

**AN AUDIT OF THE MANAGEMENT OF DIABETIC
KETOACIDOSIS AT THE KENYATTA NATIONAL
HOSPITAL**

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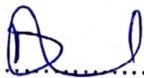
A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF
MASTER OF MEDICINE IN INTERNAL MEDICINE

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STUDENT'S DECLARATION

I declare that this dissertation entitled "**An audit of the management of Diabetic Ketoacidosis at The Kenyatta National Hospital**" is my original work and that to the best of my knowledge it has not been presented either wholly or in part to this or any other university for the award of any degree or diploma.

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This dissertation is submitted with our approval as University Supervisors.

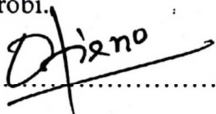
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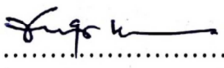
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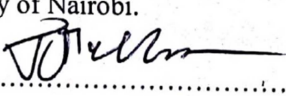
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LIST OF ABBREVIATIONS

DKA – Diabetic ketoacidosis

DM – Diabetes Mellitus

GCS – Glasgow coma scale

HCO₃ – Bicarbonate

ICU – Intensive Care Unit

IV - Intravenous

K – Potassium

KCl – Potassium chloride

KNH – Kenyatta National Hospital

mEq/L – milliequivalents per liter

mg/dL- milligrams per deciliter

mmol/kg – millimoles per kilogram

mmol/L – millimoles per liter

Na - Sodium

NaCl – Sodium chloride

pH – Potential of Hydrogen

U/kg – Units per kilogram

SHO – Senior House Officer

UK – United Kingdom

USA – United States of America

WHO – World Health Organisation

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ABSTRACT

BACKGROUND

DKA is the most serious hyperglycemic emergency in patients with both Type 1 & 2 DM. The mortality rate is still high in developing countries. Standard DKA management guidelines ensure optimal management.

OBJECTIVES

- To assess the level of adherence to DKA management guidelines in KNH.
- To assess outcomes of DKA patients in KNH.
- To assess the diabetes-related knowledge of doctors and nurses in KNH.

STUDY DESIGN

A prospective descriptive study.

STUDY SETTING

The Accident and Emergency Department, Medical ICU and General medical wards in KNH.

METHODOLOGY

Patients with DKA were screened for eligibility and recruited upon signing informed consent. Patients' socio-demographic and clinical characteristics were captured in a study proforma. The Principal Investigator used a checklist, based on standard DKA management guidelines to assess patient management as documented in the patients' inpatient files, treatment and monitoring charts, and assessed the extent of conformity to DKA management guidelines. Key informants were interviewed on systems in place to manage DKA patients in KNH. Doctors' diabetes-related knowledge was assessed using a pre-tested questionnaire. Nurses' perceived diabetes-related knowledge was assessed using the Diabetes Self-Report Tool (DSRT); their actual diabetes-related knowledge was assessed using the Diabetes Basic Knowledge Test (DBKT).

RESULTS

Forty two patients with clinico-laboratory diagnosis of DKA over a four month period were recruited. Eight key informants, 49 doctors, and 70 nurses were also interviewed.

Prompt management according to guidelines was not observed. There were delays in patient review by SHOs or ICU doctors upon arrival in hospital; the median time was 10 hours. There were also delays in initiation of management. Guidelines were adhered to in initial patient clinical and laboratory assessment. However, subsequent clinical and laboratory monitoring was suboptimal; 64.3% of patients had less than 6 vital signs assessments done in the first 24 hours.

All prescriptions for intravenous fluids (IVF), insulin, and potassium were according to guidelines. All patients had the correct type of IVF administered. However, only 11.9% had the correct amounts of IVF administered; the median amount of IVF administered in 24 hours was 3.0 litres. All received subcutaneous insulin as prescribed, while 74.3% received insulin infusion as prescribed. 23.7% did not receive potassium as prescribed.

DKA resolution was not confirmed according to guidelines in 46.2% of patients. The median time to resolution was 59 hours. The all-cause inpatient mortality rate at 2 weeks was 11.9%.

The doctors' mean score in the questionnaire was 59.1%. Most respondents had sufficient knowledge on practical inpatient diabetes management and diabetes pharmacology. There was insufficient knowledge on diabetes diagnosis and targets. The nurses had a mean (SD) of 72.46 (12.01) points out of 88 on the DSRT. Generally, the respondents had a high perception of diabetes knowledge. On the DBKT, they had mean (SD) score of 26.96 (4.64) points out of 45.

CONCLUSIONS

This study demonstrated lack of adherence to guidelines, in terms of delays in initiation of management, insufficient administration of fluids, insulin and potassium, and inadequate monitoring. This may have contributed to the prolonged DKA resolution times and the high all-cause mortality rate. Areas to improve on, therefore, are prompt patient review and initiation of management, consistent patient monitoring during care, and guideline adherence in terms of fluid, insulin and potassium treatment.

Healthcare workers, both doctors and nurses, had sufficient knowledge on various aspects of DKA management. However they had insufficient knowledge on certain aspects of diabetes pharmacology and glucose dynamics. The areas of insufficient diabetes related knowledge are important areas to focus on in rolling educational programs for the healthcare workers.

1.0 INTRODUCTION

Diabetes is a chronic disease and is characterized by elevated levels of blood glucose. It is an important public health problem. In 2014, there were an estimated 422 million adults living with diabetes globally, a prevalence of 8.5% among the adult population (1).

In Africa, there were an estimated 12.1 million people living with diabetes in 2010. The prevalence is projected to increase to 23.9 million people by 2030 (2). The World Health Organization (WHO) estimates the prevalence of diabetes in Kenya to be at 3.3%, and predicts a rise in prevalence to 4.5% by 2025 (3).

Diabetic ketoacidosis (DKA) is regarded as the most serious hyperglycemic emergency in patients with both type 1 and type 2 diabetes mellitus, and is associated with significant morbidity and mortality (4). DKA comprises the biochemical triad of hyperglycemia, ketonemia, and high anion gap metabolic acidosis (5). The annual incidence of DKA was estimated to be 4 to 8 episodes per 1,000 patient admissions with diabetes in a population-based survey, in Minnesota, USA (5). Majority of the cases of DKA occur in individuals with Type 1 diabetes, but a significant proportion occurs in individuals with Type 2 diabetes(6) (7). Generally, the prevalence of DKA decreases with increasing age(8).

Management of DKA involves use of integrated care pathways that are modifications of the Alberti's regime. The original Alberti's (GIK) regime was designed as a method to control blood glucose levels in diabetic patients who are being fasted for whatever reason. It involves intravenous infusion of a solution of glucose (G), insulin (I), and potassium (K) chloride over a standard period of time (9).The blood glucose and potassium levels are measured regularly so that appropriate adjustments can be made to the mixture as necessary.

The Alberti's regime has been modified over several years, to create the standard evidence based DKA management guidelines. However, where the evidence base is not strong, management guidelines are based on experience and consensus.

Use of these integrated care pathways helps to reduce the time taken to initiate management, and ensures all management principles are instituted, thus optimizing care (10).

However, despite dissemination of these guidelines, adherence to them is still lagging behind. As a result, the mortality associated with DKA is still high, especially in developing countries.

In India, an analysis reported a mortality of 30%(8). At the Kenyatta National Hospital the mortality in 2010 was 29.8% of the DKA patients (11).

The overall goal of this study was to audit the implementation of DKA management guidelines at KNH, to assess outcomes of DKA patients in KNH, and to assess diabetes-related knowledge of doctors and nurses in KNH.

2.0 LITERATURE REVIEW

2.1 DEFINITION AND CLASSIFICATION

Diabetic ketoacidosis is an acute metabolic emergency that occurs in individuals with absolute or relative insulin deficiency, and that is further aggravated by the resultant dehydration, hyperglycemia, and acidosis, resulting in derangements in intermediary metabolism (12). It occurs mainly in patients with type 1 diabetes, but may occur in some patients with type 2 diabetes.

Clinically, DKA is defined as an acute state of severe uncontrolled diabetes mellitus with associated ketoacidosis, that necessitates emergency treatment with intravenous fluids and insulin (12).

Biochemically, DKA is defined as blood glucose greater than 13.8mmol/L (250mg/dL), an increase in the serum concentration of ketones greater than 5mEq/L, urinary ketones, a blood arterial/venous pH less than 7.3, and a serum bicarbonate level of 18 mEq/L or less. This is associated increased anion gap, increased serum osmolarity and increased serum uric acid (13).

The American Diabetes Association classifies DKA into mild, moderate, and severe categories.

Summary of Diabetic ketoacidosis severity criteria

PARAMETER	Mild DKA	Moderate DKA	Severe DKA
Serum glucose	>13.8 mmol/L	> 13.8 mmol/L	> 13.8 mmol/L
Arterial /Venous pH	7.24 – 7.3	7 - <7.24	< 7
Serum bicarbonate	15 – 18 mEq/L	10 - <15mEq/L	< 10 mEq/L
Anion gap	>10 mEq/L	> 12 mEq/L	> 12 mEq/L
Mental status	Alert	Alert / Drowsy	Stupor / Coma

2.2 PRECIPITATING FACTORS

DKA may be the first presentation in new onset diabetes. In established type 1 diabetes, it may occur due to inadequate insulin dosage or discontinuation of insulin (14).

DKA may also occur due to stresses that act by increasing insulin requirements and increasing secretion of the counter regulatory hormones glucagon, catecholamines, growth hormone and cortisol. Such stresses include infection, pancreatitis, myocardial infarction, stroke, trauma, and alcohol and drug abuse (14). Missed insulin doses and infections are the most common precipitating causes(15) .

2.3 PATHOGENESIS AND PATHOPHYSIOLOGY

The absolute or relative insulin deficiency in DKA, accompanied by an increase in the counter-regulatory hormones glucagon, cortisol, epinephrine and growth hormone, enhances hepatic gluconeogenesis, glycogenolysis, and lipolysis (12).

The hyperglycemia results from hepatic gluconeogenesis and glycogenolysis, as well as from increased proteolysis, and the decreased glucose uptake by peripheral tissues due to insulin deficiency and counter regulatory hormone excess (14). The excess glucose overflows into urine causing glycosuria, which leads to osmotic diuresis, dehydration and hyperosmolarity. Severe dehydration may cause acute kidney injury (12).

Metabolic acidosis results from increased ketones and ketoacids, namely acetone, beta-hydroxybutyrate and acetoacetate. These are formed due to increased hepatic lipolysis of serum free fatty acids as an alternative source of energy. Progressive accumulation of these substances in blood leads to ketonemia. When they accumulate beyond the body's capacity to excrete them, they overflow into urine causing ketonuria (13). Respiratory compensation for this acidosis results in Kussmaul breathing. In addition, beta-hydroxybutyrate induces nausea and vomiting further aggravating electrolyte loss, while acetone produces the fruity breath odor (16).

Electrolyte disturbances occur due to the resultant hyperglycemia, osmotic diuresis, serum hyperosmolarity and metabolic acidosis. Potassium loss occurs due to shift of potassium from the intracellular to the extracellular space in exchange with hydrogen. Most of the shifted extracellular potassium is lost in urine because of the osmotic diuresis. Sodium is also lost in urine during osmotic diuresis. Also, dilutional hyponatremia occurs because the high serum osmolarity drives water from the intracellular to the extracellular space (16).

Patients have altered consciousness as a result of combined effects of serum hyperosmolarity, dehydration and acidosis which result in increased osmolarity in brain cells (12).

2.4 CLINICAL PRESENTATION

Patients will present with polyuria, polydipsia, nausea, vomiting, abdominal pain, shortness of breath and altered mental state. Physical examination findings include hypotension, tachycardia, dehydration, kussmaul respiration, obtundation and possibly coma. They will also have symptoms of the precipitating cause (17).

2.5 DIAGNOSTIC MODALITIES

Laboratory evaluation involves determination of plasma glucose, electrolytes with anion gap, osmolality, serum and urinary ketones, arterial/venous pH, and serum bicarbonate (14).

Patients with DKA will have a plasma glucose of 13.8mmol/L (250 mg/dL) or greater, increased anion gap, increased serum osmolality, arterial/venous pH of 7.30 or less, decreased bicarbonate to 18 mmol/L or less, and ketones in the blood and urine (18).

Other laboratory investigations include serum electrolytes. Serum potassium (may be high due to extracellular shift, later low reflecting total body potassium depletion), serum sodium (may be high due to osmotic diuresis, or low due to increased extracellular water in the hyperosmolar state). A full blood count may show mild leukocytosis which suggests dehydration and stress while severe leukocytosis suggests infection. HbA1C is done as an indicator of diabetes control. And blood urea and creatinine as indicators of renal function (16).

Other investigations indicated to identify precipitating factors include serum amylase and lipase, blood, urine and sputum cultures, cardiac enzymes, 12-lead ECG, and chest x-ray (16).

2.6 MANAGEMENT

Objectives of management are to restore normal extracellular fluid volume and tissue perfusion, correct electrolyte imbalances and hyperglycemia, resolve the ketoacidosis, and treat the precipitating illnesses (19). Timely initiation of management is emphasized, since delay has been associated with poor outcomes (20), including poor functional and morphological neurological consequences(21). DKA patients can either be managed in an ICU set up, or in a general ward with equally good outcomes(22).

2.6.1 EVOLUTION OF DKA MANAGEMENT

In the pre-insulin era, patients with DKA, or diabetic coma as it was referred to, were given supportive management such as bed rest and gentle laxatives to rid their bowels of nitrogenous substances (23). However, all these patients died soon after development of coma.

The management DKA evolved after the introduction of insulin in 1922-1923. However, it was not clear how to use the drug initially. And in the first 20 years after availability of insulin, patients with DKA were managed with high dose insulin (24). An average of 265 units of IV insulin were used for those who were drowsy but arousable, an average of 726 units for those who were arousable with difficulty, and an average of 870 units for those who were unconscious on admission (25) .

In 1972 it was shown that intravenous low dose insulin infusion adequately lowered ketone and glucose levels (26). In 1974, fluid replacement was shown to be an important component of DKA management, in addition to continuous intravenous insulin infusion (27). Thus, aggressive fluid replacement and low dose intravenous insulin infusion became the standard DKA care for the next four decades.

By late 1990s and early 2000s, the consensus was that DKA should be managed with aggressive fluid replacement, low dose intravenous insulin infusion and potassium replacement. In addition it was agreed that regular monitoring of blood gases was important to aid in management decisions (28).

These components of management of DKA have been constructed into integrated pathways, which promote implementation of research evidence into clinical practice (29). The pathways organize, sequence, and time the major interventions that the patient should receive (30) (31). Emphasis is put on prompt diagnosis, assessment of severity, close monitoring, specific advice on timing and administration of IV fluids, potassium and insulin therapy (32). The principles of management are described below.

2.6.2 FLUID REPLACEMENT

Average fluid loss in DKA is approximately 6-9 Liters. The goal of fluid therapy is to replace the total volume loss within 24-36 hours, with 50% of the resuscitation fluid being administered during the first 8-12 hours (33).

1-2 Liters intravenous normal saline is initially administered to correct shock, otherwise the fluid is given at a rate of 500ml/hr for 4 hours, then 250ml/hr for 4 hours (19). Modification in the rate and volume of fluid replacement may need to be made in patients with kidney failure, heart failure, and in elderly patients (34).

Crystalloids are preferred to colloids, and 0.9% sodium chloride is recommended as the initial replacement fluid(32). Once the blood glucose drops to below 14 mmol/l, the fluid administration should be changed to a solution containing dextrose (either 5% dextrose water or 5% dextrose in 0.9% NaCl solution or 5% dextrose in 0.45% NaCl solution) (35).

2.6.3 POTASSIUM SUPPLEMENTATION

The potassium deficit in DKA is 2-5 mmol/kg(19). The treatment goal is to maintain serum potassium levels within the normal range of 4-5mEq/L (14).

Potassium supplementation should be started for serum potassium less than 5mmol/L, once diuresis has been established, and before initiating insulin therapy (19).

Summary of Guide to Potassium chloride replacement (36)

Serum K+	Replacement
<3 mmol/L	40 mmol KCl per litre
3.1-4.0 mmol/L	30 mmol KCl per litre
4.1-5.0 mmol/L	20 mmol KCl per litre
>5 mmol/L	Omit KCl

2.6.4 INSULIN

Soluble insulin is used in management of DKA (37). Insulin should be initiated with an IV bolus of 0.1-0.5 U/kg followed by a continuous infusion of 0.1U/kg/hour (35). The insulin infusion should be continued until the acidosis and ketosis have cleared (37).

Subcutaneous insulin may be used as an alternative to intravenous insulin in patients with uncomplicated DKA. Rapid-acting insulin analogues, such as lispro, may be given subcutaneously every hour (bolus of 0.3 units per kg, then 0.1 units per kg), or two hours (bolus of 0.3 units per kg, then 0.2 units per kg) may be given for treating uncomplicated DKA (38).

Once the DKA is resolved (glucose <11 mmol/L, pH> 7.3, anion gap <10 and bicarbonate >18 mEq/L (39)), the patient can be started on a subcutaneous insulin regimen. That should include an intermediate- or long-acting insulin and a short- or rapid-acting insulin. When intravenous insulin has been used in the initial DKA management, it should remain in place for one to two hours after subcutaneous insulin is initiated (38).

2.6.5 BICARBONATE THERAPY

There is no indication for use of bicarbonate therapy in mild and moderate forms of DKA. However bicarbonate therapy may be indicated if the pH is 6.9 or less (33).

2.6.6 MONITORING

Monitoring of serum glucose, electrolytes, BUN (blood urea nitrogen), creatinine and ketones should be done at regular intervals (39).

Summary of Checklist of DKA management milestones (33)

Phase I (0-6h)	Phase II (6-12h)	Phase III (12-24h)
Perform history, physical exam and order initial lab studies	Continue biochemical and clinical monitoring	Continue biochemical and clinical monitoring
Implement monitoring plan (biochemical and clinical)	Change isotonic fluid to hypotonic fluid if corrected Na normal/high	Adjust therapy to avoid complications
Give IV bolus isotonic fluids	If glucose <14mmol/L, add dextrose to IV fluids	Address precipitating factors
Start insulin therapy (after fluids started and only if K>3.3mmol/L)	Adjust insulin infusion rate as needed	If DKA resolved, stop IV insulin and start subcutaneous insulin
Consult diabetes team	Maintain K 3.3-5.3mmol/L range	Consult diabetes educator

2.7 EFFECTIVENESS OF STANDARD DKA MANAGEMENT

Use of standard management guidelines promotes evidence-based practice, with improvement in patient outcomes (40).

Summary of Studies demonstrating effectiveness of standard DKA management

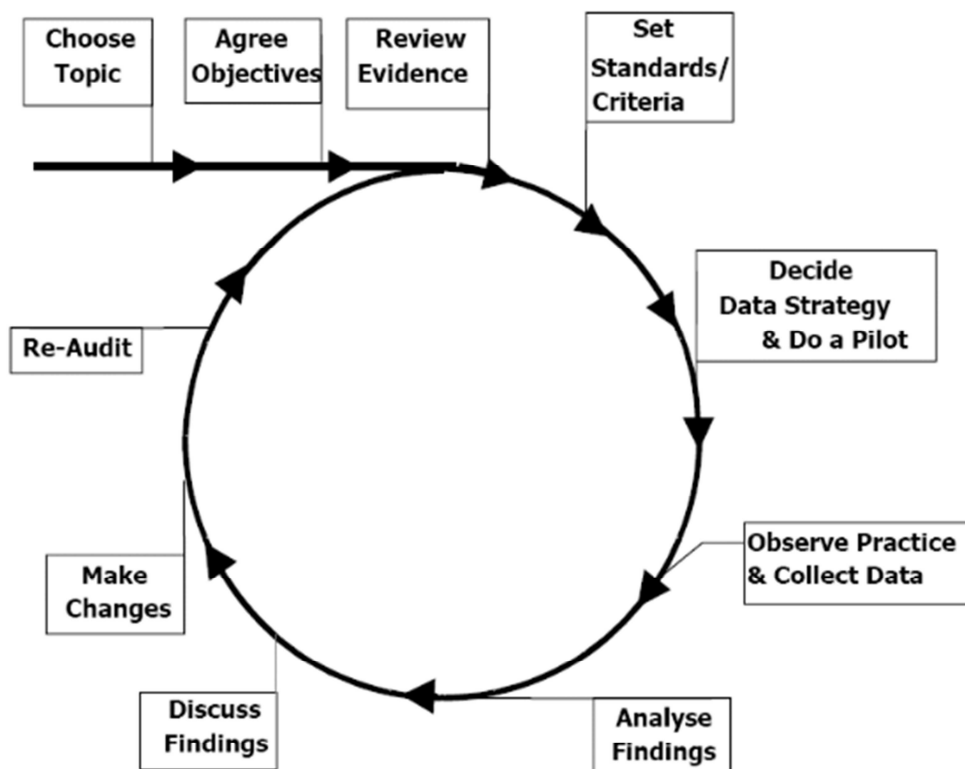
Study (n)	Location	Study design	Variables assessed	Results
Hara et al (41) n=143 (non-protocol) n=113 (Protocol)	USA	Retrospective chart reviews	Time to resolution of DKA, Length of ICU stay, Length of hospital stay, Hypoglycemic events, Hypokalemia events	Decreased time to DKA resolution (13.5hrs in protocol group, 22.7hrs in non-protocol group) Decreased ICU stay by 28.1hrs Decreased hospital stay (3.7days in protocol group, 5.4days in non-protocol group) No difference in hypoglycemia or hypokalemia events (but these were not statistically significant)
Bull et al (42) n=241 (before and after implementation of a mandatory DKA treatment protocol)	USA	Retrospective chart reviews	Length of ICU stay, Length of hospital stay, Time to correction of anion gap, Ketone clearance, Hypoglycemic events	Decreased ICU stay (44hrs before protocol implementation, 34hrs after protocol implementation) Decreased hospital stay (64hrs before protocol implementation, 91hrs after protocol implementation) Decreased time to anion gap closure and ketone clearance Similar no. of hypoglycemic events
Maghrabi et al (43) n=88 (1yr prior to guideline implementation) n=70 (1yr after guideline implementation)	USA	Retrospective chart reviews	DKA resolution time, Hypoglycemic events, Potassium balance	Shorter DKA resolution time (11.5hrs before guideline implementation, 8.5hrs after guideline implementation) Fewer hypoglycemic events Improved potassium balance

2.8 REVIEW OF HEALTH CARE AUDIT

Clinical audit has been defined as “a quality improvement process that seeks to improve patient care and outcomes through systematic review of care against explicit criteria and the implementation of change (44)” (National Health Service (NHS) guidelines 2013).

