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Clinico-laboratory characteristics and glycemic events among hospitalized COVID-19 patients with diabetes mellitus at KNH

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ABSTRACT:

— ***Objective:*** Since its emergence in 2019, patients with pre-existing comorbidities such as diabetes mellitus (DM) have been reported to experience severe Coronavirus Disease (COVID-19). It has been associated with poorer outcomes among DM patients. This retrospective cross-sectional study aimed to determine the clinical-laboratory characteristics, glycemic events, and management among hospitalized patients with COVID-19 and DM.

— ***Patients and Methods:*** We reviewed 244 medical records of patients with COVID-19 and DM admitted to Kenyatta National Hospital between March 2020 and March 2022. We extracted the patients' demographics, clinical laboratory features, DM-related events, and management. Continuous variables were expressed as mean/standard deviation and categorical variables as numbers or percentages.

— ***Results:*** The median age was 58 years, with males comprising 53% of the participants. Hypertension (61%) was the most common comorbidity. 78% had pre-existing DM, while 54 (22%) had newly diagnosed diabetes (NDDM). 82% of the patients had poor long-term glycemic control, with a mean glycated hemoglobin of 9%, and 65% had admission hyperglycemia. The most frequent symptoms were dyspnea (60%) and cough (62%), while the median admission SpO_2 was 84%. Elevated C-reactive protein (90%) and D-dimers (70%) with lymphopenia (32%) were among the laboratory observations. Diabetic ketoacidosis (DKA) occurred in 26% of patients, and 11% experienced hypoglycemia.

— ***Conclusions:*** Hospitalized COVID-19 patients with DM had elevated random blood sugar (RBS) at admission with poor overall glycemic control and elevated inflammatory markers. Glycemic events, including DKA/hyperosmolar hyperglycemic state (HHS), were common during hospitalization. Our findings underscore the importance of closely monitoring and managing glycemic control in patients with COVID-19 and diabetes.

— ***Keywords:*** COVID-19, Diabetes mellitus, Glycemic events, Kenyatta National Hospital.

INTRODUCTION

Coronavirus Disease-19 (COVID-19) is a respiratory illness caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a newly emergent coronavirus, that was first recognized in Wuhan, China, in December 2019[1]. It is principally transmitted from person to person through respiratory droplets and aerosols[2,3]. As of February 2025, an estimated 778 million people had been infected globally, with

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a death toll of 7.1 million; in Africa, the cumulative number of confirmed cases was approximately 9.6 million[4]. The pandemic has remained a global concern due to the numerous new strains and mutations with variable degrees of virulence and severity, resulting in repeated surges in the worldwide number of cases and fatalities[5]. However, the introduction of vaccination has seen a dip in the number of severe cases and mortality globally[6].

Severe COVID-19 was associated with intensive care unit (ICU) admission and mortality in those with pre-existing comorbidities such as diabetes and hypertension. New-onset hyperglycemia was found to be an independent predictor of severe COVID-19 and death in hospitalized patients[7]. Furthermore, patients presenting with acute metabolic dysfunctions on admission, including hyperglycemia, were more likely to require intensive care services[8].

Accordingly, severe COVID-19 patients with diabetes are far more likely to require critical care admission, stay in the hospital longer, and are at increased risk of death[9].

In Kenya, there is a lack of data on the clinical course and outcomes of patients with diabetes, including those with newly diagnosed hyperglycemia in COVID-19. This study examines the clinical characteristics and in-hospital metabolic control of patients with diabetes in our local setting, providing valuable insights and identifying opportunities to improve patient outcomes, thus contributing valuable data to the existing body of knowledge.

PATIENTS AND METHODS

Study Design

We conducted a retrospective study including individuals admitted to Kenyatta National Hospital-Mbagathi Infectious Disease Unit (KNH-Mbagathi IDU) with COVID-19 and diabetes between the periods of 13th March 2020 to 13th March 2022.

Study Site

The study was carried out at the Kenyatta National Hospital, a public level six hospital in Nairobi that also serves as the University of Nairobi's training facility and that offers both general and advanced (specialized) medical and surgical treatments. KNH was designated as a COVID-19 treatment center during the epidemic.

Case Definition

We defined SARS-CoV-2 positive as medical records of patients who were admitted to the KNH-Mbagathi and had a positive polymerase chain reaction (PCR) or rapid antigen test for SARS-CoV-2 infection or disease code B34.2 (disease code for COVID-19 at KNH).

Pre-existing DM is defined as a history of known diabetes demonstrated using anti-diabetic medication before hospitalization.

