Global Scientific JOURNALS
GSJ: Volume 11, Issue 6, June 2023, Online: ISSN 2320-9186
www.globalscientificjournal.com

# Prevalence and Risk Factors of Diabetic Ketoacidosis and Hyperglycemic Hyperosmolar State in Patients with Diabetes Mellitus at Kigali University Teaching Hospital Rwanda

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## Abstract

Diabetes mellitus is a heterogeneous metabolic disorder characterized by chronic hyperglycemia resulting from impaired insulin secretion, insulin action, or both. Diabetic emergencies, such as Diabetic Ketoacidosis (DKA) and Hyperglycemic Hyperosmolar State (HHS), are significant reasons for diabetic patients to seek emergency care. This study aims to retrospectively examine the prevalence of DKA and HHS in Rwanda, along with associated risk factors and treatment outcomes. During the study conducted at the University Teaching Hospital of Kigali (CHUK) from 2020 to 2021, 217 patients with either type 1 or type 2 diabetes were admitted, with 60% being females. Out of these patients, 68.7% were cured, 29.5% died, and the remaining 1.8% were either counter-referred or transferred. HHS was associated with higher mortality compared to DKA. The prevalence of DKA was found to be 36.4%, with an age range of 7 to 92 years and a mean age of 42.78 ± 20.07 years. The prevalence of HHS was 8.3%, with an age range of 2 to 78 years and a mean age of 42.89 ± 22.88 years. Significant risk factors for DKA development included sepsis, urinary tract infections (UTIs), hypertension (HTN), alcohol consumption, and gastric disease. Pneumonia, sepsis, and UTIs were strongly associated with DKA development. Only steroids were found to be associated with HHS development. The average hospital stay for DKA was 15.3 ± 13.44 days, while for HHS, it was 13.39 ± 20.68 days. This study highlights the high prevalence of DKA and HHS among diabetic patients in Rwanda, emphasizing the urgent need for diabetes education, early detection, and prevention strategies for complications. It also calls for subsidized diabetes medications to improve access for those who cannot afford them, similar to the approach taken for communicable diseases like HIV. A multidisciplinary approach involving physicians, dieticians, and physical therapists is essential to enhance diabetes awareness, early detection, and education on complication prevention. These efforts are crucial for improving the management and outcomes of diabetic emergencies in Rwanda. This study provides valuable insights into the prevalence, risk factors, and treatment outcomes of DKA and HHS, highlighting the need for comprehensive strategies to address the challenges faced by diabetic patients in Rwanda and reduce the burden of diabetic emergencies.

**Acronyms:** UR: University of Rwanda, CMHS: College of Medicine and Health Sciences, CHUK: University Teaching Hospital of Kigali, ED: Emergency department, DM: Diabetes mellitus, DKA: Diabetic ketoacidosis, HHS: Hyperglycemic hyperosmolar state, T1DM: Type 1 diabetes mellitus, T2DM: Type 2 diabetes mellitus, MI: Myocardial infarction, IRB: Institutional Review Board

# CHAPTER 1: INTRODUCTION

## 1.1. Background

Diabetes mellitus is a general term of heterogeneous disturbances of metabolism for which the main finding is chronic hyperglycemia. It can result from either impaired insulin secretion, insulin action or both [1]. Women are more sensitive to insulin than men. However, the prevalence of type 2 diabetes mellitus is like both genders of which the sex difference is based on endogenous androgens levels where the higher bioavailable testosterone in women is correlated with increased risks in women whereas for men, lower testosterone levels are associated with increased risks.

Diabetic ketoacidosis (DKA) one of acute complications of type 1 diabetes mellitus and the leading cause of morbidity and mortality [4], results from increased fatty acid metabolism and the accumulation of ketoacids i.e. acetoacetate and β-hydroxybutyrate, that is often accompanied by hyperglycemia and presents with a triad of hyperglycemia, metabolic acidosis and ketonemia [5]. Its occurrence is in insulin dependent DM in association of insulin or other illnesses such as an infection, gastric diseases, pancreatitis, or myocardial infarction that increases insulin requirements. In HHS, a triad of severe hyperglycemia, high serum osmolarity and dehydration is used to describe the condition. The study has found that DKA admissions in UK hospitals increased in patients with both type 1 and type 2 diabetes mellitus with a mortality rate reaching up to 5% where HHS accounts less than 1% of all admissions together with a mortality rate of 10-20% [5].



In this study, we aim at evaluating the prevalence of DKA and HHS at CHUK to better understand the rate at which these conditions reach the tertiary hospitals.

## 1.2. Problem statement

There was a high number of 23.4% for the patients with hyperglycemic states (DKA and HHS) five years back at CHUK, though there is still need of further studies to elicit data related to diabetic emergencies (DKA and HHS). A study done in tertiary hospitals of which 143 patients participated, showed that 85 out of 143 patients (59.4%) were diagnosed with DKA, 51 (35.6%) were diagnosed with HHS and 7 (4.9%) patients were unclassified. Diabetes mellitus type 2 were the most prevalent 105 (73.4%) of the patients, 35 (25.2%) type 1 and 2 (1.4%) unclassified [6].

In a study done at tertiary hospitals in Rwanda, the leading precipitating factors include the infections 56 (34.5%), while in another study done in ED at CHUK showed that infections accounted for 33.3%, newly diagnosed DM 48 (27%), poor drug adherence 31 (21.6%) in internal medicine, while in ED poor adherence ranged from 34-69% [7] and drug run out 15 (42.8%) of which depression were the most contributing

factor. The overall mortality was found to be 27.9% (40 out of 143 patients) which was high (34.1%) in ED with a similar median hospital stay of 11 days.

Factors like Myocardial infarction, trauma, stroke, severe dehydration, bedridden or impaired thirsty response in elderly people were shown to trigger the counterregulatory hormones, thus resulting in development of HHS. In this line, there is a need to further carry out this study about the prevalence and associated risk factors of hyperglycemic emergencies (DKA and HHS) with possible outcomes at CHUK. Although some research has been conducted to provide the information about the prevalence of hyperglycemic emergencies and their associated risk factors at tertiary hospitals in Rwanda, there is still a need to provide data about these conditions as a basis for developing preventive strategies [8].

## 1.3. Research gap

The conduction of this study on prevalence of DKA and HHS and their associated risk factors will help CHUK in the development of the prevention strategies and effective management plan. In line with the knowledge of the trend in prevalence and associated risk factors of diabetic emergencies with possible outcomes, patients will acquire the knowledge of the risk factors as precipitating factors to the development of these diabetic emergencies and provide evidence-based insights about the preventive measures.

## 1.4. Research questions

- What is the prevalence of diabetic ketoacidosis (DKA) and hyperosmolar hyperglycemic state (HHS) among patients admitted with diabetes mellitus at CHUK in 2020-2021?
- What are the associated risk factors for the development of DKA and HHS among patients with diabetes at CHUK in 2020-2021?
- What was the peak age, age at presentation, and most affected gender for patients who developed DKA and HHS at CHUK in 2020-2021?

## 1.5. Research Objectives

### 1.5.1. Main objective

- To determine the prevalence of DKA and HHS at CHUK in patients with Diabetes Mellitus

### 1.5.2. Specific objectives

- Assess the social demographic characteristics of patients with emergency hyperglycemia by examining factors such as age, gender, socioeconomic status, and educational background.
- Identify the risk factors associated with the development of diabetic ketoacidosis (DKA) and hyperosmolar hyperglycemic state (HHS) among diabetic patients, including insulin non-compliance, comorbidities, medication adherence, and lifestyle factors.