The processes involved in an audit are summarized in the flowchart below, from the same guidelines:

Figure 1: Overview of Audit Process



Auditing clinical practice against a treatment guideline is one of the ways to assess the challenging areas in guideline implementation.

2.9 ASSESSMENT OF DKA MANAGEMENT

Assessment of DKA management should be done regularly in all centers in order to ensure that these patients are getting optimal care as recommended in the management guidelines. The assessment also helps to identify challenges in management and challenges in implementation of guidelines which can then be addressed.

In assessing DKA management, important variables are:

- patient clinical assessment;
- necessary investigations including capillary blood glucose, arterial/venous pH, blood ketones, urine ketones, serum bicarbonate, full blood count, and investigation for precipitating causes;
- adequate prescription of IV fluids, potassium and insulin;
- review by diabetes specialists, and regular patient monitoring;
- adherence to prescriptions by the nurses;
- and management post resolution of DKA

2.10 STUDIES ASSESSING DKA MANAGEMENT

SUMMARY OF STUDIES ON ASSESSMENT OF DKA MANAGEMENT

Study (n)	Location	Variables assessed	Results
Abela et al n = 15	Malta	Parameter monitoring, Investigations performed, Type of IV fluids given, Amount of IV fluids given, Insulin regime, Potassium supplements used, Reasons for DKA	Deviations from protocol were identified in parameter recording, type of IV fluids given, the doses of insulin and potassium supplementation administered.
Dave et al n = 46	Leceister	Clinical evaluation, Investigations performed, Fluid placement, IV insulin regimen, Monitoring	Clinical management of DKA closely followed local guidelines in most cases.

McGeoch et al (National audit)	Scotland	Time to first IV fluid administration, Potassium replacement, Appropriate insulin use, Intravenous dextrose use, Blood monitoring frequency	Deficiencies in the management of DKA with delay in IV fluid and insulin administration, and laboratory monitoring being undertaken less frequently than recommended.
Crasto et al n = 50	Leceister	Time to IV insulin infusion, Time to IV fluids administration, Potassium supplementation, Hypoglycemia and its treatment	Adherence to the Joint British Diabetes Society DKA guideline was good in the immediate stage of treatment. However there was inadequate metabolic monitoring and fluid management, and iatrogenic hypoglycemia.
Pal et al n= 70	Reading, UK	Time to IV fluid replacement, Time to insulin administration, Adequacy of fluid replacement, Potassium supplementation, Biochemical monitoring, Identification of precipitating factor	In a significant proportion of patients treatment was delayed, insufficient IV fluid and potassium were administered, and monitoring was inadequate.
Dawkins et al n = 72	UK	Time to insulin and IV fluids replacement, Biochemical monitoring, IV dextrose commencement	Poor adherence to protocol in some important areas of management.
Bulsari et al n = 27	Queensland, Australia	Fluid resuscitation, Insulin administration, Potassium replacement,, Biochemical monitoring, Identification of precipitating factor	Inadequate biochemical monitoring and hypokalemia were ongoing issues.
Dhatariya et al n = 281	UK	Time to starting IV fluids, Time to starting insulin, Clinical and biochemical outcomes, Patient monitoring, Risk and discharge planning	Several areas of management of DKA are suboptimal, being associated with avoidable biochemical and clinical risk.

Abela et al (45) conducted an audit of the management of diabetic ketoacidosis at St Luke's Hospital in Malta between August 2004 and August 2005. They obtained data from patients' medical records and assessed parameter monitoring, investigations performed, the type and amount of intravenous fluids given, the insulin regime and potassium supplements used. In their study, 80% of patients had all the necessary investigations performed; Majority of patients received fluids in the first 22 hours as stated in the protocol; However intravenous insulin infusions were administered as per protocol in only 40% (n=6) of the cases; potassium supplements were given at a later stage than required in the protocol. This study helped to identify some of the problems encountered in the management of the patients admitted with DKA. The mean duration of stay for the patients analyzed was 4.8 days.

Dave et al (46) did an evaluation of admissions and management of diabetic ketoacidosis in a large teaching hospital. Their findings: IV access was established immediately in all patients; Glasgow Coma Scale was used to assess neurological status in 52%. A total of 86% had their blood glucose levels checked and 80% had their biochemical profiles assessed on arrival, including plasma glucose, renal profile, electrolytes and venous bicarbonate. A nasogastric tube was inserted in 82% of patients with absent bowel sounds and/or altered level of consciousness. The entire study group received IV fluids in accordance with protocol. Insulin therapy was administered by a variable dose IV regimen in 89%, with appropriate blood glucose monitoring in 91%. Treatment by insulin infusion was not documented for five episodes. 87% had monitoring of renal function, potassium and urine output as recommended intervals. All (100%) received potassium supplementation. 85% had their insulin therapy reviewed. In their study, the clinical management of DKA closely followed local guidelines in most episodes. There were no deaths.

McGeoch et al (47) conducted a prospective audit of DKA management. They found deficiencies in the management of DKA with delay in intravenous fluid and insulin administration, and laboratory monitoring being undertaken less frequently than recommended by local guidelines.

Crasto et al (48) conducted a retrospective study on management of DKA following implementation of the Joint British Diabetes Society DKA guidelines in the University Hospitals of Leicester between February and December 2012. They found that in the first 60 minutes of diagnosis, median time to fixed rate intravenous insulin infusion was 49 (29-110) minutes, and to intravenous fluids was 19 (0-42) minutes. During ongoing management, 46% of patients developed hypokalemia, and, of those, in 70% potassium supplementation was not prescribed as per protocol. 40% of patients developed hypoglycemia in the first 24 hours, of whom 80% had 10% dextrose

prescribed appropriately according to protocol. Median length of hospital stay was 2 days. There were no deaths due to DKA or complications of its management.

Pal et al (49) audited the management of DKA against the standards set in the guidelines, in a busy district general hospital. They found that intravenous fluid replacement was delayed in 56% while insulin was delayed in 33% of patients. Intravenous fluid replacement was inadequate in 36% of cases and potassium was under-replaced in 64% of cases. Frequency of biochemical monitoring was inadequate in 34% of cases. Median length of admission was 3 days, and there was 1 death.

Dawkins and Oyibo (50) audited the management of DKA in a District General Hospital after adopting the Joint British Diabetes Societies guidelines between May 2010 and May 2011. They found that intravenous fluid and insulin were commenced within 1 hour for less than half the patient admissions, blood glucose and venous pH monitored according to protocol in less than a third, and intravenous dextrose commenced appropriately for two thirds of applicable admissions. The median hospital stay was 4 days and no deaths were reported.

Bulsari et al (51) audited in-patient management of DKA in a University Hospital in Queensland Australia in the year 2012, with an objective of reviewing level of adherence to statewide DKA management protocol. They found inadequate frequency of biochemical monitoring at 37.5%, with serum ketones checked in only 22% at the time of admission. There was inadequate initial fluid resuscitation in 31.25% and hypokalemia observed in 37.5%. In 16% intravenous insulin was changed to subcutaneous regime prior to clearance of acidosis and ketonemia. Adequate cross-over between intravenous and subcutaneous insulin was done in 56% of cases. Precipitating cause was identified in 84%. No in-hospital mortality was observed.

Dhatariya et al (52) conducted a National survey of the management of DKA in the UK in 2014. Data were collected in a standardized form covering biochemical outcomes, risk and discharge planning. The form was sent to all UK diabetes specialist teams. They found that the median times to starting 0.9% sodium chloride was 41.5 minutes, the median time to starting intravenous insulin was 60 minutes. Significant adverse biochemical outcomes occurred, with 27.6% of patients developing hypoglycemia and 55% developing hypokalemia. Initial nurse-led observations were carried out well, but subsequent patient monitoring remained suboptimal.

2.11 BARRIERS TO OPTIMAL DIABETES AND DIABETIC KETOACIDOSIS CARE

According to the Diabetes Working Group (DWG) in the USA, there are many interconnected obstacles to achieving optimal diabetes care, including patient barriers (behavioral, psychosocial, and socioeconomic), health care provider barriers, and delivery system barriers (structural and technological) (53).

In developing countries, the World Health Organization has identified several barriers to adequate diabetes care, including: lack of organizational structure for the care of chronic diseases; minimal staffing and training provided to healthcare workers; poorly organized healthcare information systems; and a lack of resources (54).

Healthcare provider barriers to care include suboptimal knowledge and training. Knowledge regarding diabetes and DKA management plays an important role in ensuring optimal patient management. In addition, the influence of convenience rather than efficacy during patient management contributes to poor patient management (55).

Poor health care delivery systems have a negative impact on management of diabetes, especially DKA. These include poor healthcare infrastructure, lack of critical care units, erratic insulin supply, shortage of glucose monitoring equipment and consumables including medication and intravenous fluids (56).

Patient related barriers include poor health related behavior such as non-compliance to insulin, compounded by cultural issues regarding diabetes care, and poverty (57). However, these may not be relevant to hospital DKA management.

2.12 STUDIES ASSESSING DIABETES AND DKA KNOWLEDGE AMONG HEALTHCARE WORKERS

SUMMARY OF STUDIES ON ASSESSMENT OF KNOWLEDGE OF HEALTHCARE WORKERS ON DIABETES AND DKA

Study (n)	Location	Variables assessed	Results
Singh et al n = 73	India	General information on diabetes and DKA, regarding signs, symptoms and management.	Most students had basic knowledge on diabetes, its clinical features and management. Only 50% of the respondents were aware about the general features and management of DKA.
Van Zyl et al n = 115	South Africa	Knowledge and attitudes of hospital staff regarding inpatient management of diabetes.	Most had good attitude towards importance of proper diabetes management. Knowledge was suboptimal.
Ahmed et al n = 381	Pakistan	Knowledge related to the management of diabetes.	The percentage knowledge based questions answered correctly was low, with the mean correct percentage among all participants at 50% (+/-21).
Tofeec et al (Entire Central Manchester Foundation Trust audited)	Manchester, UK	Medical team's knowledge on DKA and its management.	There was major need for education in relation to DKA management.
Rubin et al n = 163	USA	Diabetes knowledge of nurses and residents in surgery, internal medicine and family practice.	Participants had insufficient knowledge about diabetes.

Singh et al (58) conducted a cross-sectional study on knowledge and awareness of diabetes and DKA among final year medical students in a tertiary teaching hospital in Tamilnadu, Southern India, in 2014. The study tool was a pre-validated semi-structured questionnaire. The questions consisted of general information on diabetes and DKA, signs, symptoms, and management. His results showed that most students had basic knowledge on diabetes, its clinical features and management. However, only 50% of the respondents were aware about the general features and

management of DKA. He concluded that further teaching and post teaching evaluation were needed, since medical students are the pillars of the future healthcare system.

Van zyl et al (59) studied the knowledge and attitudes of hospital staff regarding inpatient management of diabetes at Kalafong hospital in South Africa, in 2012. He did a survey of 54 doctors and 61 nurses taking care of inpatients, using the third version of the Diabetes Attitude Scale and the Diabetes knowledge questionnaire (O'Brien). 80.9% of the respondents felt that special training for management of diabetes is needed, 90.5% realized that diabetes is a serious condition, and 92.2% valued the importance of tight glycemic control. However, despite this perception of importance, the knowledge of doctors and nurses caring for diabetic inpatients were suboptimal, with the doctors achieving a mean score of 68.3% and the nurses 53.9%.

Ahmed et al (60) conducted an assessment of knowledge among residents and nurses at tertiary care hospitals of Karachi, Pakistan in 2012. He found considerable gaps in knowledge, with an overall mean correct percentage among all the participants at 50% (+/-21). He concluded that there was a need of providing additional education to improve the delivery of diabetes care.

Tofeac et al (61) undertook a service development audit within medical teams in the Central Manchester Foundation Trust to review knowledge on DKA and its management in 2016. In the initial audit, only 8% felt confident in managing DKA, while 66% did not feel confident in prescribing insulin. Only 28% said they would continue basal insulin while on fixed rate intravenous insulin infusion and no one identified the correct fluid regime to prescribe or when to obtain further blood tests on DKA patients. They went on to give education sessions on DKA management. Post teaching, results improved with 55% saying they felt confident in prescribing insulin, 70% said they would prescribe basal insulin while on fixed rate intravenous insulin infusion, 30% identified the correct fluid regime in DKA and 27.5% recognized the correct time to obtain blood samples for further test in DKA. The need for further education was noted.

Rubin et al (62) assessed and compared the diabetes knowledge of registered nurses and residents in surgery, internal medicine, and family practice at the Thomas Jefferson University Hospital, Philadelphia, Pennsylvania, USA, in 2007. The total mean percent correct for all participants was 61%. Collectively, all survey participants averaged less than 50% correct on several items. Most residents and nurses required additional education in order to provide optimal care to patients with diabetes.

STUDIES ASSESSING PERCEIVED AND ACTUAL DIABETES RELATED KNOWLEDGE AMONG NURSES

SUMMARY OF STUDIES ASSESSING PERCEIVED (DSRT) AND ACTUAL (DBKT) DIABETES RELATED KNOWLEDGE AMONG NURSES

Study (n)	Location	Results
Drass et al(63) n=184	Maryland, USA	Mean 47 +/-8.9 on DSRT. Mean 64% correct on the DBKT. Low negative correlation (r= -.36, p<.001) between DSRT and DBKT. Nurses who scored higher on the DSRT got lower scores on the DBKT.
Kupris et al (64) n=60	Michigan, USA	Mean 77 +/-8 on DSRT. Mean 70% correct on DBKT. Low positive correlation (r= .2306, p=.038) between DSRT and DBKT. Nurses' perceived knowledge of diabetes was positively correlated to actual diabetes related knowledge.
Reichelt et al (65) n=41	Montana, USA	Mean 78% on the DSRT. Mean 74% correct on the DBKT. Moderately positive linear correlation between DSRT and DBKT. Nurses who scored higher on the DSRT scored higher on the DBKT.
Findlow et al (66) n=97	Manchester, UK	Mean 69% correct on the DBKT.
Ledbetter et al (67) n=50	North Carolina, USA	Mean 59% on the DSRT (SD=8.9). Mean 59% on the DBKT (SD=14.51). Positive correlation between perceived and actual knowledge of diabetes by nurses. Participants perceived a lack of their actual knowledge relative to their predominately low scores of the overall DBKT.
Alotaibi et al (68) n=423	Saudi Arabia	Mean 78% on DSRT. Mean 51% correct on the DBKT. Significant gap between nurses' perceived and actual knowledge.

3.0 PROBLEM STATEMENT

DKA is associated with high mortality in Sub-Saharan Africa, with a reported death-to-case ratio of 26 to 29% in studies from Kenya, Tanzania and Ghana. In the developed world however, the death-to-case ratio is reported at 5-10%, and as low as <1% (69) in some centers.

Factors contributing to this high mortality in the third world comprise healthcare provider problems, poor health infrastructure, and patient related problems.

Variance between standard management and actual practice is an important contributor to the high mortality.

Guidelines had been introduced in some clinical areas in KNH, but their impact was yet to be established.

3.1 STUDY JUSTIFICATION

Use of standard DKA management guidelines has been associated with improved outcomes (40) (41) (42) (43).

Auditing clinical practice against a treatment guideline will help to assess the areas of challenge in providing standard DKA care.

The study also determined the capacity of the healthcare providers and the system they are working in, thus interrogating the system.

Discovering challenges in management will form the basis for quality improvement interventions.

4.0 RESEARCH QUESTION

What is the current practice of DKA management at the Kenyatta National Hospital, what are the outcomes of DKA patients at the Kenyatta National Hospital, and what is the level of diabetes related knowledge among doctors and nurses at the Kenyatta National Hospital?

5.0 OBJECTIVES

5.1 BROAD OBJECTIVE

To evaluate the management of DKA and determine adherence to standard DKA management guidelines at the Kenyatta National Hospital.

5.2 SPECIFIC OBJECTIVES

Primary objective

1. To assess the care given to patients with DKA at Kenyatta National Hospital and determine the level of adherence to standard DKA management guidelines.

The aspects assessed were:

- I. Specified aspects of patient clinical assessment (level of consciousness, blood pressure, pulse rate, respiratory rate, temperature and oxygen saturation),
- II. Accuracy of management prescriptions for fluids, insulin and potassium, and adherence to these management prescriptions at the point of care,
- III. Evidence of laboratory investigations (capillary blood glucose, arterial/venous pH, serum bicarbonate, urine ketones, urea and potassium) at diagnosis and monitoring of these laboratory parameters during care,
- IV. Specified aspects of patient clinical monitoring (blood pressure, pulse rate, respiratory rate, temperature, oxygen saturation, input/output charts) during care.

Secondary objectives

1. To determine the outcome, within 2 weeks of admission, of DKA patients in KNH in form of:
 - I. Resolution of ketosis,
 - II. And all-cause inpatient mortality.
2. To assess the level of diabetes-related knowledge among healthcare workers in KNH.
 - I. Diabetes-related knowledge of doctors was determined.
 - II. Nurses' perceived diabetes-related knowledge was assessed using the Diabetes Self Report Tool (DSRT).
 - III. Nurses' actual diabetes-related knowledge was assessed using the Diabetes Basic Knowledge Test (DBKT).

6.0 METHODOLOGY

6.1 STUDY DESIGN

A prospective descriptive study.

6.2.1 STUDY SITE

The study was carried out at the Kenyatta National Hospital which is the largest teaching and referral hospital in East and Central Africa. In Kenya, it is one of two referral hospitals with the other hospital being Moi Teaching and referral hospital in Eldoret. It is located in Nairobi with the catchment population being mainly from Nairobi, Central and Eastern regions of the country. At the time of the study, KNH had six general medical wards and one medical intensive care unit.

The main study areas were the acute medical units in the accident and emergency (A&E) department, the medical intensive care unit (ICU) and the six general medical wards.

6.2.2 STUDY CONTEXT

The layout of KNH at the time of the study was such that all patients, upon arrival to hospital, would first be seen at the A&E by a medical officer who would order necessary laboratory investigations and institute stat medication. Thereafter, when the laboratory results were ready, the patients would then be reviewed by a Senior House Officer, or ICU Medical Doctor who would then prescribe the necessary management. Patient admission to either ICU or general wards was based on available beds.

In the context of KNH, hospital policy is such that patients are expected to make some payment before management can be instituted or laboratory tests can be done. Those that cannot afford to make this payment or have no medical insurance have to wait until the waiving process is finalized. For those patients with medical insurance, there is cost-sharing meaning that patients are expected to make a percentage of payment out of their own pocket that is not covered by insurance.

6.3 STUDY POPULATION

Patients diagnosed to have DKA in the accident and emergency department, the medical intensive care unit and the medical wards in KNH between December 2017 and March 2018; and healthcare workers in these areas.

6.4 CASE DEFINITION

Study subjects were defined as all patients above the age of 13 years in the Accident & Emergency area, the medical ICU and the medical wards that fulfilled the criteria for diagnosis of DKA ie hyperglycemia greater than 13.8 mmol/L (250 mg/dL), ketonuria (++ or more), blood arterial/venous pH less than 7.3, and a serum bicarbonate level of 18 mEq/L or less, with associated increased anion gap.

Healthcare workers in this study were defined as senior house officers (SHOs), ICU medical officers and registered nurses in active duty working in the study areas, who document patients' examination findings, participate in a care plan and document the treatment given to the patient.

The SHOs in this context were doctors undertaking post-graduate training in Internal Medicine. They were involved in most of the decision making regarding patient management.