Newly diagnosed diabetes mellitus is defined based on a negative history of prior DM but meeting the criteria for diagnosis of diabetes [HbA1C > 6.5%, random blood sugar (RBS) > 11.1 mmol/l or fasting blood sugar (FBS) > 7.0 mmol/l][10].

Eligibility

Inclusion criteria

- Evidence of SARS-CoV-2 infection.
- Diagnosis of diabetes mellitus (pre-existing or newly diagnosed).
- Above the age of 18 years
- Admitted at KNH-Mbagathi IDU

Exclusion criteria

- Patient hospitalized for more than three days in another facility.
- Contracted SARS-CoV-2 infection while in hospital.
- Incomplete files- missing PCR reports, Incomplete documentation of DM status and temporary files.

Sample Size Calculation

The sample size was calculated using Cochran's formula. We utilized a mortality proportion of 20% based on a study by Saha et al[11].

$$n_0 = \frac{(Z^2\, pq)}{e^2}$$

Where:

- Z is the value for the selected alpha level (1.96)
- p is the mortality proportion in DM
- q is 1-p
- e is acceptable error margin – 5%
- n_0 = 244

Thus, a minimum of 244 files was required for the study.

A pooled mortality proportion among DM patients was selected since mortality, as an outcome of interest, was deemed measurable, hence its adoption from the above study for sample size calculation.

Sampling Method

Systematic random sampling was employed. The population size in our study was 475, and the required sample size was 244. As a result, the sampling interval was estimated as:

sampling interval = population size ÷ required sample size

sampling interval = 475 ÷ 244

= 1.9467 thus every 2nd file was chosen.

Then, while analyzing for eligibility, we chose every second file from the population, i.e., every 1, 3, 5, 7, and so on, until we reached the desired 244 files.

Data Management and Analysis

Data collection procedure

The files of COVID-19 patients with DM meeting our inclusion criteria were reviewed. Data was extracted with the aid of a standardized extraction proforma created using KoboCollect app (free and open-source Android application designed for field data collection).

Demographic information such as age, gender, and cigarette smoking were recorded, as well as the presence of documented comorbidities [hypertension, chronic kidney disease, chronic obstructive pulmonary disease (COPD), asthma, and human immunodeficiency virus (HIV)], the presenting complaint (cough, fever, difficulty breathing), initial oxygen saturation (SpO_2), and initial/index laboratory results [C-reactive proteins (CRP), D-dimers, lymphocytes, lactate dehydrogenase (LDH), admission random blood sugar (RBS), and glycated hemoglobin (HbA1c)].

The index laboratory results were documented if completed within 24 hours of admission. Additionally, HbA1c recorded during hospitalization was also documented if it had not been done at the time of admission. Information on point-of-care glucose (POC) readings in the inpatient period was collected for the first three days (72 hours) of hospitalization, and when more than one reading was available, the average value for each day was calculated. Data on the total daily dose (TDD) of insulin was extracted for the initial 72 hours of hospitalization. The first three days are considered the best reflection of a patient's glucose load and, thus, the overall representation of the patient's physiology at hospitalization. Additionally, data on glycemic events was obtained from charts as blood glucose readings to evaluate for hypoglycemia (< 3.9 mmol/l) or hyperglycemia (> 10.0 mmol/l), arterial blood gas report to look at anion gap and, or urinalysis report to look for the presence of ketones to diagnose diabetic ketoacidosis (DKA) (Ketonuria +++) and serum osmolality (serum sodium levels) in the case of hyperosmolar hyperglycemic state (HHS). The reference time for glycemic events was the first 72 hours following hospitalization. Management of glycemic events was assessed by examination of data on glycemic treatment strategies during hospitalization [insulin, oral glycemic agents (OGLA), dosing trends, mode of administration, and discharge prescription] and administered co-treatment (steroids, oxygen).

Study Variables

Patient variables: documented age on the chart, documented gender, documented comorbidities (hypertension, HIV, asthma, COPD, and others), as well as the recorded smoking history.

Laboratory variables: recorded data on laboratory parameters were collected within the first 24 hours of hospitalization. The reference laboratory values included admission random blood sugar, markers of inflammation (CRP, D-dimers, lymphocyte count, and LDH), as well as HbA1c.

Clinical variables: documented presenting symptoms at the time of admission to include the presence of dyspnea, cough, fever, chest pain, and SpO_2 as recorded.

Glycemic events were defined as the occurrence of DKA/HHS as documented on the charts, while hypoglycemia was defined as a single blood glucose level < 3.9 mmol/l and hyperglycemia by levels greater than 10 mmol/l during the first 72 hours of hospitalization.