## 1.6. Significance of the study

The significance of this study lies in its potential to contribute to the early recognition and treatment of diabetes, thereby reducing the risk factors associated with complications. By identifying the precipitating risk factors of diabetic emergencies, healthcare providers, particularly medical doctors, can gain valuable insights that enable them to take proactive measures.

Furthermore, this research can aid in the early detection of diabetes mellitus and the development of preventive measures for diabetic emergencies. Finally, it serves as a valuable source of information for researchers interested in the field of endocrinology, providing a foundation for further studies.

# CHAPTER 2: LITERATURE REVIEW

## 2.1. Definitions

Diabetes mellitus, commonly referred to as DM, is a metabolic disorder characterized by abnormally high levels of glucose in the bloodstream. This condition encompasses various categories such as type 1, type 2, maturity-onset diabetes of the young (MODY), gestational diabetes, neonatal diabetes, and secondary causes resulting from endocrine disorders, steroid usage, and other factors [39]. The primary subcategories of this disorder consist of type 1 diabetes mellitus (T1DM), which is characterized by inadequate insulin secretion, and type 2 diabetes mellitus (T2DM), which arises from impaired insulin action. Acute and potentially life-threatening complications of diabetes include diabetic ketoacidosis (DKA), hyperglycemic hyperosmolar state (HHS), lactic acidosis (LA), and hypoglycemia [40]. DKA and severe hypoglycemia are more frequent in type 1 diabetes, while HHS, without ketoacidosis, is more commonly observed in type 2 diabetes.

## 2.2. Clinical presentation

The symptoms observed in clinical presentations consist of heightened thirst, frequent urination, heightened appetite, low energy levels, fatigue, susceptibility to bacterial and fungal infections, and delayed healing of wounds. In addition, certain patients may experience sensations of numbness or tingling in their hands or feet, along with blurry vision [40]. Diabetic ketoacidosis is one of serious acute emergent complications of type 1 diabetes mellitus (T1DM) in the children population. The international society of Pediatric and Adolescents defines DKA as a blood glucose >11 mmol (≃200 mg/dl), Venous PH < 7.3 or bicarbonate 15 mmol, ketonemia and ketonuria [4]. HHS is a syndrome characterized by a severe hyperglycemia, hyperosmolarity and dehydration without the presence of ketoacidosis and the diagnostic seven criteria include: plasma glucose concentration >33.3 mmol/L (>600 mg/dl), arterial PH ≥ 7.3, serum bicarbonate ≥15 mmol/l, serum osmolarity > 320 mOsm/kg, decreased consciousness or seizures, absent or mild ketonuria and absent ketonemia [14].

## 2.3. Pathogenesis

The major histocompatibility complex (MHC) or human leukocyte antigens (HLA) accounts for a significant portion (40-50%) of the familial aggregation observed in Type 1 diabetes (T1DM). Polymorphisms in class II HLA genes encoding DQ and DR4-DQ8, with DR3-DQ2 being prevalent in 90% of T1DM patients, play a crucial role in the disease [42].

Latent autoimmune diabetes of adults (LADA) is another form of T1DM, typically appearing in adulthood and characterized by a slower onset compared to other variants. T1DM is marked by a rapid destruction of pancreatic beta cells in children, while adults experience a faster rate of destruction. Serum analysis often reveals the presence of autoantibodies against islet cells, insulin, glutamic acid decarboxylase-65 (GAD-65), and zinc transporter 8 (Zn T8) in T1DM patients [40];[43].

Type 2 diabetes (T2DM) involves insulin resistance and beta-cell dysfunction. Initially, there is compensatory increased insulin secretion to maintain normal glucose levels. However, as the disease progresses, beta cells undergo changes, resulting in inadequate insulin secretion and subsequent hyperglycemia. Risk factors for T2DM development include lack of physical activity, a history of gestational diabetes mellitus (GDM), and the presence of hypertension or dyslipidemia [39];[40].

Hyperglycemic Hyperosmolar state (HHS) and diabetic ketoacidosis (DKA) are both associated with reduced circulating insulin levels, elevated counterregulatory hormones, increased hepatic and renal glucose production, impaired peripheral glucose utilization, and changes in osmolarity [15];[41]. HHS is characterized by glycosuria and subsequent osmotic diuresis, leading to the loss of water, sodium, potassium, and other electrolytes. Insulin levels in HHS are insufficient to promote glucose utilization by sensitive tissues but still adequate to prevent lipolysis and ketogenesis [15].



## 2.4. Precipitating risk factors

The resurgence factors of DKA and HHS is still unknown, but some clinical conditions like urinary tract infections, pneumonia, myocardial infarction, and stroke specifically associated with HHS are thought to be among the risk factors. During the same time period of DKA and HHS increase, myocardial infarction and stroke are increased among adults with diabetes in young age groups [17].

Though the incidence of DKA in Africa is scarce, some data show a high frequency in countries like Sudan 92.1%, North western Nigeria 62.2%, South Africa 69.8% whereas it is 35.8% in Addis Ababa of prevalence among those patients diagnosed with DM of whom there is as a lack of 95% of them don't perform self-blood glucose monitoring, 33% don't take medications regularly and 75% of direct or indirect admissions due to uncontrolled diabetes mellitus [19]; (20)

Stressful events, missing out insulin therapy, behavioral modifications, non-adherence to self-monitoring at home are among others recorded risk factors and over 95% of these patients showed poor glycemic control (HbA1c $\geq$ 6.5%) [3].

Contrary to DM1 which is an autoimmune destruction of Beta cells in Langerhans cells of the pancreas, DM2 has found risk factors among others to include alcohol consumption, unhealthy diet high in fat, smoking, lack of physical inactivity, obesity and high blood pressure [4].

## 2.5. Prevalence of Diabetic ketoacidosis and Hyperglycemic hyperosmolar state

Globally, a yearly estimate of 79 100 to 96 000 children under the age of 15 develop T1DM of which up 80% have already developed DKA at diagnosis of diabetes [9]. This number can reach as high as 132,600 cases if the age is extended up to 20 years. Cerebral injury is the main cause of morbidity and mortality where cerebral edema accounts for 60-90% of deaths in DKA.

The overall prevalence of DKA was 29.9% with six countries (Australia, Denmark, Germany, Norway, Sweden and Wales) reporting a lower prevalence and a high prevalence in five countries (Austria, Italy, Luxembourg, USA and Slovenia) with male predominance of 52% [2]. In Sub-Saharan Africa, this prevalence is not well known. But some observational studies round its frequency varying from 71-88% [4]; [9].

It is limited to an extent unclear ([10] data about the T1DM among the adult population and the risks are higher among those <1 year or ≥ 10 years old. In the study, the prevalence of T2DM recorded in <1 year decreased and increased in among those with ≥ 10 years old making it prevalent among adult people. An overall prevalence in Northern America is 50-100 per 1000 people, in the European region were reported to be the same as that of Northern America. The incidence rates were reported to range from 8 to 51.3 per 1000 cases [11].

Both DKA and HHS are diabetic emergencies that are characterized by severe hyperglycemia of which HHS has more morbidity and mortality rate and both conditions can result in coma. Unlike DKA, HHS lacks Kussmaul breathing in its definition [12]. Both DKA and HHS occur in patients with T1D and T2D, but DKA is prevalent in young people aged by 18-44 years old whereas HHS is commonly found in adult patients in a range of 45-64 years old with a minimal 2% prevalent in adolescents at presentation especially in those with 6q24 related transient neonatal diabetes mellitus [2]; [13]. The incidence of HHS is unknown because of the lack of population-based studies and multiple comorbidities associated with this disease whereas its prevalence ranges from 15 to 45 percent. It can occur at any age, but it is common in elderly patients who are suffering with other comorbidities such as infections, cancer and cardiovascular diseases among others as compared with DKA. HHS accounts for less than 1% of all diabetes related admissions but can reach up to 4% of new type 2 diabetes patients.