6.5 PARTICIPANT SELECTION

6.5.1 Inclusion criteria for Patients

- Patients with a diagnosis of DKA.

6.5.2 Exclusion criteria for Patients

- DKA patients with concomitant cardiac disease, end-stage renal disease, and the elderly (>65yrs).
- DKA in pregnancy

6.5.3 Inclusion criteria for Healthcare workers

- Doctors undertaking post-graduate training in Internal medicine, medical officers in ICU and nurses in each of the study areas who gave consent.

6.6 SAMPLING PROCEDURE AND SAMPLE SIZE CALCULATION

6.6.1 SAMPLING TECHNIQUE FOR PATIENTS

Consecutive sampling

6.6.2 SAMPLE SIZE FOR PATIENTS

An estimated number of 8 patients are seen monthly in KNH translating to a total of 48 patients during the 6 months study period. A representative sample was drawn from this population and the sample size calculation was obtained using a formula for finite population (less than 10,000).

The calculation was as follows:

$$n = \frac{NZ^2P(1 - P)}{d^2(N - 1) + Z^2P(1 - P)}$$

N = population of patients presenting with DKA in KNH during the study period =48

n = minimum required sample size

Z = standard normal for a 2-sided test at 95% confidence interval (CI) = 1.96

P = estimated proportion of DKA patients receiving proper management (estimated using adequacy of fluid replacement = 64% Pal et al)

d = margin of error of estimation =5%

Substituting into the formula,

$$n = \frac{48 \times 1.96^2 \times 0.64 (1 - 0.36)}{0.05^2(48 - 1) + 1.96^2 \times 0.64 (1 - 0.36)}$$

n = 42

A minimum of 42 patients was required to assess DKA management and estimate proportion of DKA patients receiving proper management within 5% margin of error.

6.6.3 SAMPLING TECHNIQUE FOR HEALTHCARE WORKERS

Consecutive sampling

6.6.4 SAMPLE SIZE FOR HEALTHCARE WORKERS

Sample size calculation for finite population.

$$n = \frac{Nz^2pq}{E^2(N - 1) + z^2pq}$$

n = Desired sample size

N = population size (number of healthcare workers i.e. doctors and nurses at the wards, ICU and casualty at the Kenyatta National Hospital. There were approximately 8 doctors and 12 nurses in each of the units i.e. wards, ICU and the casualty. This brought the total to approximately 160. The ratio of doctors to nurses was 2:3.

Z = value from standard normal distribution corresponding to desired confidence level ($Z=1.96$ for 95% CI)

p = expected true proportion (estimated at 50.0%, from a Pakistan study on assessment on knowledge of healthcare workers on diabetes and DKA)

$$q = 1 - p$$

E = desired precision (0.05)

$$n = \frac{160 \times 1.96^2 \times 0.50 \times 0.50}{0.05^2(160 - 1) + (1.96^2 \times 0.50 \times 0.50)} = 113$$

The ratio of doctors to nurses was 2:3, therefore minimum 45 doctors and 68 nurses was required.

A minimum sample of 6 doctors and 9 nurses from each unit was selected.

6.7 SCREENING AND RECRUITMENT

The principal investigator reviewed medical records of patients in casualty resuscitation room B (RRB) every day, medical records of patients in the medical ICU every day, and admission records in the general medical records on each admission day during the study period.

Study information was provided to eligible participants and/or their guardians/next of kin (for patients too sick to communicate), and a duly signed informed consent obtained.

Healthcare workers in each study site were selected based on consecutive sampling, and those who gave consent for participation were recruited.

6.8 STUDY EXECUTION

International standards for DKA management are available, and these are adapted to local standards. Principles of management agreed upon by the UK National Institute for Health Care Excellence (NICE) and the American Diabetes Association (ADA) are fluid replacement, potassium supplementation and insulin administration, with or without bicarbonate therapy as described:

- Normal saline (0.9% NaCl) or Hartmann's as the fluid of choice.
- Amount of fluids: The ADA recommends 15–20 mL/kg body weight or at 1–1.5 L during the first hour. Subsequent rates depend on patient hemodynamic and hydration status and serum electrolytes. NICE guidelines recommend rapid initial fluid replacement (2L in the first 2hrs), with replacement of the total volume lost (6-9L) within 24-36hrs.
- Potassium supplementation rates between 20 and 40 mmol in 1 L of rehydration fluid.
- When pH < 6.9 bicarbonate replacement should be considered.
- IV infusion of regular insulin at fixed weight-based rates.
- Glucose infusion is recommended when blood glucose levels falls below 14 mmol/L.

The standard guidelines in this study were adapted from the Joint British Diabetes Societies (JBDS) management guidelines, and represent internationally accepted principles of DKA management.

Evaluation of adherence to guidelines was undertaken as the patient was undergoing management either in the Accident & Emergency area, or in the medical wards, or in the medical ICU. The evaluation is as described below:

- I. Patients' clinical notes were examined for evidence of documentation of specified aspects of clinical assessment including level of consciousness, blood pressure, pulse rate, respiratory rate, temperature and oxygen saturation at diagnosis.
- II. Patients' clinical notes were examined for availability of results for necessary investigations done including: capillary blood glucose, urinalysis for urine ketones, arterial/venous pH, serum bicarbonate, full blood count, urea, potassium and creatinine; and investigations for possible precipitating causes at diagnosis and during care.
- III. Treatment charts were examined to determine appropriateness of the IV fluids used. Type of IV fluid recommended is 0.9% sodium chloride or hartmann's fluid for initial resuscitation, then once the blood glucose drops to <14mmol/L either 5% dextrose water or 5% dextrose in 0.9% sodium chloride solution or 5% dextrose in 0.45% sodium chloride are recommended.
- IV. Treatment charts were examined for quantity of IV fluids in the first 24-36 hours. Target fluid recommended is 6-9 liters replaced over 24-36 hours; or replacement of estimated total fluid volume lost (10% body weight) in 24-36 hours.
- V. Treatment charts were examined for appropriateness of potassium (K) supplementation; the recommendation being 40mmol KCl per litre if K<3mmol/L, 30mmol KCl per litre if K 3.1-4.0mmol/L, 20mmol KCl per litre if K 4.1-5.0mmol/L and no KCl if K>5mmol/L and/or patient anuric.
- VI. Treatment charts were examined for adequacy of insulin prescriptions as measured by units/kg given as insulin infusion or subcutaneous boluses. The recommendation is 0.1-0.5 U/kg IV initial bolus followed by continuous infusion of 0.1U/kg/hr, or regular subcutaneous boluses.
- VII. Treatment charts were examined for adherence to management prescriptions at point of care.
- VIII. Patients' notes and charts were examined for evidence of documentation of regular clinical monitoring of vital signs, input & output, and changing hemodynamic status.

Lack of record of interventions was considered as interventions not done.

The patient outcome was described in form of DKA resolution and all-cause inpatient mortality at 2 weeks. DKA resolution was defined as arterial/venous pH >7.3, and/or venous bicarbonate >18mmol/L.

The Nursing Officer In-Charge of each of the study areas was interviewed. The questions focused on 4 major areas: accessibility to and implementation of standard management guidelines, number of nurses per 30 beds, availability of bedside glucose testing meters, urine ketone testing meters and insulin infusion pumps, and mechanisms of audit of DKA management in terms of regular morbidity and mortality meetings to discuss management of DKA patients. These constitute the minimum institutional standards for management of DKA, and were described by the Joint British Diabetes Society (JBDS) in 2014.

A questionnaire was used to assess doctors' diabetes related and DKA knowledge. This consisted of 20 multiple-choice or fill-in-the-blank questions related to diabetes awareness, based on current diabetes standards of care. The questions were clear and focused on basic diabetes knowledge; and responses are not altered by culture or training. The questionnaire was acquired from a study done at the Thomas Jefferson University Hospital, Philadelphia, USA, with permission from the primary author (Rubin et al) (55). This was a prospective diabetes knowledge study among nurses and residents in internal medicine, surgery and family medicine in 2007. The only modification made to the original questionnaire was units in mmol/L which was added in brackets next to the equivalent units in mg/dL used. The same questionnaire has been used in a set up similar to KNH. This was a cross sectional study on diabetes related knowledge among trainee residents of internal medicine, family medicine and surgery, and registered nurses in Karachi, Pakistan, in 2012 (53).

Registered nurses' perceived diabetes related knowledge was assessed using the Diabetes Self-Report Tool (DSRT); and actual diabetes related knowledge was assessed using the Diabetes Basic Knowledge Test (DBKT).

The DSRT (56) was developed as a tool to assess nurses' perception of diabetes knowledge. Statements in the tool reflect perceived knowledge in each diabetes-related content area. The content areas covered include: etiology of diabetes, basic treatment of diabetes, hypoglycemia, hyperglycemia, diabetes and surgery, diet in diabetes, emergencies, diabetic ketoacidosis, glucose monitoring, insulin administration, oral hypoglycemic agents, stress, exercise, urine testing and sick-day guidelines. The tool consists of 22 statements on a Likert-type scale with a numerical value of 1-4, where 1 indicates strong disagreement, and 4 indicates strong agreement. The tool has been scored so that a higher total score indicates perception of a high level of diabetes knowledge. Possible scores range from 22 – 88.

The DBKT (56) is a modification of the Scheiderich's Diabetes Knowledge Test (DKT). It is a 45-item multiple-choice questionnaire used to assess level of diabetes knowledge among nurses. The DBKT is divided into theoretical questions and practice-based questions. Each of the 45 questions is followed by 3 responses and an "I do not know" response. There is one best response per question. The "I do not know" response is considered a wrong answer. The questionnaire was scored by using each correct answer as one point. The overall pass rate for this questionnaire was been set at 70%, as described by the primary author.

7.0 DATA VARIABLES

7.0.1 Exposure Variables

- Patient age – based on KNH admission records.
- Patient sex – based on KNH admission records.
- Type of diabetes – was acquired from the patient's medical records if available, and from history acquired from the patient.
- Duration of illness, other chronic conditions, current treatment, compliance to treatment, previous DKA admissions, education level, occupation, marital status, living arrangement – was acquired from taking the patient's history.
- Demographic characteristics of doctors and nurses – was reported by the participants.

7.0.2 Outcome Variables

- Evidence of timely patient review within three hours of arrival in hospital, and early initiation of management within three hours of arrival in hospital.
- Evidence of documentation of specified aspects of clinical assessment namely: level of consciousness using the Glasgow coma scale, blood pressure, pulse rate, respiratory rate, temperature, and pulse oximetry at diagnosis.
- Evidence of hourly clinical monitoring of patient vital signs namely: blood pressure, pulse rate, respiratory rate and temperature in the first 24 hours of patient hospitalization.
- Availability of results for laboratory investigations necessary for diagnosis of DKA which are: capillary blood glucose, urinalysis for urine ketones, arterial/venous pH, serum bicarbonate.
- Evidence of results for other supportive laboratory investigations namely: full blood count, urea, potassium and creatinine; and investigations for possible precipitating causes of DKA.

- Evidence of hourly capillary blood glucose monitoring, 2 hourly urine ketone monitoring, and 4 hourly blood gas analysis (pH, bicarbonate, potassium) in the first 24 hours of patient hospitalization.
- Appropriateness of management prescriptions/therapeutic interventions for intravenous fluids, insulin and potassium. These are:
 - Sodium chloride 0.9% or Hartmann's fluid for initial resuscitation; at a volume of 6-9 litres (or 10% of the patient's body weight) in the first 24-36 hours.
 - Dextrose 5% or dextrose saline when capillary blood glucose <14 mmol/L.
 - Potassium supplementation at: 40mmol KCl per litre if K<3mmol/L, 30mmol KCl per litre if K 3.1-4.0mmol/L, 20mmol KCl per litre if K 4.1-5.0mmol/L and no KCl if K>5mmol/L or patient anuric.
 - Insulin as 0.1-0.5 U/kg initial bolus followed by continuous infusion of 0.1U/kg/hr, or regular subcutaneous insulin boluses in uncomplicated DKA.
- Adherence to all the management prescriptions/therapeutic interventions at point of care.
- Evidence of specified aspects of clinical monitoring: hemodynamics, input/output chart.
- Outcome at 2 weeks of DKA patients in form of resolution of ketosis and all-cause inpatient mortality.
- Total score of healthcare workers in the different questionnaires.

8.0.1 DATA MANAGEMENT

Data was coded, entered and managed in a Microsoft Access 2013 database. The database was encrypted to ensure safety of the data and also confidentiality. Data validation checks were in-built in the database to minimize transcription errors during data entry. Data cleaning was done continuously in the course of data entry. All the data tools in hard and soft copy were kept in a lockable cabinet only accessible to the principal investigator.

8.0.2 DATA ANALYSIS

Data was exported to SPSS version 21.0 for statistical analysis.

The study population was described using demographic and clinical characteristics. Categorical variables such as gender, type of DM, level of formal education, employment status, and living arrangement, were summarized into percentages; and Continuous data such as age into means or medians as appropriate.

Time from arrival to patient review by senior house officers or ICU medical doctors, and time from patient arrival to initiation of management was summarized into means and medians as appropriate.

Patient clinical data was summarized as percentage of patients with vital signs (blood pressure, pulse rate, respiratory rate, temperature) done at hospitalization; and frequency of monitoring of these clinical parameters in the first 24 hours of hospitalization.

Patient laboratory data was summarized as percentage of patients with capillary blood glucose, urinalysis, blood gas analysis (pH, bicarbonate, potassium), full blood count, urea and creatinine done at hospitalization. Laboratory monitoring was summarized as frequency of monitoring of these laboratory parameters in the first 24 hours of hospitalization.

DKA management parameters were presented as percentage of patients with accurate prescriptions for intravenous fluids, potassium and insulin. This was presented as patients for whom these aspects of guidelines were met or unmet. The percentage of patients for whom these management prescriptions were adhered to during care was also evaluated. Amount of IV fluids replaced over the first 24 hours was summarized into means and medians.

The 2-week patient outcomes, in terms of resolution of ketosis and all-cause inpatient mortality, were recorded and summarized.

Data on diabetes related knowledge was reported as frequencies and percentages for the variables. Unanswered questions were counted as wrong (score 0) with an assumption that participants most probably were not aware of the correct response.

The total scores of the doctors' questionnaire was acquired and expressed as mean percentages. Responses were summarized into themes.

Nurses' scores for the Diabetes Self Report Tool (perceived knowledge) and the Diabetes Basic Knowledge Test (actual knowledge) were summarized into mean scores for each tool. Pearson correlation was used to determine the correlation between actual and perceived knowledge in diabetes management.

All statistical tests were significant at 5% level.

9.0 ETHICAL CONSIDERATIONS

The study was conducted after approval by the Department of Clinical Medicine and Therapeutics, University of Nairobi and the Kenyatta National Hospital Scientific and Ethical Review Committee.

The study objectives were explained to eligible participants in English or Kiswahili prior to inclusion in the study. Only participants who gave written informed consent were enrolled into the study. Those who declined to give consent or withdrew from the study for any reason were not victimized and still received management.

Parental/guardian consent was obtained for participants aged less than 18 years. In addition, assent was obtained for the participants aged less than 18 years.

For those participants unable to give own consent due to the nature of their illness (altered consciousness, inability to communicate), informed consent was obtained from the next of kin/closest relative prior to inclusion of the patient into the study.

Information gathered from the study participants was kept confidential.

The study was an audit of care given to the patient. There were no invasive procedures involved during execution of the study.

The study did not interfere with the patients care operations. However any assistance necessary for the patient's benefit was offered.

The study objectives were also explained to healthcare workers and informed consent obtained before their inclusion into the study.

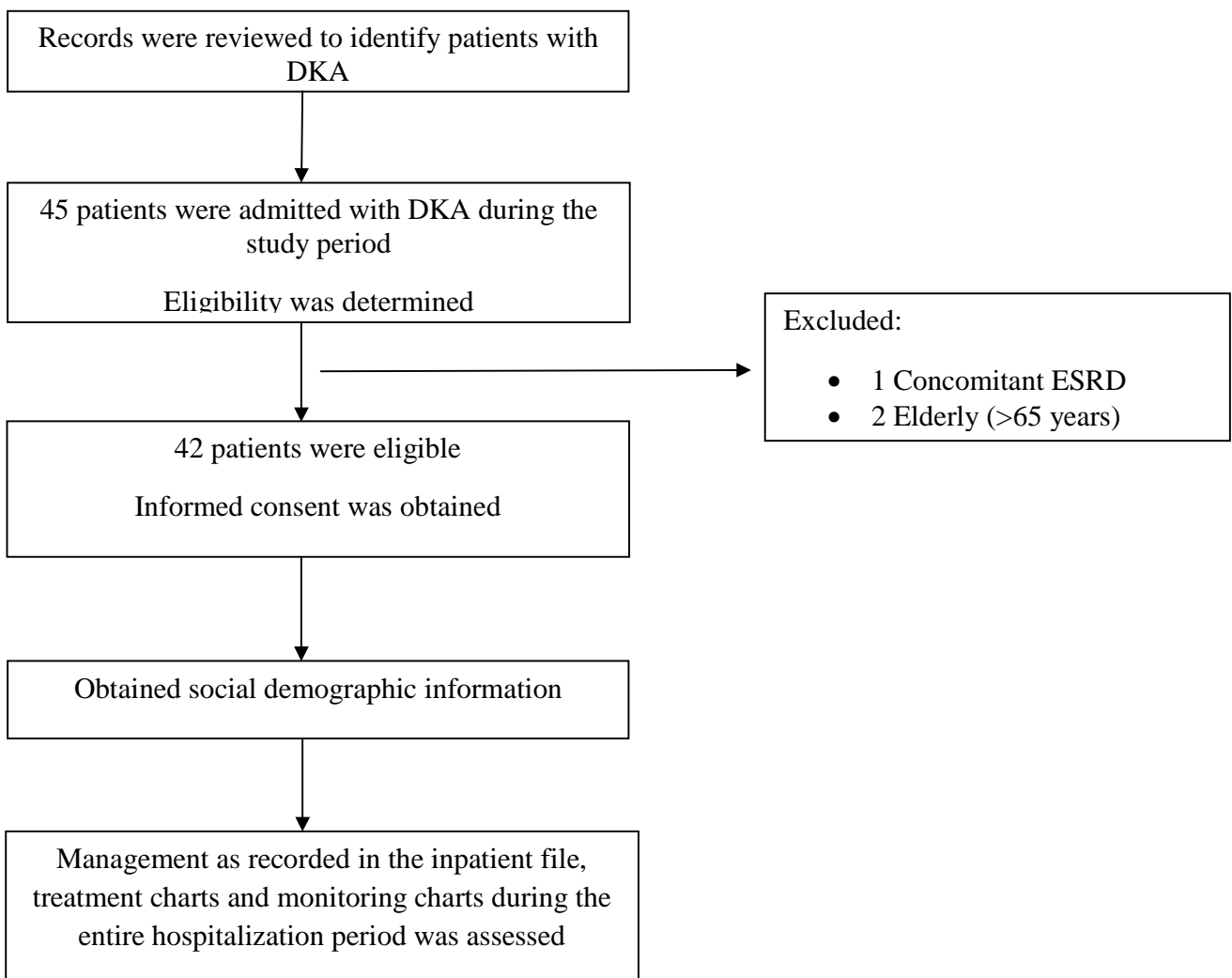
The study results will be disseminated to health care providers to aid in patient care.

10.0 RESULTS

10.1 ASSESSMENT OF PATIENT CARE

The study was conducted between December 2017 and March 2018. Medical records of patients in casualty resuscitation room B and those of patients in the medical ICU were reviewed daily, and admission records in the admitting general medical wards were reviewed on each admission day to identify patients with DKA. 42 patients were recruited (Fig 2).

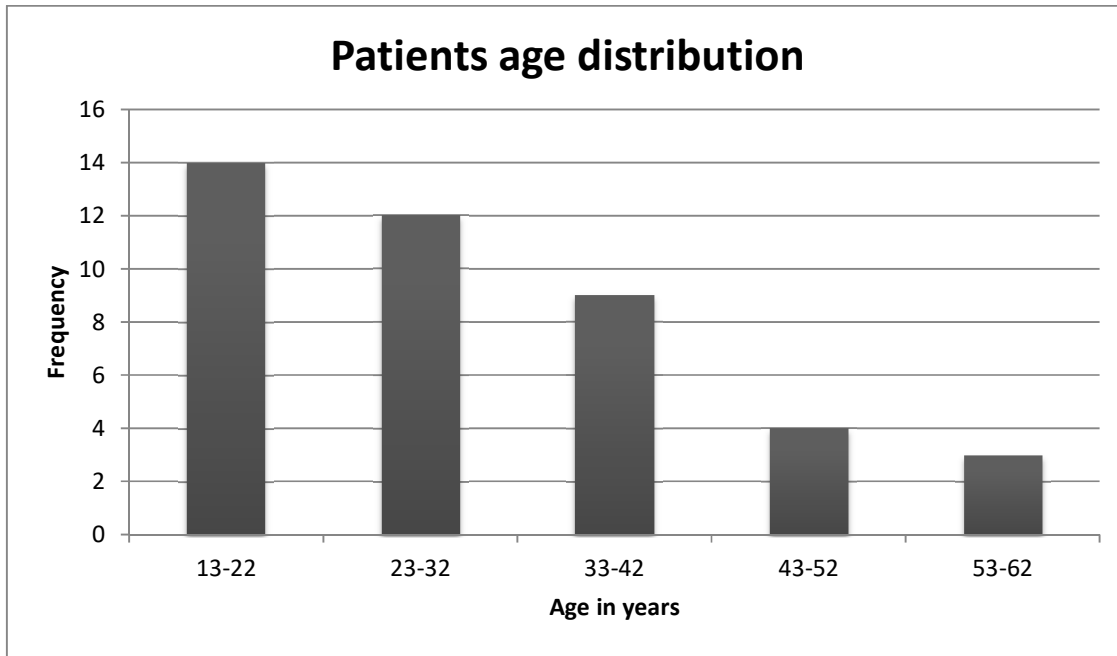
Figure 2: Summary of Patient recruitment



10.1.1 Patient Socio-Demographic and Clinical Characteristics

There were 24 (57.1%) males. The patients were aged between 13 and 61 years. The median age was 28.5 years (IQR of 17). A third (33.3%) of the patients were adolescents. (Fig 3).