Management Variables

The treatment approach employed for managing glycemic events during hospitalization. This included the use of insulin, which encompassed the mode of administration and the total daily dose (TDD). Additionally, the use of oral glucose-lowering agents and the treatment plan upon discharge were also taken into consideration.

Statistical Analysis

The statistical software SPSS version 26 (IBM Corp., Armonk, NY, USA) was used for the analysis. Categorical variables are reported as frequencies (n) and percentages (%), while continuous variables are presented as means with standard deviations (mean ± SD) or medians with interquartile ranges (IQR), as applicable. Bivariable and multivariable logistic regression analyses were performed to calculate crude (COR) and adjusted (AOR) odds ratios with 95% confidence intervals, respectively. A p-value < 0.05 was considered statistically significant.

RESULTS

Five hundred seventy-five COVID-19 patients with diabetes mellitus were hospitalized at the KNH between 13th March 2020 and 13th March 2022. A total of 244 patient records were analyzed, as shown in Figure 1.

Characteristics and Outcomes

The population (Table 1) consisted of 129 (52.9%) male patients. Most of the participants were within the age group of 45 to 59 years, accounting for 44.7% (109) of the total patients. The median age of the participants was 58.5 years (IQR 48-61.25). Comorbidities were prevalent among the study group, with 169 (69.3%) individuals reporting one or more comorbid conditions. The most common comorbidity was hypertension (60.7%), although a sizable fraction of patients (51.6%) also had additional illnesses such as dementia, osteoarthritis, acute renal damage, pulmonary embolism, chronic kidney disease, and hyperthyroidism. HIV, on the other hand, was present in 5.7% of the sample population.