A study done in the U.S.A has found that there may be overlapping characteristic features between DKA and HHS and some patients with severe dehydration have mild or moderate acidosis that is mainly due to hypoperfusion and lactic acidosis. Conversely, some children with type 1 diabetes mellitus can present features of HHS such as severe hyperglycemia especially when fed with sugary beverages to quench thirst [2]. A study in the U.S done on 1027 youth people aged between 9-18 years old found that the prevalence of HHS is common in non-Hispanic, African-America, male, government aided and adolescents with obesity with a recognizable familial history. There were 38% insulin resistance, with 25% of those prescribed insulin prior to admission [16].

In Rwanda, the number of patients with diabetes mellitus per a thousand is 297.0 among the age group of 20-70-year-old, the prevalence is among the same age group is 4.5% and the undiagnosed patients per a thousand is 171 [21]; [22]. The hyperglycemic states that include DKA and HHS among the patients with DM was found to be 23.4% compared to those who present with hypoglycemic state of 16% of who DKA was found to be the most prevalent and the most indicator of admission among the patients with DM and it poses a significant mortality of 5.2% for the patients who present with it for the first time which increases to 23.4% when it is recurrent. The numbers are thought to be higher as these conditions are emergent cases of which this department lacks sufficient recording resources.

# CHAPTER 3: METHODOLOGY

## 3.1. Study design

A retrospective study was conducted to evaluate the prevalence of DKA and HHS in the patients with DM and their associated risk factors. During the study, data were collected from pre-recorded files of the patients from their stores after getting the approval from the research committee of CHUK.

## 3.2. Study setting

The study was conducted at CHUK, involving patients who present with diabetic ketoacidosis (DKA) or hyperosmolar hyperglycemic state (HHS) in the departments of Internal Medicine, Pediatrics, and Emergency. The results of the study will be shared with the hospital and the school for epidemiological purposes and future research.

**Population:** All patients who consulted at CHUK having developed DKA or HHS in the department of Internal medicine, Pediatrics and Emergency.

## 3.3. Sample size

The sample size was calculated using formulae in two steps:

### 3.3.1. Sample size for the infinite population

$$S = \frac{z^2 * p * (1 - p)}{M^2}$$

## Symbols standing for:

**S:** Sample size for infinite population,

**Z:** ***Z-score***, which is calculated based on the confidence level, where the confidence level of 95% is equivalent to Z-value of 1.96

**P:** Population proportion which rounded to be 50% of the population which is equivalent to 0.5

**M:** Margin of error which is rounded to be 5% of the population which is equivalent to 0.05.

Then the Sample size for infinite population,

$$S = \frac{(1.96)^2 * 0.5 * (1 - 0.5)}{0.05^2} = 384$$

### 3.3.2. Adjusted sample size.

The adjusted sample size is calculated from the sample size of the infinite population.

**Adjusted sample size** $(\boldsymbol{S}) = \frac{\boldsymbol{S}}{\mathbf{1}+\left(\frac{\boldsymbol{S}-\mathbf{1}}{\boldsymbol{P}}\right)}$.

For our study, we specifically considered a population (represented by the letter "P") of 500 individuals who were diabetic patients and sought consultation at CHUK. Among them, some individuals either developed diabetic ketoacidosis (DKA) or hyperglycemic hyperosmolar state (HHS), while others did not have these conditions upon arrival.

**Then the adjusted sample size:** $(\boldsymbol{S}) = \frac{\mathbf{384}}{\mathbf{1}+\frac{\mathbf{384}-\mathbf{1}}{\mathbf{500}}} = \frac{\mathbf{384}}{\mathbf{1.766}} = \mathbf{217.44}$

## 3.4. Inclusion criteria

Every patient consulted at CHUK from January 1st, 2020, to December 31st, 2021, with diabetes mellitus.

## 3.5. Exclusion criteria

Every patient with diabetes mellitus whose file was found incomplete.

## 3.6Data collection process and tools

Data was recorded from the files of the patients, recorded in data collection form, and then put in the computers.

**Tools:** laptops, questionnaires, pens

## 3.7. Dependent variables

Presence of the risk factors

## 3.8. Independent variables

Patients were diagnosed with diabetes mellitus.

## 3.9. Data analysis

For data analysis, we utilized IBM SPSS statistics software. The data was summarized in tables and figures, and percentages were used for interpretation. Microsoft Word and Microsoft Excel were employed to generate texts and tables. To determine the statistical significance of our findings, we performed Chi-square tests to assess variable distribution and used a P-value (P= 0.05) to support evidence against the null hypothesis.

## 3.10. Ethical consideration

Following the approval of the University of Rwanda (UR) Institutional Review Board (IRB) at the College of Medicine and Health Sciences (CMHS), the study was conducted. Subsequently, the approval was obtained from the CHUK ethical committee of research to access the patients' files store, while ensuring the confidentiality of the patients' information. To ensure data security, the patients' information stored in our computers was protected with passwords.

## 3.11. Limitations

Poorly completed patients' files as well as poor handwriting.

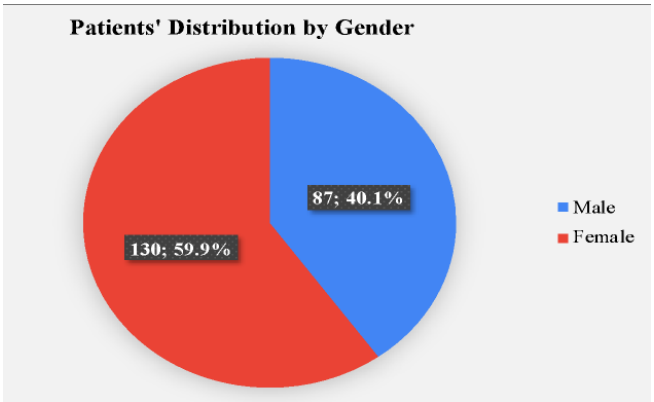
Limited financial resources.

# CHAPTER 4: DATA ANALYSIS AND PRESENTATION OF RESULTS

We collected data from 217 files of patients treated for either type 1 diabetes mellitus or type 2 diabetes mellitus during a one-year period from 2020 to 2021.

## 4.1. Sociodemographic status of the patients

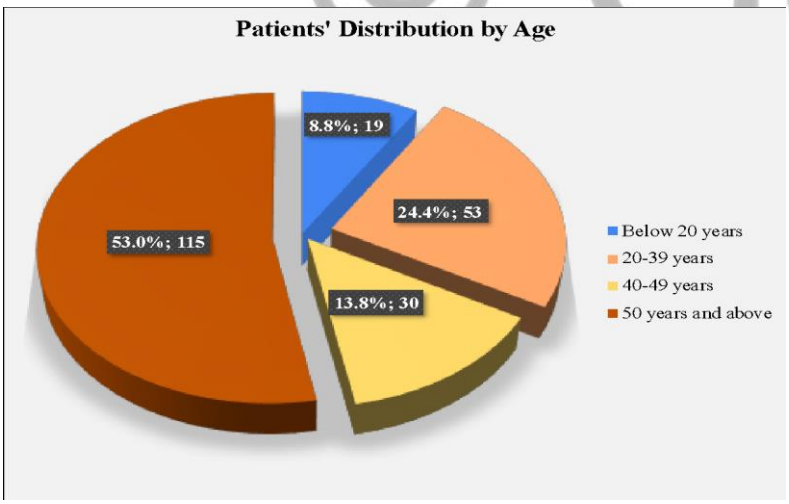
### 4.1.1. Gender




The majority of T1DM or T2DM patients admitted at CHUK between 2020 and 2021 were females (60%, N=130) while 40%(N=87) represented males.