Figure 3: Age distribution of the study patients (n=42)



Majority of the patients, 76.2%, had Type 1 diabetes. Most of the patients, 61.9%, had attained post-primary education. About half, 54.8%, of them had some form of employment, whether in the formal or informal sectors, or were self-employed; with almost half of them, 45.2%, being dependents ie unemployed or students (Table 1).

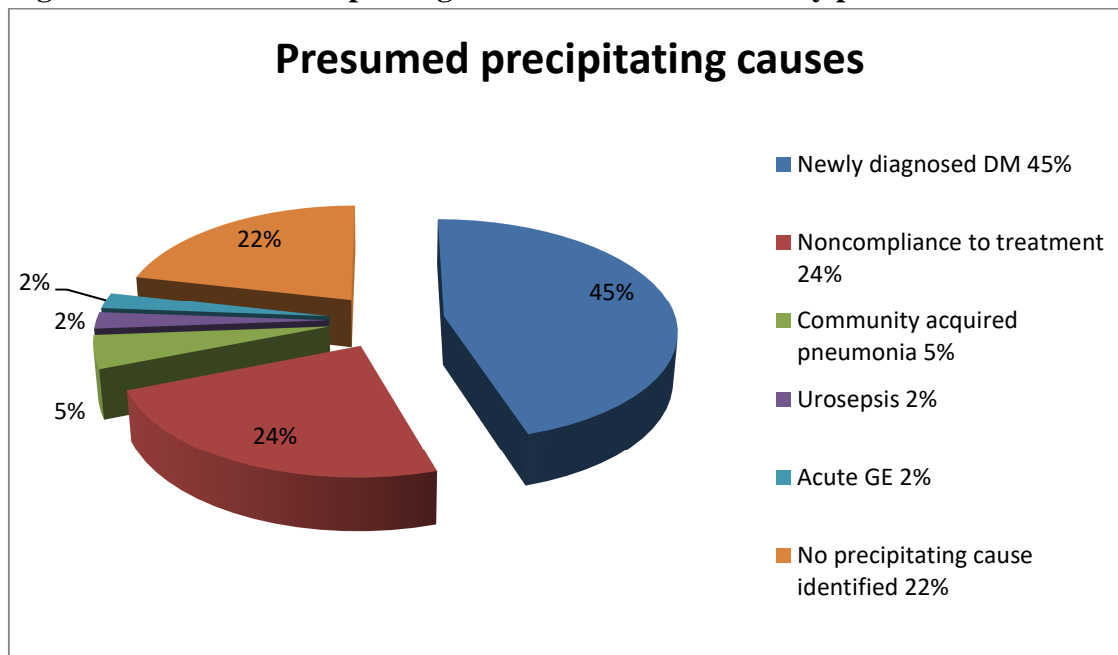
Table 1: Clinical and Social Characteristics of the study patients (n=42)

Variable	n=42	
	Frequency,n	Percentage (%)
Type of Diabetes Mellitus		
Type 1	32	76.2
Type 2	10	23.8
Level of Formal Education		
None	0	0.0
Primary	16	38.1
Post-primary	26	61.9

Occupation/Employment status		
Unemployed	7	16.7
Formally employed	4	9.5
Informal sector workers	12	28.6
Self-employed	7	16.7
Student	12	28.6
Living arrangement		
Alone	2	4.8
With others	40	95.2

Most (45%) of the patients were newly diagnosed diabetic with DKA as the initial presentation (Fig. 4). In 24%, DKA was presumed to have been precipitated by noncompliance to diabetes treatment, in patients already known to be diabetic. No precipitating cause was identified for 22% of the patients.

Figure 4: Presumed Precipitating Causes of DKA in the study patients



Potassium (K⁺) level of study patients at hospitalization

Majority of the patients, 92.9%, had potassium of < 5 mmol/L at admission, and therefore required potassium supplementation during therapy (Table 5).

Table 2: Potassium (K⁺) level of study patients (n=42) at hospitalization

Admission K ⁺ (mmol/L)	Frequency n (%)
< 3	15 (35.7)
3.0 - 5	23 (54.8)
>5.0	4 (9.5)
Total	42 (100.0)

10.1.2 Patient Review and Monitoring

All patients were first seen at the Accident and Emergency department. 32 (76.2%) of them were then subsequently managed in the general wards, while 10 (23.8%) were subsequently managed in the ICU.

Early patient review, within 3 hours of hospital arrival, is recommended in DKA management guidelines. However, in this study there were delays noted. The mean (SD) time taken by the ICU doctor or SHO to the evaluation/review of the patients was 9.7 (4.95). The median time was 10 hours. Only 11.9% of the patients were reviewed within 3 hours of arrival in hospital (Table 2).

Table 3: Timelines of Review of the study patients

Variable	n=42	
	Frequency,n	Percentage (%)
Review by ICU or SHO within 12 hours		
Yes	34	81.0
No	8	19.0
Time taken to review by ICU or SHO (hours)		
<3	5	11.9
3-6	6	14.3
6-12	23	54.8
>12	8	19.0

10.1.2.1 Clinical Monitoring

Upon arrival in hospital, initial evaluation of patients' vital signs (blood pressure, pulse rate, respiratory rate, temperature) and level of consciousness, using the Glasgow coma scale, was done for majority of patients. Therefore, clinical evaluation upon arrival in hospital was adequate. Pulse oximetry was measured for only about half of the patients (Table 3).

Table 4: Proportion of patients with Clinical Assessments Done upon arrival in hospital

Clinical assessment/ Evaluation parameters	n=42	
	Frequency, n	Percentage (%)
Glasgow Coma Scale	38	90.5
Vital signs	42	100.0
Pulse oximetry	19	45.2

The frequency of patients' vital signs monitoring in the first 24 hours of hospitalization was assessed (Table 4). Majority of the patients, 64.3%, had < 6 assessments done. Therefore, clinical monitoring in the first 24 hours of hospitalization was inadequate.

Table 5: Frequency of Monitoring of Vital Signs in the first 24 hours of hospitalization (n=42)

Frequency of clinical monitoring in the first 24 hours	n=42	
	No. of patients	Percentage (%)
None	0	0.0
1-2	16	38.1
3-6	11	26.2
7-10	1	2.4
>10	2	4.8
Continuous cardiac monitoring	12	28.6

10.1.2.2 Laboratory Evaluation

All patients (100%) had capillary blood glucose done at hospitalization. In addition, all patients had a full blood count and urea and electrolytes done at admission. Therefore, these aspects of laboratory evaluation were adequate according to guidelines. However, 8 (19%) patients did not have a urinalysis done at admission, while 1 (2.4%) patient did not have blood gas analysis done at hospitalization; these aspects of laboratory evaluation were inadequate according to guidelines.

Frequency of Laboratory Monitoring of pH, Potassium, and Bicarbonate of the study patients in the first 24 hours

The number of times the patients' pH, potassium and bicarbonate were monitored in the first 24 hours was reviewed. These investigations were done at once as Blood Gas Analysis (BGA) (Table 6). Majority of the patients, 71.4%, had only one or two assessments done. These BGAs may not have been done at regular intervals. Therefore these aspects of laboratory monitoring were inadequate according to guidelines.

Table 6: Frequency of Laboratory Monitoring of pH, Potassium, and Bicarbonate of the study patients (n=42) in the first 24 hours of hospitalization

Frequency of BGA monitoring in the first 24hrs	No. of patients, n (%)
None	1 (2.4)
1-2	30 (71.4)
3-4	10 (23.8)
5-6	1 (2.4)

Frequency of Monitoring of Urinary Ketones, for the study patients in the first 24 hours

The number of times the patients' urinary ketones were monitored in the first 24 hours was reviewed. Majority of the patients, 76.2%, had their urinary ketones measured only at hospitalization, with no further monitoring. Only 2 (4.8%) patients had more than 6 urinary ketone measurements during on-going care in the first 24 hours. Therefore, urinary ketone monitoring was inadequate according to guidelines.

Frequency of Monitoring of Capillary blood glucose for the study patients in the first 24 hours

The number of times the patients' capillary blood glucose (CBG) was monitored in the first 24 hours was reviewed (Table 7). Only a few patients, 6 (14.3%), had > 12 CBG monitoring in the first 24 hours. Therefore CBG monitoring was inadequate according to guidelines.

Table 7: Frequency of Monitoring of Capillary blood glucose for the study patients (n=42) in the first 24 hours of hospitalization

Number of tests of CBG in the first 24 hours	Frequency n (%)
1-2	9 (21.4)
3-4	12 (28.6)
5-6	7 (16.7)
7-8	3 (7.1)
9-10	0 (0.0)
11-12	5 (11.9)
>12	6 (14.3)

Lowest Recorded CBG of the study patients in the First 24 Hours of hospitalization

Patients' levels of capillary blood glucose as recorded in the laboratory analyses done in the first 24 hours were reviewed, and the lowest level recorded. The mean (SD) lowest recorded capillary blood glucose during the first 24 hours was 13.7 (6.7) mmol/L. The median was 12.25 mmol/L (IQR 8.55). One patient developed severe hypoglycemia (<3 mmol/L) and required dextrose resuscitation.

10.1.3 Patient Management

The study sought to evaluate management prescriptions for DKA, as recommended in the guidelines, and adherence to these management prescriptions. The findings are as shown below.

10.1.3.1 Fluid Management

Type and amount of intravenous fluids prescribed was reviewed (Table 9). Sodium chloride (0.9%) or Hartmann's fluid were appropriately prescribed for initial resuscitation, and appropriate quantities of the fluids were prescribed. Therefore type and amount of initial resuscitation fluids was adequate according to guidelines. Nineteen (67.9%) patients had 5% dextrose or dextrose saline appropriately prescribed when CBG fell to <14 mmol/L. Therefore prescriptions of dextrose containing fluids were inadequate according to guidelines. Fourteen (33.3%) patients' CBG was persistently >14 mmol/L while in DKA, therefore 5% dextrose or dextrose saline were not prescribed.

Table 8: Prescriptions for IV fluids for the DKA patients (n=42)

IV fluid prescriptions	Met n (%)	Unmet n (%)	N/A n (%)
Type of IV fluids			
Prescription of 0.9% NaCl or Hartmann's fluid for initial resuscitation	42 (100.0)	0 (0.0)	0 (0.0)
Prescription of 5% dextrose water or dextrose saline when CBG <14 mmol/L	19 (67.9)	9 (32.1)	14
Quantity of IV fluids			
6-9 litres prescribed over 24-36 hrs	42 (100.0)	0 (0.0)	0 (0.0)

Adherence to prescriptions for Intravenous fluids

Adherence to the type of IV fluids prescribed was observed in almost all patients. However, adherence to prescribed amounts of intravenous fluids was observed in only 5 (11.9%) patients. (Table 10). Therefore amount of IV fluids replaced was inadequate according to guidelines. The mean (SD) amount of IVF given in the first 24 hours was 3.59 (1.78) L, and the range was 7.50 L (1.0- 8.50 L). The median IVF given was 3.0 L (IQR 1.50).

Table 9: Adherence to prescriptions for IV fluids

Adherence to Fluid Prescriptions	Met n (%)	Unmet n (%)	N/A (not prescribed)	Not recorded n (%)
Type of IV fluids				
Use of 0.9% NaCl or Hartmann's fluid for initial resuscitation	41 (97.6)	0 (0.0)	0	1 (2.4)
Use of 5% dextrose water or dextrose saline when CBG <14 mmol/L	18 (94.7)	0 (0.0)	23	1 (5.3)
Quantity of IV fluids				
6-9 liters replaced over 24-36 hours	5 (11.9)	36 (85.7)	0	1 (2.4)

10.1.3.2 Insulin Use in the Study patients

IV insulin bolus was prescribed to 31 (73.8%) patients; this prescription was adhered to in all these patients. IV continuous insulin infusion was prescribed to 35 (83.3%) patients. Of these, 26 (74.3%) received the infusion as prescribed, 9 (25.7%) did not receive the infusion as prescribed. Therefore insulin infusion was inadequate according to guidelines. A few patients, 7 (16.7%), were managed with subcutaneous insulin at regular intervals instead of continuous IV insulin infusion. Adherence to subcutaneous insulin boluses was better (100%) than adherence to continuous insulin infusion.

10.1.3.3 Potassium management

Potassium chloride was appropriately prescribed for all the 38 patients who required it, based on levels of potassium at admission. About a quarter of the patients, 9 (23.7%), did not receive potassium replacement as had been prescribed. Therefore potassium replacement was inadequate according to guidelines.

Time to Initiation of Clinical Management as prescribed for the study patients

Difference between the times of patients' arrival to hospital to when treatment was initiated as prescribed was assessed (Table 11). About half, 16 (51.6%), of the patients for whom initial insulin bolus was prescribed received the first bolus of insulin within 3 hours of arrival to hospital. While only about a third, 13 (37.1%), of those for whom insulin infusion was prescribed, had insulin infusion initiated within 3 hours of arrival to hospital. Intravenous fluids were initiated within 3 hours of arrival to hospital for 24 (57.1%) patients. Significant delay was also noted in initiation of potassium; only 12 (31.6%) patients for whom potassium was prescribed had it initiated within 3 hours of arrival to hospital. Therefore time to initiation of management was inadequate according to guidelines.

Table 10: Time to Initiation of Clinical Management as prescribed for the study patients

Time to initiation of treatment(hours)	Study patients, Frequency n (%)			
	Soluble Insulin stat dose	Intravenous fluids	Insulin Infusion	Potassium
< 3	16 (51.6)	24 (57.1)	13 (37.1)	12 (31.6)
3 - 6	6 (19.4)	5 (11.9)	5 (14.3)	8 (21.1)
6 - 12	4 (12.9)	7 (16.7)	7 (20.0)	7 (18.4)
>12	5 (16.1)	6 (14.3)	9 (25.7)	11 (28.9)
Total	31 (100.0)	42 (100.0)	35 (100.0)	38 (100.0)

10.1.3.4 Supportive management

Most of the patients, 25 (59.5%), had urinary catheterization, and/or had their urine output monitored during their admission. However, urine output was not monitored for 40.5%. Therefore urine output monitoring was inadequate according to guidelines.

Table 11: Summary of findings of Assessment of patient care

Guideline recommendation (Adapted to local standards)	Study findings Proportion of patients for whom guidelines met
Early patient review within 3 hours of hospitalization	11.9%
Initiation of management within 3 hours of hospitalization:	
Initial insulin bolus given within 3 hours	51.6%
Intravenous fluids initiated within 3 hours	57.1%
Potassium replacement initiated within 3 hours	31.6%
Insulin infusion initiated within 3 hours	37.1%
Initial clinical evaluation:	
Level of consciousness using Glasgow Coma Scale	90.5%
Vital signs (blood pressure, pulse rate, respiratory rate, temperature)	100%
Oxygen saturation	45.2%
Laboratory investigations done for diagnosis of DKA:	
Capillary blood glucose (CBG)	100%
Blood gas analysis (pH, bicarbonate, potassium)	97.6%
Urinalysis for urine ketones	81%
Other supportive investigations: full blood count (FBC), urea, electrolytes and creatinine (UEC)	100%
Laboratory monitoring	
Hourly CBG monitoring in the first 24 hours of hospitalization	0
2 hourly urine ketone monitoring in the first 24 hours of hospitalization	0
4 hourly blood gas analysis monitoring in the first 24 hours of hospitalization	0
Fluid management	
Prescription of 0.9% NaCl or hartman's for initial resuscitation	100%
Prescription of 5% dext when CBG <14 mmol/L	67.9%
Prescription of 6-9 litres (or 10% body weight) in the first 24-36 hours of hospitalization	100%
Correct type of intravenous fluid replaced as prescribed	100%
Correct amount of intravenous fluid replaced as prescribed	11.9%
Potassium replacement	
KCl appropriately and accurately prescribed	100%
KCl replaced as prescribed	76.3%

Insulin management:	
Insulin infusion accurately and appropriately prescribed	100%
Insulin infusion replaced as prescribed	74.3%
Subcutaneous insulin accurately and appropriately prescribed	100%
Subcutaneous insulin replaced as prescribed	100%
Supportive management:	
Urinary catheterization and/or urine output monitoring	59.5%

10.1.4 Patient Outcomes

10.1.4.1 Resolution of DKA

Confirmation of DKA Resolution of the study patients

Twenty one patients had repeat BGAs to confirm resolution of DKA. However, 18 (46.2%) patients' DKA was presumed to have resolved when capillary blood glucose dropped to <14 mmol/L. No repeat BGA was done for these patients. Therefore confirmation of DKA resolution was inadequate according to guidelines. Three patients died before DKA resolution had been identified.

Time to DKA Resolution after Admission of the study patients

The mean (SD) time to DKA resolution was 61.7 (25.5) hours with a minimum resolution time of 8 hours and maximum resolution time of 127 hours (5 days, 7 hours). The median was 59 hours. Majority of the DKA, 31 (79.5%) resolved within 72 hours or less.

10.1.4.2 Mortality

The study sought to find the all-cause inpatient mortality rate of patients admitted with DKA, within the first 2 weeks of admission. 5 patients died out of the 42 patients admitted with DKA. The all-cause inpatient mortality rate therefore was: 11.9%.

Of the 5 patients that died, 2 died within 48 hours of admission (at 11 hours and 22 hours respectively), while the other 3 patients died within 6-9 days following hospitalization.

Three patients died before resolution of DKA had been established, at 18 hours, 22 hours, and 9 days. Two patients died after DKA resolution had been established, at 6days 18hours and 8days 10hours respectively.

10.2 KEY INFORMANTS INTERVIEWS

The Nursing Officer In-Charge of each of the study areas (6 general medical wards, Medical ICU and the Accident and Emergency/ A&E) were interviewed. All the eight key informants were interviewed. The questions focused on 4 major areas: accessibility to and implementation of standard management guidelines, number of nurses per 30 beds, availability of bedside glucose testing meters, urine ketone testing meters and insulin infusion pumps, and mechanisms of audit of DKA management in terms of regular morbidity and mortality meetings to discuss management of DKA patients.

The informants reported availability of standard management guidelines that were accessible to all health care workers. Most areas had bedside blood glucose meters. However, only the ICU and A&E had insulin infusion pumps, and bedside urine ketone meters.

Staffing of nurses varied among the study areas; the most adequately staffed area was the ICU with a nurse-to-patient ratio of 1:1.

Most of the general wards had regular morbidity and mortality meetings in which DKA cases were discussed.

Details of the key informants' interviews is shown in Appendix 12.

10.3 ASSESSMENT OF DOCTORS' DIABETES RELATED KNOWLEDGE

Sixty questionnaires were distributed to the doctors. Eleven were never returned, giving a response rate of 81.7%. Therefore 49 questionnaires were analyzed.

10.3.1 Doctors demographic characteristics

Majority of the doctors (83.7%) were 25-34 years of age. The male to female ratio was 1:1.3. Most (63.3%) had 5-10 years of clinical experience (Table 12).

Table 12: Doctors demographic characteristics

Variable	n=49	
	Frequency	Percentage
Age in Years		
25-34	41	83.7
35-44	7	14.3
>44	1	2.0
Gender		
Male	21	42.9
Female	28	57.1
Appointment		
Medical officer ICU	7	14.3
Senior house officer	42	85.7
Years of clinical experience		
<5	15	30.6
5-10	31	63.3
11-15	3	6.1
>15	0	0.0

10.3.2 Doctors' Diabetes-related Knowledge

The mean (SD) score for doctors was 11.82 (2.5) points, the mean percentage score was 59.1%. The median score was 12.0 points with IQR 4. The lowest score was 6 points and the highest score was 17 points (Fig 5). The possible scores for the tool are 0 (lowest possible score) to 20 (highest possible score).