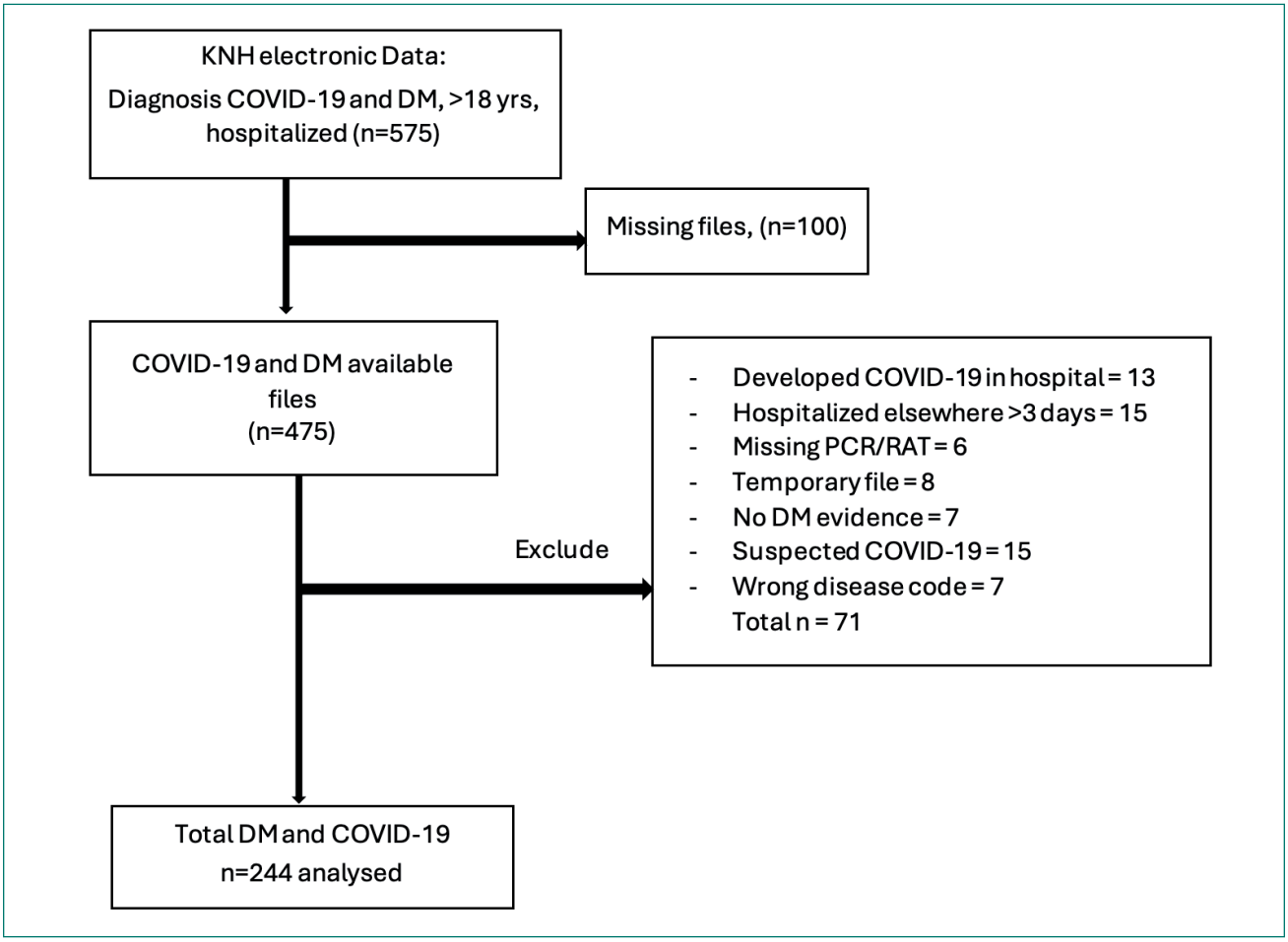

Figure 1. Recruitment flow.

Table 1. Demographic characteristics of COVID-19 patients with DM at Kenyatta National Hospital.

	Frequency (n)	Percent (%)
Age group (Median, IQR) years	58.5 (48-61.25)	
Age		
<30 years	15	6.1
30-44 years	35	14.3
4-59 years	109	44.7
≥60 years	85	34.8
Gender		
Male	129	52.9
Female	115	47.1
Cigarette smoking	10	4.1
Presence of comorbidity	169	69.3
Hypertension	148	60.7
HIV	14	5.7
COPD	3	1.2
Asthma	9	3.7
Cancer	10	4.1
Others*	126	51.6

*AKI, hyperthyroidism, pulmonary embolism, CKD, osteoarthritis, dementia, epilepsy.
AKI = Acute kidney injury, CKD = chronic kidney disease, COPD = Chronic obstructive pulmonary disease, HIV = Human immunodeficiency virus.

Regarding COVID-19 symptoms, cough [151 (61.9%)] was the most frequently reported, followed by dyspnea [147 (60.2%)], chest pain [75 (30.7%)], and fever [60 (24.6%)]. Additional symptoms included headache, sore throat, and general body malaise (**Supplementary Table 1**).

Upon admission, the median SpO_2 level was 85.5% (IQR: 70.75-90.0), and the median random blood sugar level was 13.8 mmol/l (IQR: 8.38-18.28), with approximately 64.8% of patients presenting with acute hyperglycemia (greater than 11.1 mmol/l). The average HbA1c level was 8.9% (SD 3.4). The median D-dimer level was 1.46 ug/l (IQR: 0.36-2.44), and the median lymphocyte cell count was 1.22 x 10^9/l (IQR: 0.88-1.38), with 32.4% of records indicating lymphopenia. The median CRP level was 55.9 mg/l (IQR: 27.3-59.68). A significant proportion of patients exhibited elevated LDH levels, with a median of 486 U/I (IQR: 430.3-577.5) compared to the normal reference range (Table 2).

Within the first 72 hours of hospitalization, 26 patients (10.7%) experienced hypoglycemia, 216 (88.5%) developed hyperglycemia, and 63 (25.8%) experienced diabetic ketoacidosis DKA or HHS. These events occurred in both patients with new-onset diabetes mellitus and those with pre-existing DM. The events were documented from admission to 72 hours post-hospitalization, as shown in Table 3.

Subcutaneous insulin was the primary method of insulin delivery for managing glycemic events [199 (81.6%)]. OGLA included metformin (98.2%), sulfonylureas (SU) (13%), and dipeptidyl peptidase-4 (DPP-4) inhibitors (9.7%). Insulin doses were progressively increased during the first three days, starting with a mean daily dose of 28.7 IU on day one and reaching 34.6 IU on day three. At discharge, 120 (49.2%) patients were on insulin, while 87 (64.0%) were discharged on metformin. The management of glycemic events is summarized in (**Supplementary Table 2**).

Dexamethasone was administered to 47.1% of patients, with an average dose of 6.4 mg (SD 3.8) over an average duration of 6.4 days (SD 3.8), while oxygen supplementation was required by 146 (59.8%) patients (**Supplementary Table 3**).

The mean hospital stay duration was 10.37 days (SD 6.4), with 139 (57%) patients discharged within 10 days or less. Of the study population, 55 (22.5%) patients passed away, and 32 (13.1%) remained hospitalized for over 14 days. Additionally, 11 (4.5%) patients were admitted to the critical care unit, as illustrated in (Table 4).