### 4.1.2. Age




The average age of the patients was 48.12 ± 19.36 years, with the youngest patient being 2 years old and the oldest patient being 92 years old. A significant portion of the patients (53%, N=115) were 50 years old and above. Another 24% (N=53) fell within the age range of 20 to 39 years, 14% (N=30) were between 40 and 49 years old, and 9% (N=19) were below 20 years of age.

| | Female | Male | |
|---|---|---|---|
| **Age Group** | **N (%)** | **N (%)** | **Total** |
| **Below 20 years** | 12(63.2%) | 7(36.8%) | **19** |
| **20-39 years** | 33(62.3%) | 20(37.7%) | **53** |
| **40-49 years** | 20(66.7%) | 10(33.3%) | **30** |
| **50 years and above** | 65(56.5%) | 50(43.5%) | **115** |
| **Total** | **130(59.9%)** | **87(40.1%)** | **217** |

Females were consistently more prevalent than males across all age groups. For example, in the age group of 40 to 49 years, approximately two-thirds of the patients were females.

## 4.1.3. Occupation

| Occupation | Number of Patients | Percentage |
|---|---|---|
| Businessman | 2 | 0.90% |
| Businesswoman | 2 | 0.90% |
| Constructor | 1 | 0.50% |
| Driver | 1 | 0.50% |
| Farmer | 18 | 8.30% |
| Hair cutter | 1 | 0.50% |
| Laboratory | 1 | 0.50% |
| Load lifter | 1 | 0.50% |
| Manager | 2 | 0.90% |
| Nurse | 1 | 0.50% |
| Self employed | 3 | 1.40% |
| Student | 11 | 5.10% |
| Teacher | 4 | 1.80% |
| Technician | 1 | 0.50% |
| Trader | 8 | 3.70% |

| | | |
|---|---|---|
| Unknown | 159 | 73.30% |
| Not Applicable | 1 | 0.50% |
| Total | 217 | 100% |

The occupation of the majority of patients (73.3%, N=159) was not known. Conversely, 8.3% (N=18) were engaged in farming, 5.1% (N=11) were students, 3.7% (N=8) were traders, 1.8% (N=4) were teachers, and other non-specific occupations were represented by approximately 1% of the participants in the study.

## 4.2. Diabetic Status

| | N=217 | |
|---|---|---|
| **VARIABLES** | **n** | **%** |
| **Patients' Type of Diabetes Mellitus** | | |
| T1 | 38 | 16 |
| T2 | 179 | 84 |
| **Total** | **217** | **100** |
| **States of Diagnosis** | | |
| Newly Diagnosed patients | 75 | 34.6 |
| Known Diabetic patients | 142 | 65.4 |
| **Total** | **217** | **100** |

Within our dataset, there were 35 patients diagnosed with type 1 diabetes, accounting for 16% of the total 217 patients included. Type 2 Diabetes Mellitus was the most prevalent type, observed in 182 out of the 217 patients, representing 84% of the population. Among the total patient population, 34.6% (N=75) were newly diagnosed with diabetes, while 57.1% (N=142) were previously known to have diabetes.

## 4.3. Prevalence of DKA and HHS at CHUK

| | N=217 | |
|---|---|---|
| **VARIABLES** | **n** | **%** |
| DKA patients | 79 | 36.4 |
| HHS patients | 18 | 8.3 |

| | | |
|---|---|---|
| Known diabetic mellitus patients | 120 | 55.3 |
| **Total** | **217** | **100** |

Within the patient population included in this study, approximately 36.4% had Diabetic Ketoacidosis (DKA), which is roughly 1 in every 3 patients. Additionally, the prevalence of Hyperglycemic Hyperosmolar State (HHS) was 8.3%, equivalent to 1 in every 12 patients. Notably, the prevalence of DKA was four times higher than the prevalence of HHS.

## 4.4. Relationship between Gender and Prevalence of DKA or HHS

| | **Male** | **Female** | | | |
|---|---|---|---|---|---|
| | **N %)** | **N (%)** | **Total** | **Chi-Square** | **P-value** |
| **DKA** | | | | | |
| **No** | 57 (41.3) | 81 (58.7) | **138** | **0.232** | **0.63** |
| **Yes** | 30 (38.0) | 49 (62.0) | **79** | | |
| **Total** | **87 (40.1)** | **130 (59.9)** | **217** | | |
| **HHS** | | | | | |
| **No** | 79 (39.7) | 120 (60.3) | **199** | **0.155** | **0.694** |
| **Yes** | 8 (44.4) | 10 (55.6) | **18** | | |
| **Total** | **87 (40.1)** | **130 (59.9)** | **217** | | |

The findings indicate that among patients diagnosed with Diabetic Ketoacidosis (DKA), 62% were females, while males accounted for 38% of the cases. Similarly, among patients with Hyperosmolar Hyperglycemic State (HHS), 55.6% were females. Although the rates suggest a higher vulnerability of females, a chi-square test conducted at a 5% level of significance revealed no statistically significant relationship between the prevalence of DKA or HHS and the gender of the patient. This is because in the group of patients without DKA, females were represented at a rate of 58.7%, which is comparable to the representation of females among patients with DKA. Similarly, among patients without HHS, females were represented at a rate of 60.3%, which is comparable to the representation of females among patients with HHS.

## 4.5. Relationship between Age and Prevalence of DKA or HHS

| **Age (in years)** | **DKA** | **HHS** |
|---|---|---|

| | Yes | Yes |
|---|---|---|
| **N** | 79 | 18 |
| **Minimum** | 7 | 2 |
| **Maximum** | 92 | 78 |
| **Median** | 40 | 43.5 |
| **Mode** | 30 | 69 |
| **Mean** | 42.78 | 42.89 |
| **Standard Deviation (SD)** | 20.07 | 22.88 |

The age range at presentation for patients with Diabetic Ketoacidosis (DKA) was from 7 to 92 years, while for Hyperglycemic Hyperosmolar State (HHS), the range was from 2 to 78 years. The average age of presentation for DKA was 42.78 ± 20.07 years, and for HHS, it was 42.89 ± 22.88 years. Both DKA and HHS were found to develop around the age of 43.

| | Below 20 years | 20-39 years | 40-49 years | 50 years and above | Total | Chi-Square | P-value |
|---|---|---|---|---|---|---|---|
| | N (%) | N (%) | N (%) | N (%) | | | |
| **DKA** | | | | | | | |
| **No** | 8 (5.8) | 26 (18.8) | 22 (15.9) | 82 (59.4) | **138** | **12.81** | **0.005** |
| **Yes** | 11 (13.9) | 27 (34.2) | 8 (10.1) | 33 (41.8) | **79** | | |
| **Total** | **19 (8.8)** | **53 (24.4)** | **30 (13.8)** | **115 (53.0)** | **217** | | |
| **HHS** | | | | | | | |
| **No** | 16 (8.0) | 48 (24.1) | 27 (13.6) | 108 (54.3) | **199** | **2.345** | **0.504** |
| **Yes** | 3 (16.7) | 5 (27.8) | 3 (16.7) | 7 (38.9) | **18** | | |
| **Total** | **19 (8.8)** | **53 (24.4)** | **30 (13.8)** | **115 (53.0)** | **217** | | |

In our research, we expanded the investigation to examine the impact of increasing age on the development of Diabetic Ketoacidosis (DKA) or Hyperglycemic Hyperosmolar State (HHS). Among the group of 79 patients with DKA, the majority (41.8%) were aged 50 years and above. Another 34.2% fell within the age range of 20 to 39 years, 13.9% were below 20 years old, and 10% were between 40 and 49 years old. A chi-square test conducted at a 5% level of significance demonstrated a significant association between DKA and age (Chi-square = 12.810, p-value = 0.005).