Figure 5: Doctors scores in the questionnaire

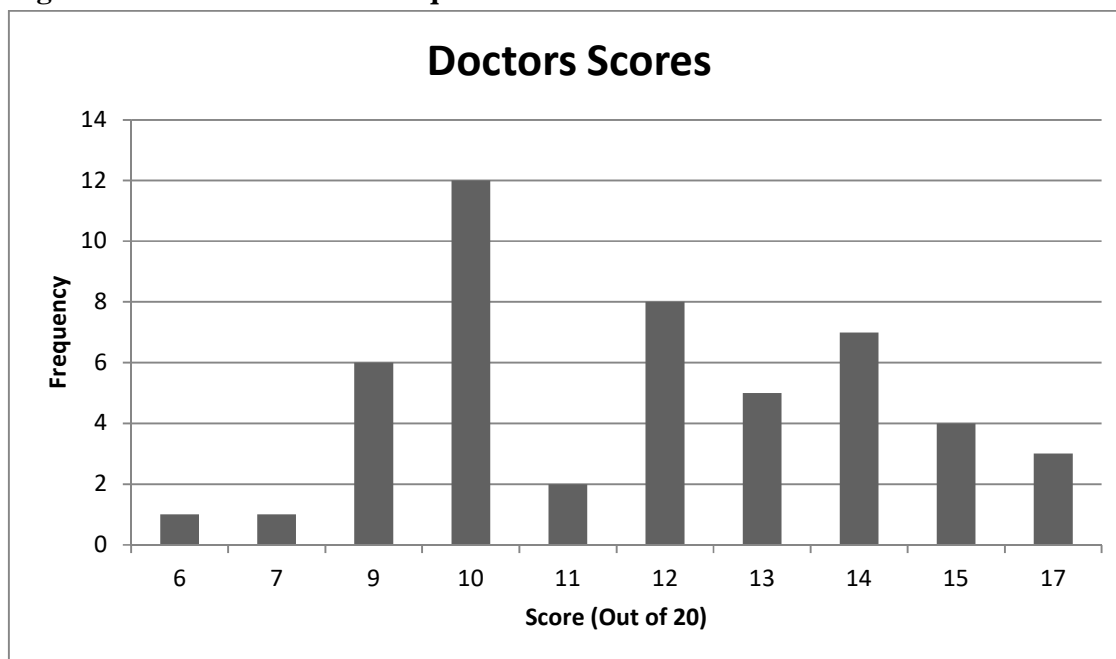


Table 13: Percentage of Correct Responses to Individual Questionnaire Items for Doctors

Correct answers (<u>underlined and bolded</u>)	Answered correctly, n (%)
<i>Fundamental knowledge on diabetes diagnosis and targets</i>	
The diagnostic criteria for diabetes mellitus is a fasting glucose of at least <u>6.9</u> mmol/L on two occasions	2 (4.1)
The American Diabetes Association hemoglobin A1c goal for a diabetic is <u>≤7%</u> .	15 (30.6)
The American Diabetes Association blood pressure goal for a diabetic is <u>≤130/80</u> .	28 (57.1)
<i>Diabetes pharmacology</i>	
Renal insufficiency is a contraindication to <u>metformin</u>	45 (91.8)
Glipizide, <u>rosiglitazone</u> , sitagliptin, or insulin should be discontinued in a patient who develops congestive heart failure	37 (75.5)
Among lispro, regular insulin, NPH, and glargine, <u>glargine</u> is the longest acting insulin	48 (98.0)

Among lispro, regular insulin, NPH, and glargine, lispro is the shortest acting insulin	33 (67.3)
Regular insulin peaks in 30 min, 60 min, 2-4 hours , or 6-8 hours	22 (44.9)
Novolin 70/30 insulin is 70% NPH and 30% Regular	32 (65.3)
<i>Practical inpatient diabetes management</i>	
Regular insulin is best administered 30 min before meals , at the first bite, or 30 min after meals	40 (81.6)
An insulin drip should or should not be discontinued in a DKA patient with ketones in the urine	34 (69.4)
For a patient with DKA on an insulin drip, dextrose containing intravenous fluid should be administered when the blood glucose falls below 5.5, 8.3 or 11.1-13.8 mmol/L	47 (95.9)
Potassium , sodium, phosphorus or magnesium is the most important electrolyte to follow for a DKA patient on an insulin drip	49 (100.0)
The blood glucose decline per hour on an insulin drip should be 0.8-1.6, 1.6-2.7, 2.7-4.1 , or 8.3-11.1 mmol/L	25 (51.0)
When transitioning a patient to subcutaneous insulin, an insulin drip should be discontinued 0 min, 30 min, 1 hour, or 2 hours following administration of glargine	22 (44.9)
Orange juice , crackers, glucagon, or ½ ampule of 50% dextrose is the preferred treatment for an alert, asymptomatic hypoglycemic patient.	32 (65.3)
Orange juice, crackers, ½ ampule of 50% dextrose , or 1 ampule of 50% dextrose is the preferred treatment for a confused hypoglycemic patient	11 (22.4)
For a patient whose total daily dose of insulin is calculated to be 50 units, 10, 25 , 35, or 40 units of basal insulin should be given daily	30 (61.2)
For a patient with T1D on NPH and lispro insulin at home who is fasting the morning of surgery, ½ the usual NPH dose, the full NPH dose, the full NPH and lispro doses, or continuous insulin infusion is the preferred therapy	23 (46.9)
A patient with T2D on 30 units of Novolin 70/30 insulin BID with a fasting blood glucose of 140 mg/dL the morning of an elective surgery should be given no insulin, sliding scale insulin, 15 units of NPH , or 20 units 70/30.	4 (8.2)

There was insufficient knowledge on diagnostic criteria of diabetes, and targets for hemoglobin A1c and blood pressure for a diabetic. Knowledge on pharmacology of drugs used in management of diabetes was mostly sufficient, except certain aspects of insulin pharmacology which was found to be insufficient. Knowledge on practical inpatient diabetes knowledge was varied. Most respondents had sufficient knowledge on DKA management; but had insufficient knowledge on preparation of a diabetic patient for surgery.

10.4 NURSES DIABETES RELATED KNOWLEDGE

One hundred questionnaires were distributed to the nurses. Twenty seven were never returned, giving a response rate of 73%. Of the 73 that were returned, 3 were incompletely filled and were excluded. Therefore 70 questionnaires were analyzed.

10.4.1 Nurses socio-demographic characteristics

Majority of the nurses (80%) were <44 years of age. The male to female ratio was 1:2. Most (68.6%) had attained diploma level of training; a few (4.3%) had masters or higher level of training. Most of them (55.7) had <10 years of clinical experience. None of the nurses was diabetic. Majority (72.9%) did not have any diabetics in their nuclear families or as close friends. (Table 14).

Table 14: Nurses socio-demographic characteristics

The nurses' socio-demographic information is as shown by the table below.

Variable	n=70	
	Frequency	Percentage
Age in Years		
25-34	33	47.1
35-44	23	32.8
>44	14	20.0
Gender		
Male	21	30.0
Female	42	60.0
Not specified	7	10.0
Highest level of education		
Certificate	1	1.4
Diploma	48	68.6
BSN	18	25.7
Masters or higher	3	4.3

Appointment		
Nursing officer	44	62.9
Senior nursing officer	25	35.7
Not specified	1	1.4
Years of clinical experience		
<5	14	20.0
5-10	25	35.7
11-15	12	17.1
>15	19	27.1
Presence of diabetes		
Self	0	0.0
Nuclear family	11	15.7
Close friend	7	10.0
None of the above	51	72.9
Not specified	1	1.4

10.4.2 Perceived Knowledge on Diabetes Mellitus among Nurses

Nurses' perceived knowledge on diabetes mellitus was assessed using the Diabetes Self Report Tool (DSRT). They scored a mean (SD) of 72.46 (12.01) points, had a median 75.0 points, the lowest observed score being 22 points and the highest observed score being 87 points (Fig 6). The possible scores for the tool are 22 (lowest possible score) to 88 (highest possible score). Generally, the respondents had a high perception of diabetes knowledge.

Figure 6: Nurses Scores in the DSRT

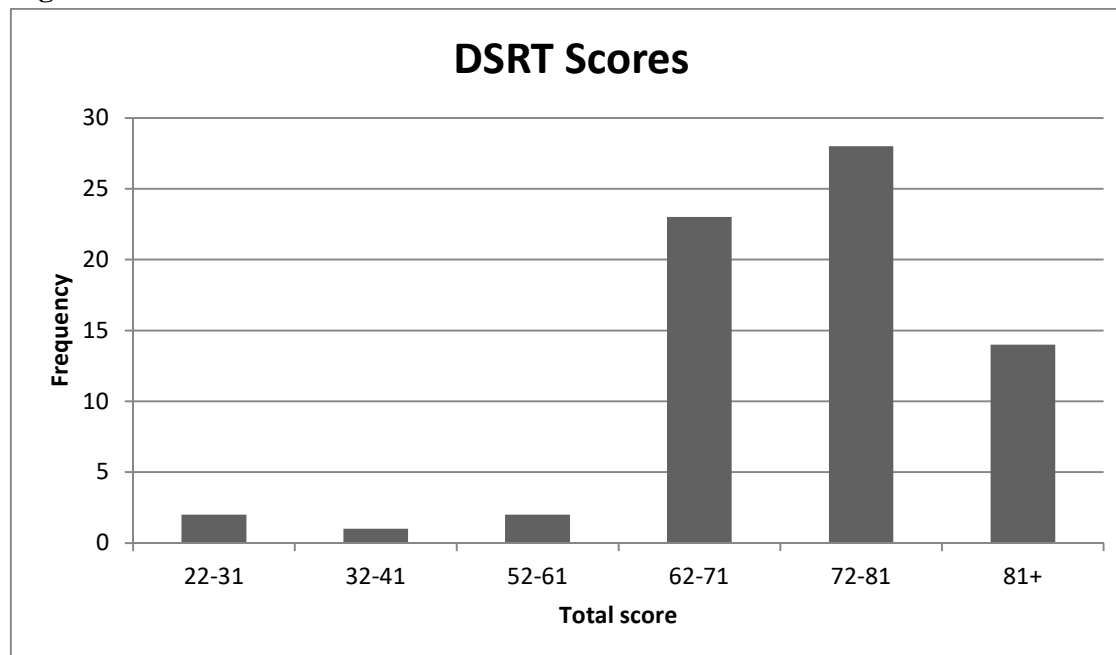


Table 15: Responses to Individual items on the DSRT

	Strongly disagree	Disagree	Agree	Strongly agree
I can describe the etiology of Type I diabetes	6 (8.6)	2 (2.9)	36 (51.4)	26 (37.1)
I can describe the etiology of Type II diabetes	4 (5.7)	3 (4.3)	37 (52.9)	26 (37.1)
I can describe the basic treatment plan for Type I diabetes	4 (5.7)	1 (1.4)	39 (55.7)	26 (37.1)
I can describe the basic treatment plan for Type II diabetes	4 (5.7)	3 (4.3)	40 (57.1)	23 (32.9)
I can identify the nursing needs of the diabetic patient undergoing surgery	3 (4.3)	2 (2.9)	39 (55.7)	26 (37.1)
I can manage the nursing care of a diabetic experiencing mild hypoglycemia	3 (4.3)	1 (1.4)	22 (31.4)	44 (62.9)
I can manage the nursing care of a diabetic with a loss of consciousness	2 (2.9)	1 (1.4)	37 (52.9)	30 (42.9)
I can interpret urine results for a diabetic	5 (7.1)	6 (8.6)	35 (50.0)	24 (34.3)
I can instruct a diabetic on self-care management for a “sick day”	4 (5.7)	7 (10.0)	36 (51.4)	23 (32.9)
I can describe the action and effect of insulin	3 (4.3)	4 (5.7)	36 (51.4)	27 (38.6)
I can list the steps of the procedure for administering insulin	3 (4.3)	4 (5.7)	18 (25.7)	45 (64.3)
I can describe the action and effect of oral hypoglycemic agents	2 (2.9)	12 (17.1)	41 (58.6)	15 (21.4)
I can assess the diabetic for the development of diabetic ketoacidosis	4 (5.7)	3 (4.3)	40 (57.1)	23 (32.9)
I can explain how stress affects diabetes control	3 (4.3)	16 (22.9)	39 (55.7)	12 (17.1)
I can identify the long-term complications associated with diabetes	2 (2.9)	1 (1.4)	22 (31.4)	45 (64.3)

	Strongly disagree	Disagree	Agree	Strongly agree
I can explain how exercise affects diabetes control	5 (7.1)	4 (5.7)	32 (45.7)	29 (41.4)
I can describe the diet recommended for Type I diabetes	3 (4.3)	6 (8.6)	34 (48.6)	27 (38.6)
I can describe the diet recommended for Type II diabetes	3 (4.3)	2 (2.9)	43 (61.4)	22 (31.4)
I can perform one method of blood glucose monitoring	3 (4.3)	2 (2.9)	17 (24.3)	48 (68.6)
I can instruct a diabetic on daily personal care	3 (4.3)	1 (1.4)	21 (30.0)	45 (64.3)
I can identify three sites for insulin administration	3 (4.3)	0 (0.0)	10 (14.3)	57 (81.4)
I can manage the nursing needs of the diabetic patient experiencing hyperglycemia without ketosis	2 (2.9)	1 (1.4)	28 (40.0)	39 (55.7)

Most respondents either agreed or strongly agreed to have sufficient knowledge and skills stated in the DSRT. The content areas covered included: etiology of diabetes, basic treatment of diabetes, hypoglycemia, hyperglycemia, diabetes and surgery, diet in diabetes, diabetic emergencies, diabetic ketoacidosis, glucose monitoring, insulin administration, oral hypoglycemic agents, effects of stress and exercise on diabetes control, urine glucose testing and sick-day guidelines.

10.4.3 Actual Knowledge on Diabetes Mellitus among Nurses

Nurses' actual knowledge on diabetes mellitus was assessed using the Diabetes Basic Knowledge Test (DBKT). They had mean (SD) score of 26.96 (4.64) points, with a median score of 27.5 points. This translates to a mean percentage score of 59.9%. The lowest observed score was 15 points (33.3%), while the highest observed score was 36 points (80%) (Fig 7). The possible scores for the tool are 0 (lowest possible score) to 45 (highest possible score).

Figure 7: Nurses Scores in the DBKT

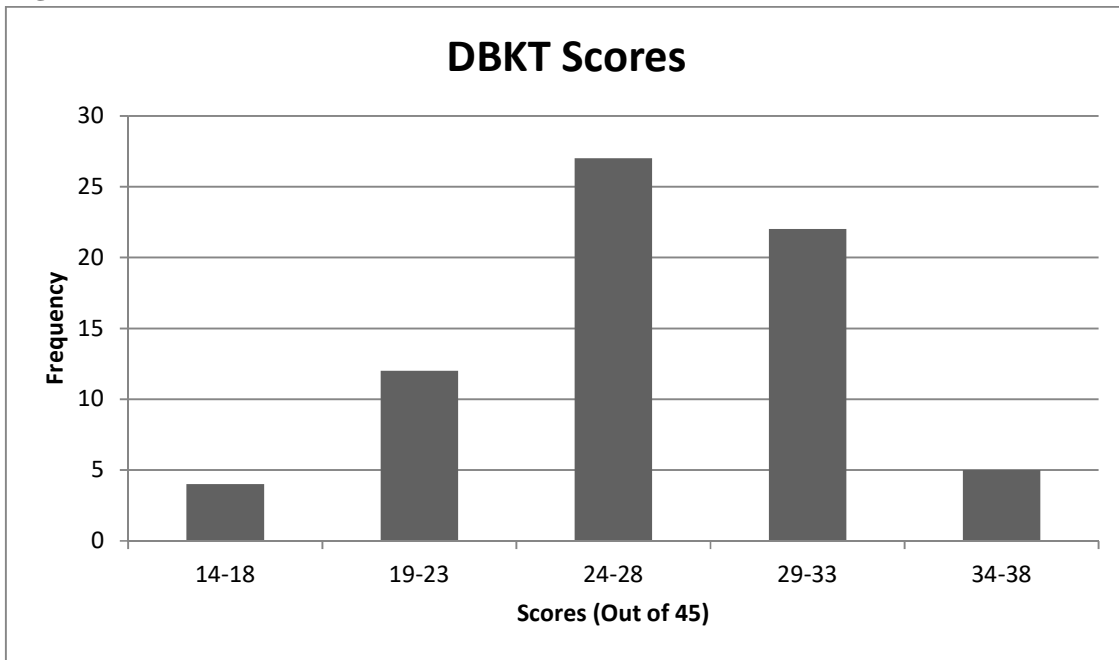


Table 16: Percentage of Correct Responses to Individual DBKT Questionnaire Items

Correct answers (underlined and bolded)	Answered correctly, n (%)
<i>Etiology and management of Type 1 diabetes</i>	
Etiology of Type 1 diabetes is <u>autoimmune, viral or toxic destruction of the beta cells</u>	28 (40.0)
In management of Type 1 diabetes <u>insulin injections are necessary to maintain life</u>	60 (85.7)
<i>Etiology and management of Type II diabetes</i>	
Etiology of Type II diabetes is <u>frequently associated with obesity and resistance to insulin</u>	54 (77.1)
Management of Type II diabetes involves <u>a controlled diet and exercise program</u>	49 (70.0)
<i>Insulin</i>	
Insulin <u>causes blood glucose to decrease</u>	64 (91.4)
Insulin <u>transports glucose across cell membrane for use by the cells and enhances the formation of proteins from amino acids</u>	34 (48.6)

The correct sites for subcutaneous insulin administration: <u>abdomen, top outer area of the thighs, and the upper outer area of the arms</u>	44 (62.9)
<i>Diabetes monitoring</i>	
If a known diabetic is found unresponsive, assumption that the person's blood glucose <u>may be very low</u> should guide your initial actions	58 (82.9)
Normal fasting blood glucose level can best be described as <u>between 3.8 and 6.6 mmol/L</u>	62 (88.6)
The accuracy and precision of tests obtained with most of the blood glucose monitoring strips is affected by <u>size and placement of the blood sample on reagent pad, timing of the test, method of removal of blood from the reagent pad, and the patient's hematocrit level</u>	7 (10.0)
A negative urine glucose test indicates that the blood glucose level in a diabetic with a normal renal threshold is <u>less than 10 mmol/L</u>	26 (37.1)
<u>Glycosylated hemoglobin</u> can determine the patient's average blood glucose over an extended period of time	42 (60.0)
One of the best reasons for utilizing blood glucose monitoring rather than urine testing is that <u>urine retention and changes in kidney function can increase the lag time between blood glucose rise and spillover of glucose into the urine</u>	30 (42.9)
A "double voided" urine specimen can best be described as <u>urine that is collected and tested 30 to 60 minutes after the bladder has been emptied</u>	24 (34.3)
Well controlled diabetics should always check their urine for ketones <u>whenever urine glucose is 2% or blood glucose is greater than 13.3 mmol/L</u>	24 (34.3)
A diabetic who has been showing 2% urine glucose or blood glucose greater than 13.3mmol/L for two consecutive days and now has positive ketone urine tests should <u>call the doctor, continue to test urine/blood every four hours or as directed by a physician and continue insulin or oral hypoglycemic medication</u>	48 (68.6)
<i>Diabetes pharmacology</i>	
The maximum effect (peak) of regular insulin occurs <u>2-4 hours after injection</u>	55 (78.6)
The maximum effect (peak) of both NPH and Lente insulin occurs <u>8-12 hours after injection</u>	42 (60.0)

Insulin that is PRESENTLY being used should be stored <u>at room temperature and away from excess light</u>	45 (64.3)
A diabetic who contaminates the needle while preparing an insulin injection should <u>dispose of the needle even if this means disposing of the insulin and syringe and starting preparation from the beginning</u>	51 (72.9)
When short-acting (regular) and intermediate-acting (NPH) are ordered to be given by injection at the same time, the nurse should <u>mix them in the same syringe drawing up the short-acting insulin first</u>	4 (5.7)
The duration of action of chlorpropamide (Diabinese) is <u>24-60 hours</u>	3 (4.3)
<u>Allergic reaction</u> is NOT a reported side effect of oral hypoglycemic agents	14 (20.0)
<i>Diabetes complications</i>	
A symptom of hypoglycemia (low blood sugar) is <u>nervousness</u>	40 (57.1)
A symptom of hyperglycemia (high blood sugar) is <u>frequent urination</u>	59 (84.3)
<u>Skipping a meal</u> is one cause of hypoglycemia (low blood sugar) in a diabetic who is taking insulin or oral hypoglycemic agents	65 (92.9)
<u>Infection</u> is one cause of hyperglycemia (high blood sugar)	61 (87.1)
One symptom associated with diabetic ketoacidosis (coma) is <u>acetone (fruity) breath</u>	62 (88.6)
One cause of diabetic ketoacidosis (diabetic coma) in the Type 1 diabetic is <u>failure to take daily insulin dose</u>	59 (84.3)
Illness (for example, a “sick day”) <u>causes an increase on a diabetic’s insulin requirements</u>	48 (68.6)
In general, changes in the pattern of insulin administration for the diabetic undergoing surgery might include <u>discontinuing all subcutaneous insulin the day of surgery and infusing long-acting insulin intravenously at a constant drip</u>	19 (27.1)
Long term complications are associated with diabetes include <u>eye changes, renal and cardiovascular changes, and nervous system changes</u>	51 (72.9)
The effect of physical & emotional stress on diabetes control includes <u>the secretion of stress hormones that cause an elevation in blood glucose levels</u>	56 (80.0)

It is necessary that diabetics pay special attention to proper care of their feet because <u>persons with diabetes often have changes in sensation and poor circulation to their feet</u>	66 (94.3)
A diabetic has a small corn on the right foot and wants it removed. He/she should be <u>referred to a podiatrist</u>	41 (58.6)
A diabetic just received an abrasion on the left leg. He/she should <u>wash gently with mild soap and water, apply a small amount of iodine and observe carefully for any signs of infection</u>	31 (44.3)
Exercise <u>decreases blood glucose</u> when the diabetic's glucose is less than 16.6mmol/L?	54 (77.1)
Increased exercise <u>increases the need for food</u> if the patient has a well-controlled Type 1 diabetes?	45 (64.3)
The most appropriate INITIAL action to take for the Type 1 diabetic who is having a hypoglycemic reaction (low blood sugar) is to <u>drink 4 oz. (120ml) of orange juice with 2 teaspoons of sugar.</u>	25 (35.7)
<i>Diet in diabetes</i>	
A Type 1 diabetic does not like one of the food items on the meal tray. The best action for the nurse to take is to <u>explain to the patient that the diabetic diet is carefully calculated and that the dietician will be consulted about exchanging this item for another</u>	57 (81.4)
The main objective when developing a meal plan for the person with Type II diabetes is <u>a low-carbohydrate, high-protein diet that will prevent fluctuations in blood glucose levels</u>	28 (40.0)
A diabetic is calculated for <u>carbohydrates, protein and fat</u>	42 (60.0)
The main objective when developing a meal plan for the person with Type 1 diabetes is <u>an individualized diet plan that will maintain euglycemia and normal growth and development to include foods from the 4 groups while ensuring that calories are evenly distributed</u>	54 (77.1)
A diabetic has refused an evening snack of fruit juice and ½ of a sandwich. You should substitute with <u>a piece of fresh fruit, 1 oz. (30ml) of peanut butter and 4 crackers</u>	38 (54.3)
<i>Somogyi phenomenon</i>	
Demonstration of the <u>somogyi or rebound phenomenon:</u> -urine test results for glucose and ketones that jump from negative/negative to 1-2% /moderate to large in just a few hours, -wide fluctuations in blood glucose levels over several hours often	18 (25.7)

unrelated to meals, -2% glycosuria occurring upon wakening; preceded by nocturnal sweating, nightmares or headache	
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There was sufficient knowledge on etiology of type II diabetes, and principles of management of both type 1 and type II diabetes. However, respondents had insufficient knowledge on etiology of type 1 diabetes. Knowledge on effects of insulin on blood glucose, pharmacology of insulin, and sites of insulin injection was sufficient. However, knowledge on the mechanism of insulin action was insufficient. Knowledge on clinical identification of hypoglycemia, hyperglycemia, DKA, level of normal fasting blood glucose level, diet in diabetes, and diabetes complications was sufficient.