The results of a bi-variable analysis (Table 5) using binary logistic regression indicate significant associations between various factors and mortality among patients with DM. Patients with DM who had a comorbidity were found to be five times more likely to die compared to those without any comorbidity (COR = 5.46, 95% CI: 2.08-14.38, p = 0.001). Additionally, DM patients with hypertension were 11 times more likely to die compared to non-hypertensive diabetics (COR = 10.5, 95% CI: 4.03-27.61, $p < 0.001$). The

Table 2. Lab parameters at admission of COVID-19 patients with DM at Kenyatta National Hospital enrolled in the study.

Lab parameters at admission	Frequency or median (IQR)	Percent (%)
SpO_2 (median, IQR) % (n=223)	85.5 (70.75-90.0)	
Normal >90%	95	38.9
Low	128	52.5
Missing	21	8.6
Admission RBS (median, IQR) mmol/l (n=231)	13.8 (8.38-18.28)	
Normal (<11.1 mmol/l)	73	29.9
High (>11.1 mmo/l)	158	64.8
Missing	13	5.3
HbA1c (median, IQR) % (n=234)	8.3 (6.0-11.65)	
Normal (5.5-6.5%)	33	13.5
High (>6.5%)	201	82.4
Missing	10	4.1
D-dimers (median, IQR) ug/l (n=217)	1.46 (0.36-2.44)	
Normal (0.0-0.50 ug/l)	47	19.3
High (>0.50 ug/l)	170	69.7
Missing	27	11.1
Lymphocytes (median, IQR) 10^9/l (n=233)	1.22 (0.88-1.38)	
Low (<1.0*10^9/l)	79	32.4
Normal (1.0-3.7*10^9/l)	154	63.1
High (>3.7*10^9/l)	4	1.6
Missing	7	2.9
CRP (median, IQR) mg/l (n=235)	55.9 (27.3-59.68)	
Normal (0.0-5.0 mg/l)	15	6.1
High (>5.0 mg/l)	220	90.2
Missing	9	3.7
LDH (median, IQR) U/l (n=225)	486 (430.3-577.5)	
Normal (109-254 U/l)	13	5.3
High (>254 U/l)	212	86.9
Missing	19	7.8

CRP = C-reactive protein, DM = diabetes mellitus, HbA1c = glycated hemoglobin, LDH = lactate dehydrogenase, IQR = interquartile range, RBS = random blood sugar, SpO_2 = oxygen saturation.

Table 3. Glycemic events in the first 72 hours in hospitalized COVID-19 patients with DM at KNH.

Glycemic events	Total n (%)	DM status	
		Pre-existing diabetes n (%)	Newly diagnosed diabetes n (%)
Hypoglycemia			
Yes (<3.9 mmol/l	26 (10.7)	22 (11.6)	4 (7.4)
No (≥3.9 mmol/l)	218 (89.3)	168 (88.4)	50 (92.6)
Hyperglycemia			
>10.0 mmol/l	216 (88.5)	169 (88.9)	47 (87.0)
No (≤10.0 mmol/l)	28 (11.5)	21 (11.1)	7 (13.0)
DKA/HHS			
Yes	63 (25.8)	48 (25.3)	15 (27.8)
No	181 (74.2)	142 (74.7)	39 (72.2)

DM = Diabetes mellitus, DKA = Diabetic ketoacidosis, HHS = hyperosmolar hyperglycemic state, KNH = Kenyatta National Hospital.

Table 4. The short-term outcomes of hospitalized patients with COVID-19 and diabetes mellitus at Kenyatta National Hospital.

	Frequency (n)	Percent (%)
Outcome		
Hospitalized for more than 14 days	32	13.1
Died	55	22.5
Discharge within 14 days	146	59.8
ICU admission	11	4.5
Length of hospital (mean ± SD) days	10.37±6.4	
≤10 days	139	57.0
>10 days	105	43.0

ICU = Intensive care unit.

presence of dyspnea increased the likelihood of mortality by threefold compared to the absence of dyspnea (COR = 2.72, 95% CI: 1.35-5.51, $p = 0.004$). Furthermore, those with NDDM were twice as likely to die compared to those with pre-existing DM (COR = 2.06, 95% CI: 1.06-4.04, $p = 0.042$), and patients experiencing diabetic DKA or HHS had a two-fold increased risk of mortality compared to those without DKA/HHS (COR = 1.94, 95% CI: 1.02-3.70, $p = 0.044$). Subsequently, a multivariable analysis was conducted, incorporating significant variables ($p < 0.05$) identified in the bi-variable analysis. It revealed that hypertensive diabetic patients were six times more likely to die compared to diabetic patients without pre-existing hypertension (AOR = 6.12, 95% CI: 1.78-21.05, $p = 0.004$). Moreover, patients presenting with dyspnea were 2.5 times more likely to die compared to those without dyspnea (AOR = 2.51, 95% CI: 1.10-5.74, $p = 0.029$). Lastly, patients with DKA/HHS were 3.8 times more likely to die compared to those without (AOR = 3.83, 95% CI: 1.68-8.15, $p = 0.001$).