However, for HHS, the group of patients aged 50 years and above had a higher risk (38.9%), followed by the 20 to 39-year age group (27.8%), with both the below 20-year age group and the 40 to 49-year age group at 16.7% each. The chi-square test showed no significant effect of age on HHS (Chi-square = 2.345, p-value = 0.504).

## 4.6. Distribution of DKA or HHS by Type of Diabetes Mellitus

### 4.6.1. Type of Diabetes and Prevalence of Diabetic Ketoacidosis

| | **Diabetic Ketoacidosis** | | | | |
|---|---|---|---|---|---|
| | **No** | **Yes** | | | |
| | **N (%)** | **N (%)** | **Total** | **Chi-Square** | **P-value** |
| **T1DM** | | | | | |
| **No** | 129 (70.9) | 53 (29.1) | **182** | **25.864** | **<0.0001** |
| **Yes** | 9 (25.7) | 26 (74.3) | **35** | | |
| **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **T2DM** | | | | | |
| **No** | 10 (26.3) | 28 (73.7) | **38** | **27.652** | **<0.0001** |
| **Yes** | 128 (71.5) | 51 (28.5) | **179** | | |
| **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |

Out of the 35 patients diagnosed with type 1 diabetes mellitus (T1DM), 74% developed diabetic ketoacidosis (DKA). On the other hand, among the 179 patients with type 2 diabetes mellitus (T2DM), 28.5% developed DKA. These findings indicated that DKA was more prevalent in patients with T1DM compared to those with T2DM.

A chi-square test conducted at a 5% level of significance revealed a statistically significant relationship between the prevalence of DKA and the type of diabetes. The diagnosis of T1DM was strongly associated with the occurrence of diabetic ketoacidosis, while the association between T2DM and DKA was relatively weak.

### 4.6.2. Type of Diabetes and Prevalence of HHS

| | **Hyperglycemic Hyperosmolar State** | **Total** | **Chi-Square** | **P-value** |
|---|---|---|---|---|

| | No | Yes | | | |
|---|---|---|---|---|---|
| | N (%) | N (%) | | | |
| **T1DM** | | | | | |
| No | 167 (91.8) | 15 (8.2) | **182** | **0.004** | **0.948** |
| **Yes** | 32 (91.4) | 3 (8.6) | **35** | | |
| **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **T2DM** | | | | | |
| **No** | 35 (92.1) | 3 (7.9) | **38** | **0.01** | **0.921** |
| **Yes** | 164 (91.6) | 15 (8.4) | **179** | | |
| **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |

The likelihood of a diabetic patient developing Hyperglycemic Hyperosmolar State (HHS) was comparable between those with type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM), with rates of 8.6% for T1DM and 8.4% for T2DM. There was no significant association observed between the occurrence of HHS and any specific type of diabetes mellitus.



## 4.7. Patients' Attitudes towards Diabetes Mellitus

| **Is the patient taking medications?** | | | |
|---|---|---|---|
| | **Yes** | **No** | |
| | **N (%)** | **N (%)** | **Total** |
| **DKA** | | | |
| **No** | 89 (64.5) | 49 (35.5) | **138** |
| **Yes** | 44 (55.7) | 35 (44.3) | **79** |
| **Total** | **133 (61.3)** | **84 (38.7)** | **217** |
| **HHS** | | | |
| **No** | 123 (61.8) | 76 (38.2) | **199** |
| **Yes** | 10 (55.6) | 8 (44.4) | **18** |
| **Total** | **133 (61.3)** | **84 (38.7)** | **217** |

In total, 61.3% (N=133) of the 217 patients included in the study were receiving medication. Among the patients with Diabetic Ketoacidosis (DKA), the percentage of those taking medications was only 55.7%, which was similar to the percentage of patients with Hyperglycemic Hyperosmolar State (HHS) who were also taking diabetic medications (55.6%).

## 4.8. Risk Factors of DKA and HHS

### 4.8.1. Risk Factors of Diabetic ketoacidosis

| Risk Factors of Developing Diabetic Ketoacidosis (DKA) | | | | | | |
|---|---|---|---|---|---|---|
| **Risk Factors** | **Category** | **No** | **Yes** | **Total** | **Chi-Square** | **P-value** |
| | | **N (%)** | **N (%)** | | | |
| **Pneumonia** | No | 102 (66.7) | 51 ((33.3) | 153 | **2.115** | **0.146** |
| | Yes | 36 (56.2) | 28 (43.8) | 64 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **Sepsis** | No | 118 (72.8) | 44 (27.2) | 162 | **23.596** | **0.000**** |
| | Yes | 20 (36.4) | 35 (63.6) | 55 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **UTIs** | No | 120 (67.0) | 59 (33.0) | 179 | **5.239** | **0.022**** |
| | Yes | 18 (47.4) | 20 (52.6) | 38 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **HTN** | No | 73 (55.3) | 59 (44.7) | 132 | **10.007** | **0.002**** |
| | Yes | 65 (76.5) | 20 (23.5) | 85 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **Pregnancy** | No | 135 (63.4) | 78 (36.6) | 213 | **0.229** | **0.632** |
| | Yes | 3 (75.0) | 1 (25.0) | 4 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **Surgery** | No | 135 (64.9) | 73 (35.1) | 208 | **3.714** | **0.054** |
| | Yes | 3 (33.3) | 6 (66.7) | 9 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **Steroids** | No | 137 (63.7) | 78 (36.3) | 215 | **0.161** | **0.688** |
| | Yes | 1 (50.0) | 1 (50.0) | 2 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **Alcohol** | No | 136 (65.1) | 73 (34.9) | 209 | **5.344** | **0.021**** |
| | Yes | 2 (25.0) | 6 (75.0) | 8 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **Smoking** | No | 135 (64.0) | 76 (36.0) | 211 | **0.493** | **0.483** |
| | Yes | 3 (50.0) | 3 (50.0) | 6 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **Gastric disease** | No | 129 (66.5) | 65 (33.5) | 194 | **6.651** | **0.010**** |
| | Yes | 9 (39.1) | 14 (60.9) | 23 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **Stroke** | No | 126 (62.4) | 76 (37.6) | 202 | **1.873** | **0.171** |
| | Yes | 12 (80.0) | 3 (20.0) | 15 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |
| **PE** | No | 138 (63.9) | 78 (36.1) | 216 | **1.755** | **0.185** |
| | Yes | 0 (0.0) | 1 (100.0) | 1 | | |
| | **Total** | **138 (63.6)** | **79 (36.4)** | **217** | | |

** Means the p-value of the chi-square was significant at 5% level of significance

Patients who had previously experienced pneumonia had a 43.8% chance of developing Diabetic Ketoacidosis (DKA). For those who had suffered from sepsis, the likelihood of developing DKA increased to 63.6%. Urinary tract infections (UTIs) were associated with a 52.6% probability of DKA occurrence. Conversely, only 23.5% of patients with hypertension (HTN) developed DKA. Pregnancy posed a risk factor for DKA at a rate of 25%. Patients who had undergone surgery had a 66.7% chance of developing DKA. The use of steroids was associated with a 50% likelihood of experiencing DKA. Alcohol consumption emerged as a significant risk factor, with a 75% probability of DKA occurrence for patients who consumed excessive amounts. Patients with gastric disease had a 61% chance of experiencing DKA.