10.4.4 Correlation between Perceived and Actual nurses knowledge in diabetes management

The relationship between perceived level and actual level of knowledge was analysed using Pearson's correlation coefficients. Analysis of the scores of the DSRT and the DBKT revealed that there was a very low positive correlation ($r = 0.093$, $p = 0.443$), indicating that nurses' perceived knowledge of diabetes was only slightly positively correlated to actual knowledge, but this was not statistically significant. This showed significant gaps between nurses' perceived and actual diabetes-related knowledge.

11.0 DISCUSSION

Few audits have been done in assessment of DKA management worldwide; most of these have been in the UK. There are no local studies on the implementation of DKA management guidelines and assessment of barriers in implementation of standard management.

The demographic data showed a slight male to female preponderance; with majority of the patients being young (mean (SD) age 29.7 (12.6) years). This is similar to worldwide DKA prevalence studies that have shown that generally, the prevalence of DKA decreases with increasing age (8). Majority of the patients had Type 1 diabetes, but a significant proportion (23.8%) had Type 2 diabetes. Newton et al (6) had similar findings when they assessed clinical characteristics of patients admitted with DKA in USA. Zouvanis et al (7) in South Africa found that 55.2% of the patients admitted with DKA had type 2 diabetes.

Majority of the patients (76.2%) were transferred to general wards after management had been initiated in the Accident and Emergency area, while 23.8% were managed in the ICU. For several years, in several institutions worldwide, DKA was preferably managed in an ICU set up.

However, it is important to note that several studies have shown that DKA can safely be managed in the general wards, which have been proven to be non-inferior and have shown equally good outcomes when compared to ICU(22).

Significant delays were noted in patient review by the Senior House Officers (SHOs) or ICU medical doctors. Only an eighth of the patients, (11.9%), were reviewed within 3 hours of arrival at the hospital by the Senior House Officers or ICU medical doctors. The actual reasons for these delays were not documented in this study. It would be good to do qualitative studies to look into reasons why there was a delay in patient review by the SHOs and ICU medical doctors, and address them.

In addition, there were delays in initiation of treatment. Although slightly more than half of the patients received the first bolus of insulin, and had intravenous fluids initiated within 3 hours of arrival at the hospital, only 37.1% had insulin infusion initiated within 3 hours of arrival at the hospital, and only 31.6% of those who needed potassium had potassium supplementation initiated within 3 hours of arrival at the hospital. Notably, although Dawkins et al (50) and Dhatariya et al (52) reported delays in initiation of management, the times reported were significantly less (<1hour) than were found in this study. The DKA management guidelines state that management should be initiated within three hours of patient hospitalization. Delay in initiation of treatment has been associated with poor outcomes(20).

Initial clinical and laboratory assessments were commendable. All (100%) patients had their blood pressure, radial pulse rate, respiratory rate, temperature, capillary blood glucose, full blood count, and urea & electrolytes done. These assessments are accessible to patients regarded as emergency. Majority, 97.6% had a blood gas analysis done, 81% had a urinalysis done, and 90.5% had their Glasgow coma scale recorded.

However, subsequent clinical and laboratory monitoring was found to be suboptimal. Frequency of monitoring in the first 24 hours was analyzed. Patients' vital signs (blood pressure, radial pulse rate, respiratory rate, temperature) were recorded irregularly and infrequently, with only a third (33.3%) having more than 10 recordings in the first 24 hours. Patients' blood gases may have been analyzed infrequently, with majority (71.4%) of the patients having only 1 or 2 analyses in the first 24 hours. In addition, patients' capillary blood glucose may have been analyzed irregularly and infrequently, with only about a 14.3%) of the patients having more than 12 assessments (1-2 hourly CBG monitoring) in the first 24 hours. This was regardless of whether they were on insulin

infusion or not. Urinary ketones for most patients were only assessed at admission, with only 4.8% of the patients having their urinary ketones monitored subsequently. It was beyond the scope of this study to find out why monitoring was infrequent. Reasons may include inadequate staffing of nurses, as was brought out in the key informants' interviews. This inadequate monitoring may have affected treatment decisions, since, during DKA management, decisions are guided by findings of clinical and biochemical analyses during care.

Almost half (45%) of the patients were newly diagnosed diabetics, with DKA as the initial manifestation. In about a quarter, (24%) DKA was presumed to be precipitated by discontinuation of diabetes treatment in patients already known to be diabetic. In these two groups of patients, there was likely severe insulin insufficiency at hospitalization. The most common reason for noncompliance to treatment was financial constraints. Overt infections were identified in some patients, 5% had community acquired pneumonia, 2% had urosepsis, and 2% had acute gastroenteritis. These findings are consistent with those of Otieno et al (15) who found that newly diagnosed diabetes, missed insulin doses and infections were the most common causes or precipitants of DKA in Sub-Saharan Africa. Precipitating causes were not identified in 22% of the patients, but these were all treated empirically with antibiotics.

Management prescriptions for fluids, insulin and potassium were commendable. All (100%) patients had correct type and quantities of IV fluids prescribed for initial resuscitation. However, a significant number (32.1%) of patients did not get prescriptions for dextrose-containing fluids when required (CBG <14 mmol/L). The reasons for omission of this prescription were not documented. Prescriptions for type of intravenous fluids were adhered to in all patients; however there was poor adherence to quantity of fluids, with most patients getting suboptimal amounts. Only 11.9% of the patients received >6 L in the first 24 to 36 hours, which is the presumptive fluid deficit in DKA (26). Insulin was appropriately prescribed for all patients, with 83.3% getting prescriptions for continuous insulin infusion, and 16.7% getting prescriptions for regular subcutaneous insulin boluses. Adherence to insulin prescriptions was observed in 74.3% of the patients on continuous insulin infusion, and all (100%) patients on regular subcutaneous insulin boluses. Adherence to subcutaneous insulin boluses was therefore better than adherence to continuous insulin infusion. Potassium chloride was appropriately prescribed to all the patients who required it. However the prescription was adhered to in approximately 76.3% of the patients who needed it.

The reasons for non-adherence to prescriptions were not documented in this study. However, it is likely that the non-adherence was due to the low staffing of nurses, who are responsible for

administration of the prescribed management. This was brought out in the key informants' interviews, who reported low numbers of nursing staff especially in the general wards.

During ongoing management, only 1 (2.4%) patient developed hypoglycemia (<3 mmol/L), and the appropriate dextrose solution was prescribed and administered. Higher hypoglycemia rates were found in other audits; 40% by Crasto et al (48) and 27% by Dhatariya et al (52) in the UK. This may be related to the intensiveness of insulin management observed in these audits.

Notably, almost half (47.6%) of the patients had persistent hyperglycemia, with RBS >14mmol/L in the first 24 hours. In addition, majority (76.2%) of the patients remained hypokalemic (K^+ <3.5 mmol/L) in the first 24 hours. It is important to note that DKA is associated with both morphological and functional brain changes in affected individuals(21). The persistent hyperglycemia seen in our patients may have predisposed them to increased risk of these adverse neurological consequences associated with DKA. This persistent hyperglycemia and hypokalemia denotes insufficient fluid, insulin, and potassium management. This is not surprising when clinical monitoring was noted to be insufficient as well. This is because management decisions during DKA care are guided by findings of clinical and biochemical analyses, as observed during care.

Supportive management is another important component of DKA management. Urine output was charted in about two-thirds (64.3%) of the patients, yet patients' ability to produce urine impacts on management, especially IV fluids and potassium replacement, and could indicate renal damage. The reasons for insufficient supportive care were again not documented. It is likely that this was also due to the low numbers of nursing staff especially in the general wards.

The median time to DKA resolution after admission was 59 hours. This is significantly longer than observed in other studies, which recorded DKA resolution times of less than 24 hours; Hara et al (41) recorded DKA resolution time of 13.5 hours, Maghrabi et al (43) recorded DKA resolution time of 8.5 hours. Only 1 (2.6%) patient's DKA resolved in less than 24 hours after admission. Inadequate monitoring was again observed with regard to confirmation of DKA resolution. 53.8% of the patients had blood gas analyses done in order to objectively identify DKA resolution. However, 46.2% of the patients did not have objective confirmation of DKA resolution, but DKA was presumed to have resolved when capillary blood glucose (CBG) dropped to below 14mmol/L, which is not always true, and is almost misleading (20). However, it should be noted that CBG level guides insulin replacement therapy which is key in DKA reversal.

There was significant improvement in the all-cause inpatient mortality rate within 2 weeks of admission, which was found to be at 11.9%. This is in comparison to the previous study in KNH by Mbugua et al (11) in 2010 that reported an all-cause mortality rate of 29.8%. The actual causes of death in these patients however remain unknown as post-mortem examination was not followed up, or not done. This improved outcome may be attributed to the recent introduction of guidelines in most wards, as reported by the key informants. There is still a lot of room for improvement however, considering DKA all-cause mortality rates in the developed world are <1% (69).

Some of the characteristics of the patients who died included severe acidosis, where pH was as low as 6.99, severe hyperglycemia, capillary blood glucose levels as high as 43.5 mmol/L, and severe hypokalemia at admission. In terms of management, there were significant delays observed in review by SHO or ICU medical doctor for these patients, with one patient waiting 19 hours before being reviewed. There were also delays in initiation of IV fluids, insulin and potassium for these patients after admission, with one patient waiting almost 20 hours before management was initiated. Most of these patients received insufficient fluids in the first 24-36 hours. Clinical monitoring was also insufficient among these patients. However, similar delays and insufficiencies were observed in all the other patients. Therefore the mortalities cannot be directly linked to these delays and insufficiencies in management.

The doctors displayed an average performance in their knowledge questionnaire, with a mean (SD) score of 11.82 (2.5) points out of a possible score of 20 points. The pass rate for this questionnaire was arbitrarily set at 60%. The mean percentage score of the doctors assessed was 59.1%. This was much lower than the scores from other studies using the same tool. Rubin et al (62) in the USA recorded a mean score of 69% among internal medicine residents. Ahmed et al (60) in Pakistan recorded a mean score of 64% among internal medicine residents. Most of the doctors had sufficient knowledge on various aspects of DKA management, including use of insulin infusion, type of intravenous fluids to use depending on level of capillary blood glucose, and potassium monitoring during DKA management. The areas of sufficient knowledge were consistent with the accuracy of prescriptions for DKA patients observed in the audit of patient management. However they had insufficient knowledge on areas such as fundamentals of diabetes diagnosis, and glucose and blood pressure targets in a diabetic. They also had insufficient knowledge on certain aspects of insulin pharmacology and preparation of a diabetic patient for surgery.

The nurses had high level of perceived diabetes knowledge, scoring a mean (SD) of 72.46 (12.01), out of a possible 88 points. This perception was consistent in all the content areas covered in the

Diabetes Self Report Tool (DSRT), including etiology of diabetes, basic treatment of diabetes, hypoglycemia, hyperglycemia, diabetes and surgery, diet in diabetes, emergencies, diabetic ketoacidosis, glucose monitoring, insulin administration, action of oral hypoglycemic agents, diabetes and exercise, diabetes and stress, urine testing, and diabetes personal care.

However their actual knowledge on diabetes was found to be insufficient; the mean (SD) score on the Diabetes Basic Knowledge Test (DBKT) was 26.96 (4.64) out of a possible score of 45. This translates to a mean score of 59.9%, which is way below the overall pass rate of this questionnaire set at 70% by the primary author. They had insufficient knowledge on etiology of type 1 diabetes. However their knowledge on etiology of type II diabetes, principles of management of both type 1 and type II diabetes, clinical identification of hypoglycemia, hyperglycemia, DKA, diet in diabetes, and diabetes complications was sufficient. Therefore, the nurses appeared competent in inpatient diabetes care.

There were significant gaps between nurses' perceived and actual diabetes-related knowledge. Meaning they had a high perception of diabetes related knowledge that was not at par with their actual diabetes related knowledge.

12.0 SUMMARY AND CONCLUSION

This study demonstrated lack of adherence to guidelines, in terms of delays in initiation of management, insufficient administration of fluids, insulin and potassium, and inadequate monitoring. This may have contributed to the prolonged DKA resolution times and the high all-cause mortality rate. Areas to improve on, therefore, are prompt patient review and initiation of management, consistent patient monitoring during care, and guideline adherence in terms of fluid, insulin and potassium treatment.

Healthcare workers, both doctors and nurses, had sufficient knowledge on various aspects of DKA management. However they had insufficient knowledge on certain aspects of diabetes pharmacology and glucose dynamics. The areas of insufficient diabetes related knowledge are important areas to focus on in rolling educational programs for the healthcare workers.

13.0 RECOMMENDATIONS

Supervision of the implementation of a guideline-based approach to DKA management in KNH to ensure optimal fluid, insulin, and potassium management, and adequate monitoring.

Further prospective studies to assess DKA outcomes after implementation of a guideline approach in all clinical areas at the Kenyatta National Hospital.

Availing bedside blood glucose testing meters and urinary ketone testing meters in all treatment areas, to ensure adequate laboratory monitoring of patients with DKA.

Teamwork in patient management.

Qualitative studies on reasons for delayed patient review by Senior House Officers and addressing these reasons.

Organization of available health care workers in KNH such that acute emergencies such as DKA are prioritized for review and acute management.

Introduction of rolling educational programs for all doctors and nursing staff on key aspects of diabetes management.

14.0 STRENGTHS

The study has brought to light the deficiencies in DKA management in KNH, most of which can be addressed.

Most of the doctors interviewed are still in training and are therefore available for update of diabetes related management.

15.0 LIMITATIONS

Interventions not recorded were considered not done. This may have introduced random bias in case of omission of record keeping.

Observer effect: interviewed key informants might have changed their usual practice of patient management because they were aware of the ongoing audit. The resultant modified practice may have resulted in better adherence to guidelines than would normally be the case. However the other healthcare workers were not affected because they were not aware of the audit.

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17.0 APPENDICES

APPENDIX 1: PARTICIPANT INFORMATION

My name is Dr. Daphine Kerubo Abunga, a post graduate student of Internal Medicine at the University of Nairobi. I am the principal investigator (PI) in a study to audit the management of diabetic ketoacidosis (DKA) at the Kenyatta National Hospital. Diabetic ketoacidosis is a complication of Diabetes Mellitus. I will compare the management as recorded in the file with standard DKA management guidelines. This will help in identifying challenges that hinder provision of standard management as recommended in the guidelines.

Knowledge on diabetes and DKA by healthcare workers and structures of DKA management in each study site will also be assessed.

Below is a summary of what to expect should you choose to participate in the study. You are encouraged to ask for clarification of any point that is not clear to you. After reading and understanding the information provided, you will be required to sign an informed consent form. Parents and guardians/next of kin will sign on behalf of participants aged less than 18 years, or participants unable to give consent due to disease severity. Participants aged less than 18 years will also be required to sign assent forms prior to their inclusion into the study.

Participation

Participation is voluntary and you have the right to withdraw at any point. You will not be victimized if you refuse to participate in this study, and you will still get management.

Procedures

A brief medical history will be taken, including your age, sex, type of diabetes, duration of diabetes, current medication, and previous admission for DKA. The PI will then assess all the management procedures administered by going through your notes and charts.

Healthcare workers (doctors and nurses) will be assessed on their knowledge of diabetes and DKA. Key informants will give information on available structures for DKA management.

Risks

There are no risks (physical or financial) in this study.

Benefit

You will participate in increasing information on DKA management in Kenyatta National Hospital.

Confidentiality

Data gathered will be kept locked in a secure location at all times and only those directly involved in the research will have access to them. No identifying information will be used on the data collection form or during data analysis and presentation.

Compensation

There is no compensation, either monetary or otherwise, for participation in this study.

Enquiries

Any enquiries about the study should be directed to the following contact persons

1. DR. DAPHINE KERUBO ABUNGA
DEPARTMENT OF CLINICAL MEDICINE AND THERAPUTICS
UNIVERSITY OF NAIROBI,
Mobile: 0725 886336. **OR**

2. PROF. C.F. OTIENO
ASSOCIATE PROFESSOR OF MEDICINE
SPECIALIST DIABETOLOGIST
DEPARTMENT OF CLINICAL MEDICINE AND THERAPEUTICS
UNIVERSITY OF NAIROBI
P.O BOX 30197-00100, NAIROBI.
TEL: 0722752558. **OR**

3. PROF. J. K. KAYIMA
ASSOCIATE PROFESSOR OF MEDICINE
SPECIALIST NEPHROLOGIST
DEPARTMENT OF CLINICAL MEDICINE AND THERAPEUTICS
UNIVERSITY OF NAIROBI
P.O. BOX 30197-00100, NAIROBI.
TEL: 0733730650. **OR**

4. DR. J. O. MECHA
LECTURER AND CONSULTANT CHEST PHYSICIAN
DEPARTMENT OF CLINICAL MEDICINE AND THERAPEUTICS
UNIVERSITY OF NAIROBI
P.O. BOX 30197-00100, NAIROBI.
TEL: 0722842741. **OR**

5. CHAIRPERSON, KNH/UON ETHICAL REVIEW COMMITTEE,
TEL: 020-2726300 EXT 44355.
P.O. Box 20723, Nairobi.

Before I involve you in my study, I request you to sign the consent/assent form below.

KIAMBATISHO 1- FOMU INAYOELEZA IDHINI

Utangulizi

Mimi ni Dkt. Daphine Kerubo Abunga, kutoka Chuo Kikuu cha Nairobi. Kwa sasa nasomea uzamili katika Tiba ya Ndani. Kama sehemu ya masomo yangu ya uzamifu, ninafanya uchunguzi ambao utathmini matibabu ya Dharura ya ugonjwa wa kisukari katika Hospitali kuu ya Kenyatta na kulinganisha matibabu haya na itifaki.

