is that they are the eldest group; with a mean age of 69±11.6, and this difference was statistically significant compared to the other two groups (p value = 0.001).

While a prospective cohort study carried out in NYC was similar to our study as it addressed that older age (>75 years) was associated with higher mortality with a HR of 10.34 (95% CI 6.37 -16.79),[25] a Mexican retrospective cohort study refuted our findings by pointing out that mortality among diabetic COVID patients declined with escalating age without a clear explanation.[26]Several studies have emphasized that older age necessitates a higher glycemic goal ≤ 8% rather than normal glycemic control goal HbA1c ≤ 7% because geriatric patients are more vulnerable to high or low blood sugar events, weakness, falls, broken bones as well as their exposure to polypharmacy interactions.[19,27]

Moreover, 41.2% of this HbA1c ≤ 7% group who required ICU admission had also the highest DD of mean (1.5±2.1) and the lowest ALC (1±0.6) and all these factors were reported to be associated with increased mortality in COVID patients irrespective to comorbidities. A retrospective chart review revealed that patients who deceased had a less ALC (0.91 K/uL) than survivors (1.01 K/uL) (p = 0.047).[28] Another study showed that an increase in DD levels is a risk factor for death, where DD (>0.5 -1µg/L),HR, 95% CI, and p-value being 1.70, (1.26 to 2.28), and < 0.001 respectively.[25] Additionally, according to an Italian retrospective cohort study, ICU deaths were higher, accounting for 91% of hospital deaths.[29] Furthermore, patients in this HbA1c ≤ 7% group received only insulin sliding scale as anti-diabetic hospital management, accounting for the highest percentage (74.5%) with a p-value (0.002) among the three groups. A Peruvian study concluded that hospitalized diabetic COVID patients on an insulin sliding scale had a higher mortality rate.[30]

CONCLUSIONS

This research provides evidence that challenges the notion of HbA1c level as a predictor of mortality among hospitalized COVID-19 patients with diabetes. However, age has been found as an independent risk factor for mortality in this patient population. This provides an insight on crucial protection of elderly diabetics during pandemics. Additionally, this study highlighted other predictors of mortality in diabetic COVID hospitalized patients, which are COVID severity, ICU admission, and receiving insulin sliding scale as hospital glycemic management.

Ethical Consideration

This research has been reviewed and approved by the Research Ethics Committee of the central directorate of research and health development at Egyptian Ministry of Health and Population (approval number: 23-2021/12). Informed consent was waived because the collected data were not identifiable patient data.

***Limitations*:** Our research was confined to patients admitted to a single hospital. Conducting a

multicenter study would rather give more generalizable results to all COVID-19 diabetic patients The data collection process was manual; however, the utilization of an electronic medical record system would have facilitated access to patient information in a more efficient and accurate manner.

Recommendations: Future studies may incorporate the onset of diabetic disease in patients prior to hospitalization to observe its correlation with the outcome. Moreover, additional research is required to investigate the HbA1c association with COVID mortality in the context of the newly emerged virus variants that have been prevalent since 2021, the period during which this study was conducted.

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***Author contributions*:** Sonia S. Saleh: Literature review; Investigation; Methodology; Writing--original draft; Writing--review & editing. Mohamed Solyman Kabil: Conceptualization; Writing--review & editing; Supervision. Asia Toukhy: Formal analysis; Writing--review & editing. Amira M. Khtab: Literature review; Investigation; Writing—review & editing. Zinab M. Emam: Data management & curation; Writing--review & editing. Manar M. Ellaban: Literature search; Statistical analysis, Critical review and editing. All the authors approved the final version of the article to be published.

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