The probability of developing DKA for patients who had suffered a stroke was only 20%. Only one patient with pulmonary embolism (PE) developed DKA.

In summary, sepsis, UTIs, hypertension, alcohol consumption, and gastric disease were identified as factors contributing to an increased risk of developing DKA. Statistical analysis using the chi-square test revealed significant associations for sepsis (chi-square = 23.596, p-value < 0.0001), UTIs (chi-square = 5.239, p-value = 0.022), hypertension (chi-square = 10.007, p-value = 0.002), alcohol consumption (chi-square = 5.344, p-value = 0.021), and gastric disease (chi-square = 6.651, p-value = 0.010). No statistically significant relationship was found between pneumonia, pregnancy, surgery (to a lesser extent), steroids, smoking, stroke, and PE with the occurrence of DKA, as their respective p-values exceeded the predetermined significance level of 5%.

## 4.8.2. Risk Factors of Hyperosmolar hyperglycemic state

| Risk Factors of Developing Hyperosmolar Hyperglycemic State (HHS) | | | | | | |
|---|---|---|---|---|---|---|
| **Risk Factors** | **Category** | **No** | **Yes** | | | |
| | | **N (%)** | **N (%)** | **Total** | **Chi-Square** | **P-value** |
| **Pneumonia** | No | 141 (92.2) | 12 ((7.8) | 153 | **0.139** | **0.709** |
| | Yes | 58 (90.6) | 6 (9.4) | 64 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **Sepsis** | No | 152 (93.8) | 10 (6.2) | 162 | **3.784** | **0.052** |
| | Yes | 47 (85.5) | 8 (14.5) | 55 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **UTIs** | No | 166 (92.7) | 13 (7.3) | 179 | **1.432** | **0.231** |
| | Yes | 33 (86.8) | 5 (13.2) | 38 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **Hypertension** | No | 119 (90.2) | 13 (9.8) | 132 | **1.069** | **0.301** |
| | Yes | 80 (94.1) | 5 (5.9) | 85 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Pregnancy** | No | 195 (91.5) | 18 (8.5) | 213 | **0.369** | **0.544** |
| | Yes | 4 (100.0) | 0 (0.0) | 4 | | |
| | **Total** | **199 (91.3)** | **18 (8.3)** | **217** | | |
| **Surgery** | No | 190 (91.3) | 18 (8.7) | 208 | **0.849** | **0.357** |
| | Yes | 9 (100.0) | 0 (0.0) | 9 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **Steroids** | No | 198 (92.1) | 17 (7.9) | 215 | **4.616** | **0.032**** |
| | Yes | 1 (50.0) | 1 (50.0) | 2 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **Alcohol** | No | 191 (91.4) | 18 (8.6) | 209 | **0.751** | **0.386** |
| | Yes | 8 (100.0) | 0 (0.0) | 8 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **Smoking** | No | 193 (91.5) | 18 (8.5) | 211 | **0.558** | **0.455** |
| | Yes | 6 (100.0) | 0 (0.0) | 6 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **Gastric disease** | No | 176 (90.7) | 18 (9.3) | 194 | **2.327** | **0.127** |
| | Yes | 23 (100.0) | 0 (0.0) | 23 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **Stroke** | No | 184 (91.1) | 18 (8.9) | 202 | **1.458** | **0.227** |
| | Yes | 15 (100.0) | 0 (0.0) | 15 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |
| **PE** | No | 198 (91.7) | 18 (8.3) | 216 | **0.091** | **0.763** |
| | Yes | 1 (100.0) | 0 (0.0) | 1 | | |
| | **Total** | **199 (91.7)** | **18 (8.3)** | **217** | | |

** Means the p-value of the chi-square was significant at 5% level of significance

Steroids were the only identified risk factor associated with the development of Hyperosmolar Hyperglycemic State (HHS) in patients. The statistical analysis revealed a chi-square value of 4.616 and a

corresponding p-value of 0.032 for steroids, indicating a significant relationship. However, for all other risk factors, the p-values exceeded the 5% level of significance, suggesting no statistically significant association with the occurrence of HHS.

## 4.9. Effect of DKA and HHS on Prolonged Hospital stay.

| | DKA | HHS |
|---|---|---|
| **Hospital Stay** | **Yes** | **Yes** |
| **N** | 79 | 18 |
| **Minimum** | 0 | 1 |
| **Maximum** | 101 | 94 |
| **Median** | 13 | 5 |
| **Mode** | 10 | 4 |
| **Mean** | 15.3 | 13.39 |
| **Standard Deviation (SD)** | 13.44 | 20.68 |

On average, the hospitalization period for patients with Diabetic Ketoacidosis (DKA) was longer than that for patients with Hyperosmolar Hyperglycemic State (HHS). The average length of hospital stay for DKA patients was 15.3 ± 13.44 days, whereas for HHS patients, it was 13.39 ± 20.68 days.

| | Less than 7 days | 7-29 days | 1-2 months | More than 2 months | Total | Chi-square | P-value |
|---|---|---|---|---|---|---|---|
| | N (%) | N (%) | N %) | N (%) | | | |
| **DKA** | | | | | | | |
| **No** | 37 (26.8) | 88 (63.8) | 8 (5.8) | 5 (3.6) | **138** | **1.744** | **0.627** |
| **Yes** | 18 (22.8) | 54 (68.4) | 6 (7.6) | 1 (1.3) | **79** | | |
| **Total** | **55 (25.3)** | **142 (65.4)** | **14 (6.5)** | **6 (2.8)** | **217** | | |
| **HHS** | | | | | | | |
| **No** | 45 (22.6) | 135 (67.8) | 14 (7.0) | 5 (2.5) | **199** | **11** | **0.012** |
| **Yes** | 10 (55.6) | 7 (38.9) | 0 (0.0) | 1 (5.6) | **18** | | |
| **Total** | **55 (25.3)** | **142 (65.4)** | **14 (6.5)** | **6 (2.8)** | **217** | | |

Among patients diagnosed with Diabetic Ketoacidosis (DKA), the majority (68.5%) were discharged within 7 to 29 days, while 23% were discharged in less than 7 days. In the group of patients with

Hyperosmolar Hyperglycemic State (HHS), the majority (55.6%) were discharged within 7 days, followed by 39% discharged within 7 to 29 days. A chi-square test conducted at a 5% level of significance indicated that DKA did not have a significant association with prolonged hospital stay, whereas HHS showed a significant relationship with an extended duration of hospitalization.