Haki yako kama mshiriki katika utafiti huu

- Ushiriki wako katika utafiti huu ni wa kujitolea, na una uhuru wa kujiondoa wakati wowote.
- Utaonyesha idhini yako kwa kutia saina/ridhaa kabla ya kushiriki katika utafiti huu.
- Hautadhulumiwa hata ukikataa kushiriki katika utafiti huu.
- Una uhuru wa kuuliza maswali kabla ya kutia sahihi ya idhini na wakati wa utafiti.
- Maswala yote yatahifadhiwa kwa siri wakati wote.

Habari zitakazokusanywa zitatumika tu kwa madhumuni ya utafiti huu.

Hasara za ushiriki

Hakuna hasara yoyote utakayopitia au kupata.

Hakutakuwa na gharama zitakazotumika na wewe iwapo utaamua kujiunga na utafiti huu.

Manufaa ya kushiriki

Mwishoni mwa utafiti huu, nitawasilisha matokeo ya utafiti katika idara ya Tiba ya Ndani katika Chuo Kikuu cha Nairobi.

Habari zozote muhimu zitakazotokana na utafiti na ambazo zitafanya malezi kuwa bora, walezi watafahamishwa ili hatua mwafaka ichukuliwe.

Siri

Habari zote zitakazokusanywa wakati wa utafiti zitahifadhiwa kwa siri. Ni watafiti pekee ndio wanaoweza kufikia habari za kibinafsi. Habari zitakazokusanywa zitaandikwa na kuainishwa bila kutaja washiriki.

Fidia

Hakuna shirika la fedha kwa ushiriki wako.

Ikiwa una swali lolote wakati wa utafiti, unaweza kuwasiliana na wafuatao:

1. DKT. DAPHINE KERUBO ABUNGA
IDARA YA MAFUNDISHO YA UDAKTARI NA MATIBABU YA MAGONJWA
CHUO KIKUU CHA NAIROBI
Simu ya mkono: 0725886336. *AU*

2. PROF. C.F. OTIENO
PROFESA NA MTAALAMU WA MATIBABU YA KISUKARI
IDARA YA MAFUNDISHO YA UDAKTARI NA MATIBABU YA MAGONJWA
CHUO KIKUU CHA NAIROBI
Simu ya mkono: 0722752558. *AU*

3. PROF. J. K. KAYIMA
PROFESA NA MTAALAMU WA MATIBABU YA FIGO
IDARA YA MAFUNDISHO YA UDAKTARI NA MATIBABU YA MAGONJWA
CHUO KIKUU CHA NAIROBI
Simu ya mkono: 0733730650. *AU*

4. DR. J. O. MECHA
MTAALAMU WA MATIBABU YA KIFUA
IDARA YA MAFUNDISHO YA UDAKTARI NA MATIBABU YA MAGONJWA
CHUO KIKUU CHA NAIROBI
Simu ya mkono: 0722842741. *AU*

5. MWENYEKITI, KNH/UON KAMATI INAYOSHUGHULIKIA MAADILI,
Nambari ya simu: 020-2726300 EXT 44355.
S.L.P. 20723, Nairobi.

APPENDIX 2: CONSENT /ASSENT FORM

I.....have read the participant information above and/or it has been explained to me by Dr. Daphine Kerubo Abunga or a research assistant. I voluntarily agree to participate in the study, ‘An audit of the management of diabetic ketoacidosis at the Kenyatta National Hospital’.

CONSENT (Parents, guardians/next of kin and Participants aged more than 18 years)

SIGNED/THUMBPRINT.....

DATE.....

ASSENT (Participants aged less than 18 years)

SIGNED/THUMBPRINT.....

DATE.....

INVESTIGATOR / RESEARCH ASSISTANT STATEMENT

I have provided an explanation of the purpose and implications of the above research study to participants.

SIGNED.....

DATE.....

For any further clarification, you may contact

Dr. Daphine Kerubo Abunga, at Tel No: 0725886336

Or: Professor C.F. Otieno, at Tel No.0722752558

Or: Professor J. K. Kayima, at Tel No. 0733730650

Or: Dr. J.O. Mecha, at Tel No. 0722 842741

Or: KNH/ERC (Kenyatta National Hospital/Ethics & Review Committee) TEL: 020-2726300 EXT 44355. P.O. Box 20723, Nairobi.

KIAMBATISHO 2: FOMU YA IDHINI/KUBALI

Mimi.....

Nimesoma fomu ya maelezo na nimepewa maelezo yanayofaa kuhusu utafiti wa Dkt. Daphine Kerubo Abunga/msaidizi wake. Nimejitolea kwa idhini yangu kushiriki katika utafiti huu ambao utatathmini matibabu ya Dharura ya kisukari katika hospitali kuu ya Kenyatta.

RIDHAA (Wazazi, walezi na washiriki walio zaidi ya miaka 18)

SAHIHI /ALAMA YA KIDOLE

TAREHE.....

KUTIWA SAINI (Washiriki walio chini ya miaka 18)

SAHIHI/ALAMA YA KIDOLE

TAREHE.....

KAULI YA MCHUNGUZI

Mimi, Mchunguzi Mkuu, nimemuelimisha mshiriki wa utafiti kuhusu lengo kuu la utafiti na kinachodokezwa na utafiti huu.

SAHIHI.....

TAREHE.....

Kwa maelezo zaidi unaweza kuwasiliana na:

Dkt. Daphine Kerubo Abunga, katika nambari ya simu: 0725 886336.

Au: Profesa C.F. Otieno, katika nambari ya simu: 0722 752558

Au: Profesa J. K. Kayima, katika nambari ya simu. 0733730650

Au: Dkt. J.O. Mecha, katika nambari ya simu: 0722 842741

Au: MWENYEKITI, KNH/UON KAMATI INAYOSHUGHULIKIA MAADILI

Nambari ya simu: 020-2726300 EXT 44355

APPENDIX 3: STUDY PROFORMA – ASSESSMENT OF PATIENT MANAGEMENT

STUDY INVESTIGATOR:.....

DATE OF ASSESSMENT:.....

STUDY NO:.....

RECORD DATE AND TIME OF PATIENT’S ARRIVAL TO HOSPITAL

(dd/mm/yy).....

(hh:mm).....

DEMOGRAPHICS/PATIENT DETAILS

1. Date of birth (dd/mm/yyyy): / /
2. Age (yrs):
3. Gender:
 - Male
 - Female
4. Diabetes mellitus type
 - Type 1
 - Type 2
5. Age at diagnosis of Diabetes.....
6. Duration of Diabetes follow up
 - < 6 months
 - 6 months -1yr
 - 1-5yrs
 - 5-10yrs
 - >10yrs

7. Other chronic conditions

-
-
-

8. Current treatment (Drugs and dosages):

-
-
-
-
-

9. Are you compliant to the above treatment? Yes.....No.....

If no, kindly explain why

.....
.....
.....
.....
.....

10. How many previous admissions for DKA have you had in the last 12 months?.....

11. Education level

- None
- Standard 1-5
- Standard 6-8
- Secondary
- University/ College

12. Occupation/Employment

- Unemployed
- Formally employed
- Informal sector
- Self-employed
- Student

13. Marital status

- Never married
- Married
- Separated
- Divorced
- Widowed

14. Living arrangement

- Alone
- With others

DIAGNOSIS OF DKA

Was the diagnosis confirmed according to diagnostic criteria? <input type="checkbox"/> Yes <input type="checkbox"/> No		
a) Blood ketones mmol/L	DIAGNOSIS of DKA: Ketonaemia > 3.0mmol/L or significant ketonuria (more than 2+ on standard urine sticks) Blood glucose > 11.0mmol/L or known diabetes mellitus Bicarbonate(HCO ₃) < 15.0 mmol/L and/or arterial pH < 7.3	Was treatment area?
b) Urine ketones		a) <input type="checkbox"/> Level 1? (eg general ward area)
c) Blood glucosemmol/L		b) <input type="checkbox"/> Level 2? (eg high dependency area)
d) pH		c) <input type="checkbox"/> Level 3? (eg ICU)
e) Bicarbonatemmol/L		d) <input type="checkbox"/> Acute medical unit?(eg RRB)
	e) <input type="checkbox"/> A&E	
	f) <input type="checkbox"/> Other? (please state)	

DKA SEVERITY (Tick appropriately)

<h3 style="margin: 0;">MILD DKA</h3> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Serum glucose >13.8mmol/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Arterial pH 7.24-7.3</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Serum bicarbonate 15-18mEq/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Anion gap >10mEq/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Mental status Alert</div>	<h3 style="margin: 0;">MODERATE DKA</h3> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Serum glucose >13.8mmol/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Arterial pH 7-<7.24</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Serum bicarbonate 10-15mEq/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Anion gap >12mEq/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Mental status Alert/Drowsy</div>	<h3 style="margin: 0;">SEVERE DKA</h3> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Serum glucose >13.8mmol/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Arterial pH <7</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Serum bicarbonate <10mEq/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Anion gap >12mEq/L</div> <div style="border: 1px solid black; padding: 5px; margin: 5px; width: fit-content; margin-left: auto; margin-right: auto;">Mental status Stupor/Coma</div>
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ASSESSMENT OF PATIENT MANAGEMENT

Was the patient seen by ICU or senior medical review within 12 hours?

a) Yes b) No c) Not recorded

A. HOUR 1: IMMEDIATE MANAGEMENT UPON DIAGNOSIS: 0-60 MINUTES

(Please tick appropriately. Y=Yes, N=No, NR=Not recorded)

ASSESSMENTS DONE?	Y	N	NR
Rapid ABC (Airway, Breathing, and Circulation)			
Clinical assessment			
Blood pressure?			
Pulse?			
Oxygen saturation?			
Respiratory rate?			
Temperature?			
Glasgow Coma Scale?			
Evidence of a full history?			
Full clinical examination?			

Initial Investigations	Y	N	NR
Capillary blood glucose?			
Venous plasma glucose?			
Urinalysis?			
Arterial/Venous blood gases?			
Full blood count?			
Urea and electrolytes?			

DKA pathway – Immediate Care	Time started (hh:mm)	Yes	No	NR
a) Was a stat dose of soluble insulin given?(0.1-.0.5U/kg IV)		<input type="checkbox"/>	<input type="checkbox"/>	
b) Was IV sodium chloride 0.9%, or Hartmann’s fluid given?		<input type="checkbox"/>	<input type="checkbox"/>	
c) Was IV fixed rate insulin infusion given?(0.1U/kg/hr)		<input type="checkbox"/>	<input type="checkbox"/>	
d) Was potassium management in accordance with guidelines?		<input type="checkbox"/>	<input type="checkbox"/>	
e) Admission potassium mmol/L				
<p>Potassium replacement guide (KCl in 0.9% Sodium chloride): Serum K+>5mmol/L (or patient anuric) – omit KCl Serum K+ 4.1-5.0mmol/L – 20mmol KCl per litre Serum K+ 3.1-4.0 mmol/L – 30mmol/L Kcl per litre Serum K+ <3mmol/L – 40mmol Kcl per litre</p>				

B. ONGOING MANAGEMENT 1 TO 24 HOURS

(Please tick appropriately. Y=Yes, N=No, NR=Not recorded)

Other investigations done (Ix for precipitating causes)?	Y	N	NR
Electrocardiogram?			
Blood cultures?			
Chest radiograph?			
Urine culture?			
Serum amylase and lipase?			

Were there any precipitating causes for DKA identified? If so what were they?

.....

.....

.....

Other interventions considered?	Y	N	NR
Urinary catheterization?			
NGT insertion?			
Central line?			
DVT prophylaxis?			

Were the following parameters measured at the following intervals?						
Venous	a. pH	b. Potassium	c. Bicarbonate		d. Capillary Blood glucose (hourly)	e. Urine ketones (2 hourly)
1 hr					<input type="checkbox"/> Yes / <input type="checkbox"/> No	<input type="checkbox"/> Yes / <input type="checkbox"/> No
2 hrs						
4 hrs					f. Vital Signs (hourly)	
6 hrs						
12 hrs						
18 hrs					<input type="checkbox"/> Yes / <input type="checkbox"/> No	
24 hrs						

What was the lowest recorded potassium during this time?.....(mmol/L)

DKA Pathway 1-24 hours (ongoing management)	Yes	No	NR
a. Was IV NaCl or Hartmann's replacement given as per guidelines?	<input type="checkbox"/>	<input type="checkbox"/>	
b. Was potassium replaced as per guidelines?	<input type="checkbox"/>	<input type="checkbox"/>	
c. Did potassium levels remain within the reference range (3.5 – 5.0.mmol/L)?	<input type="checkbox"/>	<input type="checkbox"/>	
d. Was an IV insulin infusion (fixed rate continued as per guidelines)?	<input type="checkbox"/>	<input type="checkbox"/>	
e. Was an appropriate monitoring regimen established as per guidelines?	<input type="checkbox"/>	<input type="checkbox"/>	

DKA Pathway 1-24 hours (ongoing management) - continued	Yes	No	NR
a. Was a urine output documented?	<input type="checkbox"/>	<input type="checkbox"/>	
b. Was 5% glucose commenced when the CBG fell to <14mol/L?	<input type="checkbox"/>	<input type="checkbox"/>	
c. Did a review of fluid balance occur with the rate of IV sodium chloride 0.9% amended if appropriate?	<input type="checkbox"/>	<input type="checkbox"/>	
d. If patient was taking a long acting insulin prior to admission, was this continued?	<input type="checkbox"/>	<input type="checkbox"/>	
e. Was the metabolic response to treatment reviewed? <i>if so were appropriate changes in treatment made?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
f. After the confirmation of a diagnosis of DKA, did the patient become hypoglycaemic ?	<input type="checkbox"/>	<input type="checkbox"/>	
<i>i) If so when? (date / time)</i>			
<i>ii) What was the lowest recorded capillary blood glucose during the first 24 hours? (mmol/L)</i>			
<i>iii) How long did the patient remain hypoglycaemic in total(hours/minutes)</i>			

RESOLUTION OF DKA

(NA – not applicable; NR – not recorded)

DKA Pathway 12-24 hours (Resolution of DKA)	Yes	No	NA NR
a) Was resolution of DKA confirmed according to the definition? (arterial/venous pH >7.3, and/or venous bicarbonate >18mmol/L)?	<input type="checkbox"/>	<input type="checkbox"/>	
b. What date and time was the resolution of DKA identified? (date / time)			
c. If DKA was not resolved:			
<i>i) Was the treatment and monitoring reviewed by Consultant on-call?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>ii) Was the specialist DM team involved?</i>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>If so when were they seen? (date / time)</i>			

Management post DKA	Yes	No	NA NR
a. If not eating or drinking and no ketonaemia – was IV insulin continued according to the recommended prescription?	<input type="checkbox"/>	<input type="checkbox"/>	
b. If eating and drinking and no ketonaemia was the patient transferred to SC insulin regimen?	<input type="checkbox"/>	<input type="checkbox"/>	
i) If so, what date/time was the SC insulin commenced(dd/mm/yy hh:mm)			
c. After DKA resolution, was the patient reviewed by a member of the specialist diabetes team ?	<input type="checkbox"/>	<input type="checkbox"/>	
d. Did the patient receive educational support prior to discharge?	<input type="checkbox"/>	<input type="checkbox"/>	

PATIENT OUTCOME

AT 14 DAYS		
	YES	NO
DKA resolved?		
If yes, how many hours post-admission did DKA resolve?		
Patient alive?		
In no, how many hours post-admission did patient die?		

APPENDIX 4: HEALTHCARE WORKERS CONSENT FORM

Dear Doctor/Nurse: I would like to ask your voluntary participation in this scientific study in the form of survey. A questionnaire is provided for you to answer.

TITLE OF THE STUDY: An audit of the management of Diabetic Ketoacidosis in KNH.

PURPOSE OF THE STUDY: This study aims to assess the adherence to DKA management guidelines and assess barriers to standard DKA management in KNH.

RISK OF THE STUDY: There is no risk in participating in the study.

POSSIBLE BENEFITS: By participating in the study, you will aid in increasing information on current DKA management in KNH and identify any challenges in providing standard management.

COMPENSATION: There will be no compensation given.

RIGHT TO WITHDRAW: Your participation in this study is completely voluntary. You are free to decline it. You have the right to change your mind anytime without giving explanations.

CONFIDENTIALITY: All answers obtained from you will be considered privileged information. These will be documented and analyzed anonymously. Only researchers have access to personal information which only includes your age, gender, and year of study. Your identity will remain absolutely confidential. The researchers aim to publish this paper for pure academic and scientific purpose. You will be given a copy of consent form.

If you have any questions about your participation in the study, please contact:

Dr. Daphine Kerubo Abunga, at Tel No: 0725886336 (Principal investigator)

Or: Professor C.F. Otieno, at Tel No.0722752558

Or: Professor J. K. Kayima, at Tel No. 0733730650

Or: Dr. J.O. Mecha, at Tel No. 0722 842741

Or: KNH/ERC (Kenyatta National Hospital/Ethics & Review Committee) TEL: 020-2726300 EXT 44355. P.O. Box 20723, Nairobi.

CONSENT TO PARTICIPATE IN THE STUDY

I have read, or have had read to me, in language understandable to me, the above information. The content and meaning of this information has been fully explained to me. I have had time and opportunity to ask any questions that I have about the study and this s form, and all my questions have been answered. I voluntarily consent and offer to take part in this study. By signing this consent form, I certify that all information I have been given is true and correct to the best of my knowledge.

_____ Signature of Participant

_____ Signature of Investigator

_____ Date

APPENDIX 5: DOCTORS QUESTIONNAIRE

KNOWLEDGE ON DIABETES AND DIABETIC KETOACIDOSIS

You are being asked to voluntarily complete this questionnaire for a research project to establish the knowledge of medical doctors on diabetes and diabetic ketoacidosis.

If you agree to complete this questionnaire, it should take you 5-10 minutes to fill. Please answer **ALL** the questions.

The questionnaire is anonymous and confidential.

DEMOGRAPHICS/PARTICIPANT'S DETAILS

Date of assessment.....

Age (yrs): 25-34 35-44 >44

Sex: Male Female

Appointment: Medical officer ICU

 Senior house officer Part 1

 Part 2A

 Part 2B

Years of clinical experience: <5

 5-10

 11-15

 >15

KNOWLEDGE QUESTIONNAIRE

1. A fasting blood glucose of greater than or equal to _____ mmol/L on two separate occasions confirms the diagnosis of diabetes.
2. According to the ADA (American Diabetes Association) guidelines, the *HbA1c* goal in a non-pregnant diabetic patient should be less than _____%.
3. According to the ADA guidelines, the blood pressure goal in diabetes should be less than _____/_____ mm Hg.
4. Which oral anti-diabetic agent is *absolutely* contraindicated in renal insufficiency with a serum creatinine ≥ 1.5 mg/dL (132.6 μ mol/L)? _____.
5. Which medication should be discontinued for a patient with diabetes who develops acute congestive heart failure (NYHA Class III)?
 - a) glipizide (Glucotrol)
 - b) rosiglitazone (Avandia)
 - c) Novolin 70/30 insulin
 - d) Sitagliptin (Januvia)
6. Which of the following is the longest acting insulin?
 - a) NPH
 - b) lispro (Humalog)
 - c) regular
 - d) glargine (Lantus)
7. Which of the following is the shortest acting insulin?
 - a) NPH
 - b) lispro (Humalog)
 - c) regular
 - d) glargine (Lantus)

8. What is the peak time of action of regular insulin?
- a) 30 min
 - b) 60 min
 - c) 2-4 hr
 - d) 6-8 hr
9. Novolin 70/30 insulin is a mixture of 70% _____ and 30% _____.
10. What is the best time to administer regular insulin relative to meals?
- a) 30 min before meals
 - b) the start of meals
 - c) 30 min after meals
11. A patient admitted with DKA has a serum glucose of 500 mg/dL (27.7mmol/L), 3+ urine ketones, a serum bicarbonate of 12 mEq/L, an anion gap of 24 and is started on an insulin drip. Six hours later, the serum glucose is 120 mg/dL (6.6 mmol/L), bicarbonate is 18mEq/L, anion gap is 16, and there are 2+ urine ketones. Would you stop the insulin drip at this time?
..... YES or NO
12. For a patient admitted with DKA on an insulin drip, at what glucose value should you administer dextrose containing IV fluid (D5 1/2NS or D5NS)?
- a) 100mg/dL (5.5mmol/L)
 - b) 150mg/dL (8.3mmol/L)
 - c) 200-250 mg/dl (11.1 – 13.8mmol/L)
13. What is the most important electrolyte to follow in DKA patients on an insulin drip?
- a) Potassium
 - b) Sodium
 - c) Phosphorus
 - d) Magnesium

14. What should be the average blood glucose decline per hour on an insulin drip in DKA?

- a) 15-30mg/dL (0.8 – 1.6mmol/L)
- b) 30-50mg/dL (1.6 – 2.7mmol/L)
- c) 50-75mg/dL (2.7 – 4.1mmol/L)
- d) 150-200 mg/dl (8.3 – 11.1mmol/L)

15. A patient on an insulin drip is ready to be transitioned to subcutaneous insulin. The patient is given 20 units of glargine (Lantus) insulin at 7 am. At what time should the insulin drip be stopped?