DISCUSSION

Previous research[12] has well-documented the impact of COVID-19 on patients with diabetes mellitus (DM), indicating a higher risk of severe disease and mortality. In this retrospective, cross-sectional, single-center study, we sought to highlight the clinical-laboratory characteristics and glycemic events among hospitalized COVID-19 patients with DM at KNH in Kenya between March 13, 2020, and March 13, 2022.

The study population was relatively younger, with the majority (44.7%) aged between 45-59 years, which is consistent with an earlier study in Kenya by Ombajo et al[13]. This finding likely results from KNH's location in the capital, a hub that attracts younger people who are traveling through the area. The study further observed a higher prevalence of male gender among individuals who contracted and were admitted with COVID-19, which aligns with findings reported globally[14-16]. This difference in prevalence could be attributed to various factors, including biological variations in immune systems between males and females[17]. Additionally, hazardous habits or behaviors, as well as potential non-compliance with COVID-19 containment measures, may contribute to the higher incidence among men.

The study highlighted the presence of comorbidities such as hypertension, which was observed in 60.7% of the study patients as an independent risk for mortality with AOR 6.12 (1.78-21.05). DM often coexists with other chronic conditions, particularly hypertension[18,19]. A meta-analysis[20] conducted on hospitalized patients in the United States revealed a prevalence of 55% for hypertension among individuals with DM. This finding suggests a significant association between DM and hypertension in the hospitalized population. Therefore, COVID-19 pa-

Table 5. Predictors of mortality among hospitalized COVID-19 patients with DM.

Factors	Yes n (%)	No n (%)	COR (95% CI)	*p*-value	AOR (95% CI)	*p*-value
Demographic factors						
Age	56.1±14	55.1±14	0.99 (0.97-1.02)	0.576		
Gender						
Male	32 (58.2)	97 (51.3)	0.76 (0.41-1.39)	0.443		
Female	23 (41.8)	92 (48.7)	Ref			
Cigarette smoking	2 (3.8)	8 (4.7)	1.24 (0.26-6.05)	0.787		
Clinical factors						
Presence of comorbidity	50 (90.9)	119 (64.7)	5.46 (2.08-14.38)	**0.001**	3.22 (0.69-15.11)	0.139
Hypertension	50 (90.9)	92 (48.7)	10.5 (4.03-27.61)	**< 0.001**	6.12 (1.78-21.05)	**0.004**
HIV	4 (7.3)	10 (5.3)	1.40 (0.42-4.66)	0.525		
Asthma	2 (3.6)	7 (3.7)	0.98 (0.20-4.86)	0.981		
Cancer	2 (3.6)	8 (4.2)	0.85 (0.18-4.14)	0.844		
Dispnea	43 (78.2)	104 (56.8)	2.72 (1.35-5.51)	**0.004**	2.51 (1.10-5.74)	**0.029**
Fever	13 (23.6)	47 (25.7)	0.90 (0.44-1.81)	0.86		
Cough	32 (58.2)	119 (65)	0.75 (0.40-1.39)	0.425		
Chest pain	17 (30.9)	58 (31.7)	0.96 (0.50-1.85)	0.527		
DM status						
Pre-existing diabetes	37 (67.3)	153 (81)	Ref			
Newly diagnosed diabetes						
Glycemic events	18 (32.7)	36 (19)	2.06 (1.06-4.04)	0.042	2.96 (1.21-7.24)	**0.017**
Hypoglycemia	7 (12.7)	19 (10.1)	0.77 (0.30-1.93)	0.62		
Hyperglycemia	48 (87.3)	168 (88.9)	1.17 (0.47-2.91)	0.81		
DKA/HHS	20 (36.4)	43 (22.8)	1.94 (1.02 – 3.70)	0.044	3.83 (1.68-8.15)	**0.001**
Laboratory factors						
Admission RBS (mean ± SD)	15.5±7.4	15.4±7.36	1.02 (0.79-1.33)	0.883		
HbA1c (mean ± SD)	9.3 (4.2	8.9±3.3	0.22 (0.04-1.39)	0.107		
D-dimers (mean ± SD)	1.8±1.5	1.7±1.5	0.09 (0.01-1.24)	0.071		
Lymphocytes (mean ± SD)	1.2±0.9	1.4±0.7	0.14 (0.00-18.91)	0.594		
CRP (Mean ±SD)	63.0±38.7	47.2±29.2	0.88 (0.74-1.03)	0.108		
LDH (Mean ±SD)	545.0±184.5	439.5±147.1	1.04 (0.99-1.08)	0.106		
Management approaches						
Steroid (n, %)	23 (53.5)	92 (68.1)	0.54 (0.27-1.08)	0.082		
Oxygen (n, %)	38 (88.4)	108 (80)	1.90 (0.68-5.29)	0.219		