## 4.10. Outcome for Patients with DKA and HHS

| Outcome for Patients | | | | | |
|---|---|---|---|---|---|
| | **Cured** | **Died** | **Counter-referred** | **Transferred** | **Total** |
| | **N (%)** | **N (%)** | **N (%)** | **N (%)** | |
| **DKA** | | | | | |
| **No** | 94 (68.1) | 44 (31.9) | 0 (0.0) | 0 (0.0) | 138 |
| **Yes** | 55 (69.6) | 20 (25.3) | 2 (2.5) | 2 (2.5) | 79 |
| **Total** | **149 (68.7)** | **64 (29.5)** | **2 (0.9)** | **2 (0.9)** | **217** |
| **HHS** | | | | | |
| **No** | 143 (71.9) | 52 (26.1) | 2 (1.0) | 2 (1.0) | 199 |
| **Yes** | 6 (33.3) | 12 (66.7) | 0 (0.0) | 0 (0.0) | 18 |
| **Total** | **149 (68.7)** | **64 (29.5)** | **2 (0.9)** | **2 (0.9)** | **217** |



In total, 149 out of 217 patients admitted for either T1DM or T2DM (68.7%) achieved a complete recovery. Tragically, 64 out of 217 patients (29.5%) did not survive. The remaining 4 patients (1.8%) were either referred elsewhere or transferred to another facility. Notably, the mortality rate for patients with Hyperosmolar Hyperglycemic State (HHS) was higher compared to those with Diabetic Ketoacidosis (DKA). Out of the 18 patients diagnosed with HHS, 66.7% passed away, whereas the mortality rate for DKA was 25.3%.

# CHAPTER 5: DISCUSSION

The burden of communicable and infectious diseases in developing countries, including Rwanda, poses significant challenges to the healthcare system. The emergence of noncommunicable diseases, such as diabetes mellitus, further adds to the economic burden on the health system. In this chapter, we discuss the findings of our study on the prevalence and characteristics of diabetic emergencies, specifically diabetic ketoacidosis (DKA) and hyperosmolar hyperglycemic state (HHS), in Rwanda. Additionally, we examine the impact of gender, age, type of diabetes, and associated risk factors on the development of these complications.

In our study, the prevalence of DKA was found to be 36.4%, while HHS accounted for 8.3% of cases. These findings align with previous research that has consistently reported higher occurrence rates of hyperglycemic states, such as DKA and HHS, compared to hypoglycemic states [3]. Studies have shown that DKA is the most common diabetic emergency and a major cause of hospital admissions among patients with diabetes mellitus [16]. This pattern holds true not only in Rwanda but also in other regions and countries worldwide [23] as well as the level of inequality [25]; [26].

Although a chi-square test did not reveal a statistically significant relationship between gender and the prevalence of DKA or HHS, our study found a higher proportion of females experiencing these complications. Similar gender disparities have been reported in studies conducted in Germany and Saudi Arabia [27]; [28]. The underlying mechanisms contributing to these gender differences require further investigation. However, one study has suggested that females may be at a higher risk of uncontrolled hyperglycemia and emphasized the need for increased attention to blood glucose self-monitoring, nutritional factors, psychological aspects, and puberty-related issues [28].

Our study revealed that most patients (83.9%) had type 2 diabetes mellitus, consistent with previous African studies reporting high prevalence rates (76% to 90%) for type 2 diabetes [29]; [30]. This observation can be attributed to factors such as rising obesity rates, physical inactivity, and dietary changes. In contrast to developed countries where diabetes predominantly affects older individuals [23], our study found a younger age of onset (mean age 48.12 ± 19.36 years). This difference may be influenced by geographical and socioeconomic factors, including variations in life expectancy. Notably, DKA and HHS were found to develop around the age of 43 years, highlighting the importance of targeted interventions for this age group. Additionally, a significant association was observed between DKA and age, indicating a need for special attention to understand the factors contributing to increased vulnerability to hyperglycemia in younger individuals.

Consistent with existing literature, our study revealed a higher prevalence of DKA among patients with type 1 diabetes mellitus (74%) compared to those with type 2 diabetes mellitus (28.5%) [30]. However, HHS did not show a significant association with any specific type of diabetes. These findings emphasize the importance of recognizing that DKA can affect patients with both type 1 and type 2 diabetes, highlighting the need for appropriate management strategies across different types of diabetes mellitus.

Several risk factors contribute to the development of DKA or HHS, including alcohol consumption, smoking, physical inactivity, high-fat diet, obesity, and hypertension [23]. In our study, sepsis, urinary tract infections (UTIs), hypertension, alcohol consumption, and gastric diseases were found to be associated with the development of DKA. Infection, particularly lung infections and UTIs, played a significant role in triggering DKA, indicating the importance of infection control measures. Furthermore, addressing gastric diseases and advocating for alcohol reduction are crucial preventive measures in the management of diabetic emergencies.

Sepsis among other precipitating factors in diabetic patients increases the risk of diabetic ketoacidosis (DKA) [33]. Effective management of DKA is crucial due to its high mortality rate, which involves protocols such as fluid and electrolytes replacement, insulin administration, and infection control [33]. In developing countries, infection is found to be the primary trigger of DKA as well as HHS [20]; [34]; [35]. Living in a developing country with poor hygiene conditions may also contribute to urinary tract infections (UTIs) in patients with diabetes mellitus (DM). Preventive measures should focus on self-management and personal hygiene to avoid infections. Gastric diseases can also trigger DKA, leading to higher mortality rates and reduced chances of recovery. Therefore, considering the possibility of gastric disease is crucial in managing DKA effectively [36].

Our study found that HHS had a higher mortality rate (66.7%) compared to DKA (25.3%). These findings are consistent with existing literature, which suggests that HHS is a serious and potentially fatal complication of type 2 diabetes, with mortality rates reaching up to 20% [37]; [38]. According to (Fraser et al. 2016), A single episode of DKA is estimated to have a mortality rate of 5.2%, which increases to 23.4% in those with recurrent DKA admissions. The mortality rate in HHS is approximately ten times higher than that in DKA. Factors such as limited access to emergency care and challenges in reporting may further contribute to higher mortality rates, particularly in resource-constrained settings [37]. It is essential to recognize the severity of HHS and allocate appropriate resources for its prevention and management.

# CHAPTER 6. CONCLUSION

The study conducted at CHUK yielded significant findings regarding the prevalence and impact of Diabetic Ketoacidosis (DKA) and Hyperosmolar Hyperglycemic State (HHS) among diabetic patients. The results showed that approximately 36.4% of diabetic patients admitted to CHUK experienced DKA, indicating a considerable burden of this complication. Moreover, the prevalence of HHS was found to be 8.3%, affecting around 1 in every 12 patients.

Several factors were identified as significant determinants of DKA, including sepsis, hypertension, alcohol use, age, gastric diseases, and urinary tract infections (UTIs). These findings highlight the importance of prevention strategies among individuals already diagnosed with diabetes. Regular glucose monitoring, awareness of the disorder, and patient education are recommended to reduce the incidence of DKA and subsequent hospitalizations. Improved access to medical advice and follow-up care are also crucial in managing and preventing DKA cases effectively.

The study revealed a high mortality rate among diabetic patients at CHUK, with 29.5% of patients succumbing to the disease. Notably, the fatality rate for HHS was even higher at 66.7% compared to DKA, which had a fatality rate of 25.3%. These alarming statistics emphasize the urgent need for policymakers to prioritize diabetes education programs and allocate resources to address the high morbidity and mortality associated with acute diabetic complications.

Furthermore, the study identified potential reasons for management errors, such as poor medication adherence, which can be attributed to the financial difficulties faced by individuals with diabetes. Affordability of medications and monitoring supplies is critical, and it is recommended to consider subsidizing diabetes medications for those who cannot afford them, following the successful approach taken for communicable diseases like HIV.

This study provides valuable insights into the prevalence and patterns of DKA and HHS complications in Rwanda, where diabetes awareness, early detection, and prevention strategies are lacking. Early detection plays a crucial role in preventing complications, particularly in regions with limited diabetes knowledge. To ensure comprehensive care, a multidisciplinary approach involving physicians, dieticians, and physical therapists should be implemented to educate diagnosed individuals on complications prevention.

# CHAPTER 7: RECOMMENDATIONS

Based on the findings of this study, several recommendations are proposed to improve the management and prevention of diabetes complications:

1. We would strongly advise the Ministry of Health of Rwanda (MoH) to expand integrated diabetes services to lower-level health units, ensuring accessibility and early detection of diabetes and hypertension. This proactive approach would enable timely interventions and effectively reduce the burden of complications associated with these conditions.

2. Furthermore, we recommend that CHUK and the Ministry of Health launch comprehensive public awareness campaigns to promote health-seeking behaviors and encourage behavioral modifications in the population. The focus should be on educating individuals about diabetes, its risk factors, and the critical importance of regular check-ups to detect complications at an early stage.
3. Considering the financial challenges faced by patients with diabetes, it is essential for the Ministry of Health to seriously consider subsidizing diabetes medications and monitoring supplies. This vital step would alleviate the financial burden on individuals and improve medication adherence, leading to better health outcomes.

4. To enhance patient care, we urge CHUK to strengthen patient education programs, particularly in Internal Medicine, Emergency, and Pediatric departments. Healthcare providers should be equipped to provide comprehensive information to individuals diagnosed with diabetes, emphasizing disease management, prevention of complications, and self-care strategies. Additionally, implementing effective follow-up care systems will allow for continuous monitoring of patients' progress and addressing any concerns or challenges they may encounter along their healthcare journey.

5. Lastly, CHUK management should actively work towards improving the affordability and accessibility of diabetes management resources, including medications, monitoring devices, and supplies. Collaborating with relevant stakeholders and developing strategies that prioritize the financial well-being of individuals with diabetes will ensure that no one is hindered from receiving the necessary care and support they require.

By implementing these recommendations, the Ministry of Health and CHUK can make significant strides in improving diabetes care and management in Rwanda, ultimately enhancing the overall well-being and quality of life for individuals living with diabetes.

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# Appendix 1: Plan of the study

| Activities | Timeline | Person in charge | Person-days in need |
|---|---|---|---|
| Research proposal preparation and submission | Jan-Feb 2022 | 3 researchers | Students in charge |
| Ethical clearance and study approval | Mar 2022 | 3 researchers | Students in charge, Office of Dean of school, UR-CMHS and CHUK ethical committees |
| Data collection, coding, and entry | End march-Mid April 2022 | 3 researchers | Students in charge |
| Data analysis and first draft | 2 end weeks of April | 3 researchers | Students in charge |
| Supervisor's review | First week of May 2022 | 3 researchers | Students in charge, Supervisor |
| Final draft | 2 follow weeks of May 2022 | 3 researchers | Students in charge, Supervisor |
| Submission of final the study | Last week of May 2022 | 3 researchers | Students in charge, Supervisor, School's research committee |

# Appendix 2: Data collection form

| DATA COLLECTION FORM | | | | | |
|---|---|---|---|---|---|
| 1 | Patient identification | | | | |
| | Patient's initials: ..... | | ID..... | | |
| | Age | | | | |
| | Sex | | | Male | Female |
| | Occupation | | ..... | | |
| 2 | Weight | | | ..... | ***kg*** |
| | Height | | | ..... | ***cm*** |
| | BMI | | | ...…..... | ***kg/m²*** |
| 3 | **Diagnosis** | DKA | | | |
| | | HHS | | | |
| 4 | Diabetes medications | Yes | | **If yes** | Regular |
| | | No | | | Irregular |
| 5 | Glycemia level at arrival | | | | mg/dl |
| | Glycemia level at end | | | | mg/dl |
| **Associated risk factors** | | | | | |
| 6 | Newly diagnosed diabetes mellitus | | | | |
| | Gastric diseases | | | | |
| | Infections | Pneumonia | | | |
| | | UTIs | | | |
| | | Sepsis | | | |
| | Heart disease | | | | |
| | Recent stroke | | | | |
| | Pregnancy | | | | |

| | | | |
|---|---|---|---|
| | Surgery | | |
| | Medications | Steroids | |
| | | Antipsychotics | |
| | Pulmonary embolism | | |
| | Trauma | | |
| **Hospital stays** | | | |
| 7 | Days | | |
| 8 | Treatment outcome | Cured | |
| | | Died | |

## Appendix 3: The Gantt chart

| Activities / Time in month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Topic and supervisor | | | | | | | | | | | | |
| Ethical clearance | | | | | | | | | | | | |
| Data collection | | | | | | | | | | | | |
| Data analysis | | | | | | | | | | | | |
| Dissertation | | | | | | | | | | | | |

## Appendix 4: Recommendation letter

UNIVERSITY of RWANDA

COLLEGE OF MEDICINE & HEALTH SCIENCES
SCHOOL OF MEDICINE & PHARMACY

OFFICE OF THE DEAN

Kigali, 9/3/2022

NO 143...CMHS /SMP/2022

**To whom it may concern**

I, **Jean Claude BYIRINGIRO**, Dean of School of Medicine and Pharmacy, confirm that the following below medical students are registered under graduate students in General Medicine at University of Rwanda in Year 4.

Therefore this serves to recommend them to carry out research and data collection of their project entitled "**Prevalence and risk factors of Diabetic ketoacidosis (DKA) and Hyperosmolar hyperglycemic state (HHS) in patients with diabetic mellitus at CHUK in 2020-2021.** Presenting at University of Rwanda under their research supervisor, Dr. BITUNGUHARI Léopold.

1. **MBONUKURI Raphael : 215003212**
2. **NSHIMIYIMANA Jerome : 218007435**
3. **NISHIMWE Esther: 214003769**

Any support rendered to them will be highly appreciated.

Best regards!

**Jean Claude BYIRINGIRO, MD, MMED, FCS (ECSA)-Orth**
**Associate Professor of Surgery**
**Dean,**
**School of Medicine and Pharmacy**
**College of Medicine and Health Sciences**
**University of Rwanda**
**Tel: 0788868240**
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# Appendix 5: Ethical Approval

CENTRE HOSPITALIER UNIVERSITAIRE
UNIVERSITY TEACHING HOSPITAL

Quality Health Care
Training & Research

**Ethics Committee / Comité d'éthique**

6th Apr,2022 *Ref.:EC/CHUK/057/2022*

## *Review Approval Notice*

**Dear RAPHAEL MBONUKURI,**

*Your research project:* ***"Prevalence and risk factors of Diabetic ketoacidosis and Hyperosmolar hyperglycemic state in patients with diabetes mellitus at University Teaching Hospital of Kigali in 2020-2021 "***

During the meeting of the Ethics Committee of University Teaching Hospital of Kigali (CHUK) that was held on 6th Apr,2022 to evaluate your request for ethical approval of the above mentioned research project, we are pleased to inform you that the Ethics Committee/CHUK has approved your research project.

You are required to present the results of your study to CHUK Ethics Committee before publication by using this link:www.chuk.rw/research/fullreport/?appid=563&&chuk.

PS: Please note that the present approval is valid for 12 months.

Yours sincerely,

**Dr Emmanuel Rusingiza Kamanzi**
The Chairperson, Ethics Committee,
University Teaching Hospital of Kigali

ETHICS COMMITTEE
CHUK

*Scan code to verify.*

***" University teaching hospital of Kigali Ethics committee operates according to standard operating procedures (Sops) which are updated on an annual basis and in compliance with GCP and Ethics guidelines and regulations "***

*Web Site :* www.chuk.rw *; B.P. 655 Kigali- RWANDA Tél.: 00 (250) 252575462. E-Mail:* chuk.hospital@chuk.rw