AOR = adjusted odds ratio, COR = crude odds ratio, CRP = C-reactive protein, DKA = diabetic ketoacidosis, DM = diabetes mellitus, HbA1c = glycated hemoglobin, HHS = Hyperosmolar hyperglycemic state, HIV = Human immunodeficiency virus, LDH = lactate dehydrogenase, RBS = Random blood sugar.

tients who have DM, especially those with pre-existing hypertension, should receive careful and diligent monitoring. The coexistence of DM and hypertension can potentially worsen the clinical course and outcomes of COVID-19, emphasizing the need for close attention and management for this specific patient population.

At the time of presentation, cough and dyspnea were identified as the most reported symptoms among the patients. Surprisingly, fever was only reported in 24.6% of the cases. Wang et al[16] found that the most common symptoms at illness onset were fever 98.6%, fatigue 69.6%, dry cough 59.4%, myalgia 34.8%, and dyspnea 31.2%. Hu et al[21], in a systematic review and meta-analysis, found the commonest symptoms to be fever (85%) and cough (65.7%), while 21.4% of patients presented with dyspnea.

Similarly, Guan et al[22], in a retrospective study involving 1,099 patients with COVID-19, found the commonest symptoms were fever and cough at 43.7% and 67.8%, respectively. Likewise, in the CORONADO study[23], the most common symptoms and signs were fever (77.9%), cough (68.7%), fatigue (62.4%), and dyspnea (61.8%). The variation in symptomatology at presentation could be attributed to documentation and the reporting of presenting complaints at the time of hospitalization. In our study, breathlessness was found to be a significant predictor of mortality. This finding is consistent with previous research[20] that has demonstrated DM increased susceptibility to severe disease.

Moreover, the presence of dyspnea at admission serves as an indicator of the severity of the condition. In a prior study, Cariou et al[23] found that among COVID-19 patients with DM, dyspnea OR 2.17 (1.34, 3.50) on admission was positively linked with death. Therefore, it is important to recognize and monitor breathlessness in DM patients with COVID-19 as a potential marker for adverse outcomes.

The current study revealed that most of the hospitalized patients exhibited abnormalities in their inflammatory markers. The elevated makers of inflammation point to an enduring insult as well as the acute nature of the disease and the resultant hyperinflammatory state[9,24]. We noted from our study a prevalence of lymphocytopenia of 32.4%, which contrasts

with other studies[14,22,25] that observed a higher proportion of patients with lymphocytopenia, ranging from 60.1% to 83.2%. Lymphopenia in COVID-19 patients is thought to result from either myelosuppression, infection, or destruction or from functional exhaustion of the antiviral lymphocytes[26]. Low lymphocyte count is a recognized indicator of inflammation in COVID-19[25]. Elevated D-dimers could be a result of increased thrombosis due to hyperglycemia[27] or as a marker of inflammation following infection with SARS-CoV-2[28].

In our study, the proportion of NDDM was found to be 22%. The rate was similar to the 20.8% recorded in Vietnam[29]. The prevalence of DM in a study conducted in North India[30] with 401 patients was reported as 47.1% for pre-existing DM and 5.2% for new-onset DM. However, in a retrospective study by Li et al[7], the incidence of NDDM was documented as 28.4%, while the incidence among those hospitalized with COVID-19 was 20.8% in Wuhan, China. In a meta-analysis by Sathish et al[31], the incidence of NDDM was found to be 14%. Stress hyperglycemia related to acute inflammation, as well as the use of corticosteroids, could contribute to the observed upsurge in NDDM cases[31,32]. In our cohort, we found that 47.5% of patients were given steroids for an average of 6 days. The RECOVERY trial[33] conducted in the United Kingdom demonstrated that using dexamethasone at a dose of 6 mg per day for 10 days could improve survival outcomes in individuals with moderate COVID-19 pneumonia. Thus, steroid use was adopted as part of the standard of care in moderate to severe SARS-CoV-2 infection. However, the diabetogenic effect of the SARS-CoV-2 virus should be considered when trying to figure out why there are many NDDM cases in the COVID-19 pandemic[34]. Some of the cases of NDDM could be a result of previously unrecognized DM[35]. We did not continue to monitor the patients after they were discharged to see if the hyperglycemia continued beyond the hospital stay. While an American examination indicated an 8% increase in the risk of diabetes mellitus (DM) six months after hospitalization, the long-term risk of DM associated with COVID-19 is still unclear[36]. After recovering from COVID-19, patients were more likely to develop type 2 diabetes, according to the primary care study[37].

Our present study highlights the significance of glycemic control in patients with DM, particularly during COVID-19 infection, as it can impact disease outcomes. Many patients in this study demonstrated inadequate long-term glucose control. Additionally, a significant proportion of patients experienced DKA within the first 72 hours of admission, while hypoglycemia and in-hospital hyperglycemia were also prevalent. Notably, a small percentage (5.3%) of DM patients continued to use sulphonylureas (SU) during hospitalization. This observation raises concerns about the implications of SU use on glycemic control and treatment decisions in the context of COVID-19 infection. SU has been linked with increased cases of hypoglycemia among hospitalized patients[38]. Furthermore, COVID-19-induced anorexia leads to diminished oral intake, which could result in hypoglycemia[23].

DM is closely related to worse outcomes for individuals who are hospitalized. These include all-cause mortality, the requirement for ICU treatment and mechanical ventilation, as well as extended hospital stays[19,23,39]. The average duration of hospital stay in our study was ten days, with an overall mortality rate of 22.5%. This mortality rate was higher than the reported rates in other studies[11], which could be attributed to several factors, including differences in study populations and healthcare systems. Although the design of the current study prevented us from comparing the COVID-19 cohort to those without diabetes, our findings are consistent with previous research[40] that revealed diabetic patients had higher mortality and a greater need for intensive care unit treatment. There is a strong link between mortality and long-term glucose control[41,42]. However, our study found that HbA1c and admission RBS were not significantly associated with mortality. These findings are similar to those reported in ACCREDIT and CORONADO studies[23,24].

Significant predictors of mortality in our study included hypertension, dyspnea, NDDM, and the presence of DKA/HHS. Uncontrolled metabolic states in DM patients increase the odds of serious complications and death[43]. Across the literature, a weighty determinant of mortality in COVID-19 was the presence of comorbidities, with DM being a critical determinant of mortality significantly influencing the progression and severity of the disease[44,45]. Notably, DM often coexists with hypertension, which can adversely impact outcome[46]. Regarding hospitalization beyond 14 days, our study inferred that smoking, age greater than 55.4 years, cough and dyspnea were significant determinants of prolonged hospitalization. The findings emphasize the importance of closely monitoring and managing these factors to improve patient outcomes.

Limitations and Strengths

Utilizing the discharge diagnosis code along with the discharge summary guaranteed that nearly all DM patients were recorded and deemed eligible for sampling. Nonetheless, our study has several limitations; considering we centered on hospitalized COVID-19 cases, our findings cannot be applied to all COVID-19 and diabetic subjects, primarily those with a less severe form of the illness and have not compared DM *vs.* non-DM patients with COVID-19. Secondly, because the study was retrospective in nature, we were unable to determine a causal relationship. Some lab values contained missing data and thus could have impacted the analysis of our secondary objectives. Thirdly, we did not include vaccination status in our study, and this could have impaction on disease severity. It is noteworthy to mention that our study timeline

spanned both pre-vaccination and vaccination phases. However, these discoveries will both bridge the existing knowledge gap and enhance the current body of knowledge, particularly regarding Sub-Saharan data.

CONCLUSIONS

Hospitalized COVID-19 patients with DM had elevated RBS at admission with poor overall glycemic control and elevated levels of inflammatory markers. Glycemic events, including DKA/HHS, were common during hospitalization. Our findings underscore the importance of closely monitoring and managing glycemic control in patients with COVID-19 and diabetes.

Ethics Approval:
The study was approved by the Department of Clinical Medicine and Therapeutics, University of Nairobi and the KNH/UON ERC with registration number P456/05/2022 on 14/11/2022. The study was registered with the KNH Medical Research and Programs department.

Conflict of Interest:
The authors declare they have no conflict of interest.

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Informed Consent:
Informed consent was waived due to the retrospective nature of the study. Ethical clearance by the ethical committee was obtained.

Authors' Contributions:
Joseph Simel Karbolo contributed to data collection, analysis, interpretation, and drafting of the manuscript. Professor Seth. O. Mcligeyo and Professor C.F. Otieno offered expert and specialist direction and revision of the manuscript. All authors contributed to the conception and design of the study.
All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Data Availability:
Data collected to support the findings of this study is available from the corresponding author [Joseph Simel Karbolo] on request.

AI Disclosure:
The core ideas, research, and writing of this manuscript are entirely human-generated, and any use of AI was limited to non-substantive editorial support.

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