- a) 7 am
- b) 7:30 am
- c) 8:00 am
- d) 9:00 am

16. An asymptomatic, alert patient is found to have a blood glucose of 35 mg/dL (1.9mmol/L). What is the best treatment approach?

- a) orange juice
- b) crackers
- c) glucagon
- d) D50
- e) Other, specify_____

17. In a patient with confusion and a blood glucose of 35 mg/dL (1.9mmol/L), what is the preferred treatment to normalize the blood glucose?

- a) orange juice
- b) crackers
- c) ½ ampule D50
- d) 1 ampule D50
- e) Other, specify_____

18. The total daily dose of insulin for a patient is calculated to be 50 units. How much basal insulin should be given per day?

- a) 10
- b) 25
- c) 35
- d) 40 units

19. A patient with type 1 diabetes on insulin 20 NPH (N) and 10 Humalog (H) in the morning, 10 H in the evening, and 15 N at bedtime is admitted for elective surgery. He is made NPO after midnight. The morning of the surgery, the blood glucose is 250mg/dL (13.8mmol/L). How should this patient be treated?

- a) 10 NPH
- b) 20 NPH
- c) 20 NPH & 10 Humalog
- d) insulin drip

20. A patient with type 2 diabetes on Novolin 70/30 insulin (30 units in the morning and 20 units at night) is admitted for elective surgery and is made NPO after midnight. The morning of surgery, the blood glucose is 140mg/dL (7.7mmol/L). What is the best treatment option?

- a) No insulin
- b) Sliding scale
- c) 15 units NPH
- d) 20 units 70/30

Thank you for your participation.

APPENDIX 7: DIABETES SELF REPORT TOOL (DSRT)

PERCEIVED KNOWLEDGE ON DIABETES MELLITUS AMONG NURSES

You are being asked to voluntarily complete this questionnaire for a research project to establish perceived diabetes mellitus knowledge among nurses.

If you agree to complete this questionnaire, it should take you 5-10 minutes to fill.

Instructions:

- Please answer **ALL** the questions.
- Please **CIRCLE** the appropriate response to each statement. Please be as honest as you can in evaluating your knowledge and skills in caring for individuals with diabetes.

The questionnaire is anonymous and confidential.

Thank you for your participation.

4=strongly agree

3=agree

2=disagree

1=strongly disagree

1. I can describe the etiology of Type 1 diabetes.

1 2 3 4

2. I can describe the etiology of Type II diabetes.

1 2 3 4

3. I can describe the basic treatment plan for Type 1 diabetes.

1 2 3 4

4. I can describe the basic treatment plan for Type II diabetes.

1 2 3 4

4=strongly agree

3=agree

2=disagree

1=strongly disagree

5. I can identify the nursing needs of the diabetic patient undergoing surgery.

1 2 3 4

6. I can manage the nursing care of a diabetic experiencing mild hypoglycemia.

1 2 3 4

7. I can manage the nursing care of a diabetic with loss of consciousness.

1 2 3 4

8. I can interpret urine results for a diabetic.

1 2 3 4

9. I can instruct a diabetic on self-care management for a "sick day".

1 2 3 4

10. I can describe the action and effect of insulin.

1 2 3 4

11. I can list the steps of the procedure for administering insulin.

1 2 3 4

12. I can describe the action and effect of oral hypoglycemic agents.

1 2 3 4

13. I can assess the diabetic for the development of diabetic ketoacidosis.

1 2 3 4

4=strongly agree

3=agree

2=disagree

1=strongly disagree

14. I can explain how stress affects diabetes control.

1 2 3 4

15. I can identify the long-term complications associated with diabetes.

1 2 3 4

16. I can explain how exercise affects diabetes control.

1 2 3 4

17. I can describe the diet recommended for Type 1 diabetes.

1 2 3 4

18. I can describe the diet recommended for Type II diabetes.

1 2 3 4

19. I can perform one method of blood glucose monitoring.

1 2 3 4

20. I can instruct a diabetic on daily personal care.

1 2 3 4

21. I can identify three sites for insulin administration.

1 2 3 4

22. I can manage the nursing needs of the diabetic patient experiencing hyperglycemia without ketosis.

1 2 3 4

APPENDIX 8: DIABETES BASIC KNOWLEDGE TEST (DBKT)

ACTUAL KNOWLEDGE ON DIABETES MELLITUS AMONG NURSES

You are being asked to voluntarily complete this questionnaire for a research project to establish actual diabetes mellitus knowledge among nurses.

If you agree to complete this questionnaire, it should take you 15-20 minutes to fill.

Instructions:

- Please answer **ALL** the questions.
- For each item, select the **one best answer** to the question.
- The last answer to each question, “I do not know” should be used **only** if you truly do not know the answer.

The questionnaire is anonymous and confidential.

Thank you for your participation.

DIABETES BASIC KNOWLEDGE TEST

1. Which statement is characteristic of the etiology of Type 1 diabetes?
 - a. Strongly associated with obesity.
 - b. Predominately genetic.
 - c. Autoimmune, viral or toxic destruction of the beta cells.
 - d. I do not know.

2. Which of these statements about the management of Type 1 diabetes is true?
 - a. Insulin injections are necessary to maintain life.
 - b. Insulin injections are not always necessary if diet and exercise are well controlled.
 - c. Oral hypoglycemic agents are sufficient for blood control I most patients.
 - d. I do not know.

3. Which statement is characteristic of the etiology of Type II diabetes?
- Predominately non-genetic.
 - Frequently associated with obesity and resistance to insulin.
 - Autoimmune, viral or toxic destruction of the beta cells.
 - I do not know.
4. Which of these statements about management of Type II diabetes is true?
- Insulin injections are necessary to maintain life.
 - A controlled diet and exercise program is the most effective treatment.
 - Oral hypoglycemic agents are always effective.
 - I do not know.
5. What effect does insulin have on blood glucose?
- Insulin causes blood glucose to increase.
 - Insulin causes blood glucose to decrease.
 - Insulin has no effect on blood glucose.
 - I do not know.
6. Which are the physiological actions of insulin?
- 1) Transports glucose across cell membrane for use by the cells.
 - 2) Enhances the formation of proteins from amino acids.
 - 3) Enhances the breakdown of fats for energy.
- 1 & 2.
 - 1, 2 & 3.
 - 2 & 3.
 - I do not know.

7. If a known diabetic is found unresponsive, which of these assumptions about the person's blood glucose should guide your initial actions?
- It may be very high.
 - It may be very low.
 - It may be normal.
 - I do not know.
8. Normal fasting blood glucose level can best be described as:
- Below 8.3mmol/L.
 - Between 5.5 and 11.1mmol/L.
 - Between 3.8 and 6.6mmol/L.
 - I do not know.
9. Which of the following affect the accuracy and precision of tests obtained with most of the blood glucose monitoring strips?
- Size and placement of the blood sample on the reagent pad.
 - Timing of the test.
 - Method of removal of blood from the reagent pad.
 - The patient's hematocrit level.
- 1, 2, & 3.
 - 1, 2, & 4.
 - 1, 2, 3, & 4.
 - I do not know.
10. What would a negative urine glucose test indicate about the blood glucose level in a diabetic with a normal renal threshold?
- It is less than 10mmol/L.
 - It is more than 11.1mmol/L.
 - It is less than 3.3mmol/L.
 - I do not know.

11. Which of the following tests can determine the patient's average blood glucose over an extended period of time?
- Glycosylated hemoglobin.
 - Plasma rennin activity.
 - Insulin antibodies.
 - I do not know.
12. Which of these statements indicate one of the best reasons for utilizing blood glucose monitoring rather than urine testing?
- Drugs such as penicillin, ASA, cephalosporins, and barbiturates can create falsely negative urine tests results.
 - Urine retention and changes in kidney function can increase the lag time between blood glucose rise and spill over of glucose into the urine.
 - The diagnosis of diabetes can be more readily confirmed at the patient's bedside than by laboratory testing.
 - I do not know.
13. A "double voided" urine specimen can best be described as:
- Urine that is collected and tested 30 to 60 minutes after the bladder has been emptied.
 - Urine that is collected and tested twice a day, in the morning and at bedtime.
 - Urine that is collected and tested twice before the result is recorded.
 - I do not know.
14. When should well controlled diabetics always check their urine for ketones?
- Whenever exercising.
 - Whenever testing urine for glucose.
 - Whenever urine glucose is 2% or blood glucose is greater than 13.3mmol/L.
 - I do not know.

15. What should a diabetic do when he/she has been showing 2% urine glucose or blood glucose greater than 13.3mmol/L for two consecutive days and now has positive ketone urine tests?
- Omit the next dose of insulin or oral hypoglycemic medication and test urine/blood as usual.
 - Call the doctor, continue to test urine/blood every four hours or as directed by a physician and continue insulin or oral hypoglycemia medication.
 - Continue with insulin or oral hypoglycemia medication and urine/blood testing as usual. These are normal for diabetics.
 - I do not know.
16. The maximum effect (peak) of regular insulin occurs
- 2-4 hours after injection.
 - 8-12 hours after injection.
 - 24-28 hours after injection.
 - I do not know.
17. The maximum effect (peak) of both NPH and Lente insulin occurs
- 2-4 hours after injection.
 - 8-12 hours after injection.
 - 24-28 hours after injection.
 - I do not know.
18. Where should one store insulin that is PRESENTLY being used?
- In the fridge near the freezer.
 - In the fridge away from the freezer.
 - At room temperature and away from excess light.
 - I do not know.

19. A diabetic contaminates the needle while preparing an insulin injection. What would be the best action to take?
- Dispose of the needle even if this means disposing of the insulin and syringe and starting preparation from the beginning.
 - Wipe the needle with an alcohol sponge and continue preparing the injection.
 - Continue preparing the injection but wipe the injection site thoroughly with alcohol.
 - I do not know.
20. When short-acting (regular) and intermediate-acting (NPH) are ordered to be given by injection at the same time, the nurse should:
- Use separate syringes to administer each insulin.
 - Mix them in the same syringe drawing up the intermediate-acting insulin first.
 - Notify the doctor since these two insulins are not compatible.
 - Mix them in the same syringe drawing up the short-acting insulin first.
 - I do not know.
21. The duration of action of chlorpropamide (Diabinese) is
- 6-12 hours.
 - 12-24 hours.
 - 24-60 hours.
 - I do not know.
22. Which is NOT a reported side effect of oral hypoglycemic agents?
- Gastrointestinal upset.
 - Allergic reaction.
 - Skin rash.
 - Constipation.
 - I do not know.

23. A symptom of hypoglycemia (low blood sugar) is
- Frequent urination.
 - Dry mouth and dry skin.
 - Nervousness.
 - I do not know.
24. A symptom of hyperglycemia (high blood sugar) is
- Frequent urination.
 - Low grade fever.
 - Cool, clammy skin.
 - I do not know.
25. What is one cause of hypoglycemia (low blood sugar) in a diabetic who is taking insulin or oral hypoglycemic agents?
- Skipping a meal.
 - Emotional stress.
 - Too little exercise.
 - I do not know.
26. What is one cause of hyperglycemia (high blood sugar)?
- Decreased food intake.
 - Infection.
 - Negative urine for glucose.
 - I do not know.
27. One symptom associated with diabetic ketoacidosis (coma) is:
- Cold, clammy skin.
 - Acetone (fruity) breath.
 - Negative urine for glucose.
 - I do not know.

28. What is one cause of diabetic ketoacidosis (diabetic coma) in the Type 1 diabetic?
- Excessive exercise.
 - Excessive intake of diet soft drinks over a prolonged period.
 - Failure to take daily insulin dose.
 - I do not know.
29. What effect does illness (for example, a “sick day”) have on a diabetic’s insulin requirements?
- Illness causes a decrease in insulin requirements.
 - Illness causes an increase in insulin requirements.
 - Illness causes no changes in insulin requirements.
 - I do not know.
30. In general, changes in the pattern of insulin administration for the diabetic undergoing surgery might include:
- Increase the dose of long acting insulin the night before and the morning of surgery.
 - Discontinue all subcutaneous insulin the day of surgery and infuse long-acting insulin intravenously at a constant drip.
 - On the day of surgery, reduce the usual a.m. dose of insulin and give subcutaneous or IV boluses of short acting insulin per frequent blood glucose monitoring results.
 - I do not know.
31. Which of the following long term complications are associated with diabetes?
- Eye changes.
 - Renal and cardiovascular changes.
 - Nervous system changes.
 - All of the above.
 - I do not know.

32. The effect of physical & emotional stress on diabetes control includes
- The secretion of stress hormones that cause an elevation in blood glucose levels.
 - The secretion of stress hormones that cause a decrease in blood glucose levels.
 - The secretion of stress hormones that has no effect on blood glucose levels.
 - I do not know.
33. Why is it necessary that diabetics pay special attention to proper care of their feet?
- Several years of injecting insulin into the thighs can cause edema in both the legs and the feet.
 - Flat feet are commonly associated with diabetes unless preventive measures are routinely used.
 - Persons with diabetes often have changes in sensation and poor circulation to their feet.
 - I do not know.
34. A diabetic has a small corn on the right foot and wants it removed. What should be done first?
- Use a liquid corn remover, following directions carefully.
 - Refer the diabetic to a podiatrist.
 - Carefully trim the corn with a sterile cutting instrument.
 - I do not know.
35. A diabetic just received an abrasion on the left leg. What should be done to treat the abrasion?
- Wash gently with mild soap and water, dry with a clean towel, and observe carefully for any signs of infection.
 - Wash gently with mild soap and water, apply a small amount of iodine and observe carefully for any signs of infection.
 - Apply a small amount of iodine and call the doctor.
 - I do not know.

36. What effect does exercise have on blood glucose when the diabetic's glucose is less than 16.6mmol/L?
- Decreases blood glucose.
 - Increases blood glucose.
 - Has little effect on blood glucose.
 - I do not know.
37. What effect does increased exercise have on a diabetic's food intake needs if the patient has a well-controlled Type 1 diabetes?
- Decreases the need for food.
 - Increases the need for food.
 - Has little effect on the need for food.
 - I do not know.
38. Which is the most appropriate INITIAL action to take for the Type 1 diabetic who is having a hypoglycemic reaction (low blood sugar)?
- Drink 4 oz. (120ml) of regular soda.
 - Drink 4 oz. (120ml) of orange juice with 2 teaspoons of sugar.
 - Eat 4 crackers with butter or margarine.
 - I do not know.
39. A Type 1 diabetic does not like one of the food items on the meal tray. What would be the best action for the nurse to take?
- Advise the patient to eat all other items on the tray and omit the one item.
 - Advise the patient to omit that one item and adjust the next scheduled insulin dose to accommodate this deletion.
 - Explain to the patient that the diabetic diet is carefully calculated and that the dietician will be consulted about exchanging this item for another.
 - I do not know.

40. Which of these is the main objective when developing a meal plan for the person with Type II diabetes?

- a. A calorie-controlled diet that will achieve and maintain ideal body weight.
- b. A high-carbohydrate, high-protein diet that encourages an increase in body protein reserves.
- c. A low-carbohydrate, high-protein diet that will prevent fluctuations in blood glucose levels.
- d. I do not know.

41. A diabetic is calculated for which of the following nutrients:

- 1) Carbohydrates.
 - 2) Protein.
 - 3) Fat.
- a. 1 & 2.
 - b. 1 & 3.
 - c. 1, 2, & 3.
 - d. 2 & 3.
 - e. I do not know.

42. Which of these is the main objective when developing a meal plan for the person with Type 1 diabetes?

- a. A nutritionally balanced, 6 small meals/day plan that will prevent delayed stomach emptying.
- b. An individualized diet plan that will maintain euglycemia and normal growth and development to include foods from the 4 groups while ensuring that calories are evenly distributed.
- c. A low fat, low fibre diet to prevent excessive weight gain and minimize the risk of cardiovascular disease.
- d. I do not know.

43. A diabetic has refused an evening snack of fruit juice and ½ of a sandwich. You should substitute with

- a. 5 crackers and 8 oz. (240ml) of plain yoghurt.
- b. 6 crackers and 2 oz. (60ml) of cheese.
- c. A piece of fresh fruit, 1 oz. (30ml) of peanut butter and 4 crackers.
- d. I do not know.

44. For the past 2 days, a diabetic has demonstrated the following:

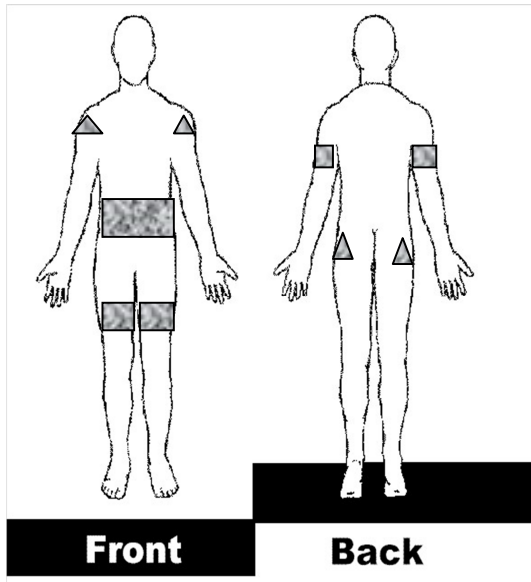
- Urine test results for glucose and ketone that jump from negative/negative to 1-2%/moderate to large in just a few hours
- Wide fluctuations in blood glucose levels over several hours, often unrelated to meals
- 2% glycosuria, occurring upon wakening; preceded by nocturnal sweating, nightmares or headache

Based on this assessment data, what is the person demonstrating?

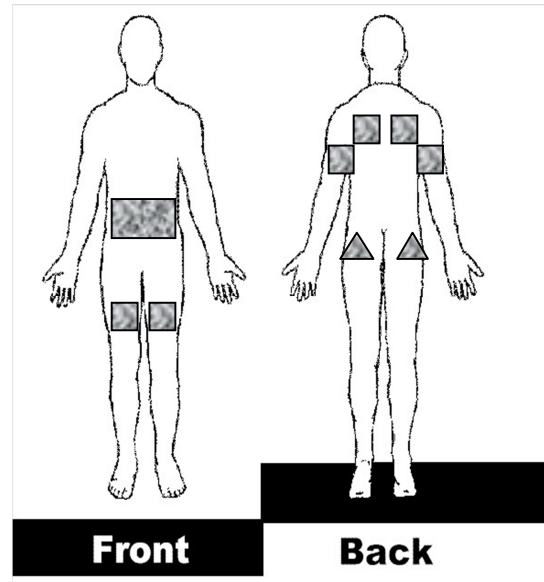
- a. Pass-through or flashback phenomenon.
- b. Somogyi or rebound.
- c. Dawn phenomenon.
- d. I do not know.

45. Which of the following sets of figures best illustrates the correct sites for subcutaneous insulin administration?

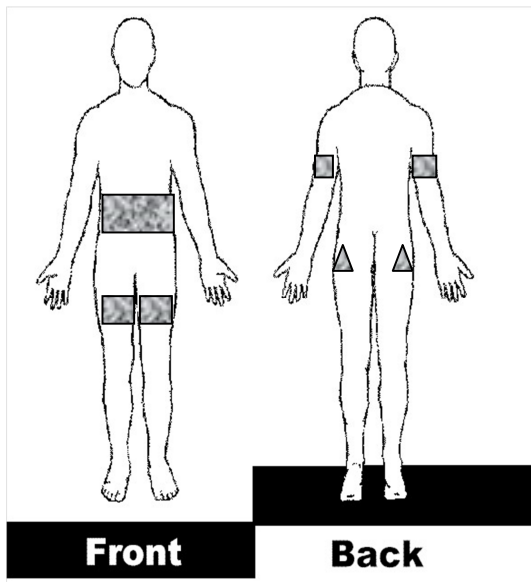
a.



b.



c.



d. I do not know.

APPENDIX 9: KEY INFORMANT INTERVIEW

**INSTITUTIONAL STANDARDS FOR THE MANAGEMENT OF DIABETIC KETOACIDOSIS (DKA)
IN ADULTS**

(COMPLETE ONE IN EACH STUDY SITE)

Study site:		Date form completed:	
Form completed by		Grade	

1. Guidelines	Yes	No	Don't know
a) Do you have a DKA treatment pathway ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) Are your guidelines accessible to all health care workers ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) Do you have an Integrated Care Plan (ICP) for DKA?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d) Are your guidelines current and valid ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e) What are your guidelines based on? <input type="checkbox"/> i) International standards? <input type="checkbox"/> ii) Local/Other..... <i>(please state)</i>			

2. Staffing	Yes	No	Don't know
a) In all of the clinical areas where patients with DKA are treated, do you have trained health care professionals available to measure urine ketones 24 hours per day?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) Do you have dedicated inpatient diabetes specialist nurses ? If the answer is NO – what is your current staffing level per 30beds?.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) Do you have a clinical lead responsible for the implementation & audit of DKA guidelines?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. Management/Monitoring	Yes	No	Don't know
a) Do you have insulin infusion pumps?			
b) In all clinical areas where patients with DKA are treated, do you have the facility to measure urine ketones at the bedside ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) Do you have blood glucose testing meters available at the bedside ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4. Audit / Education	Yes	No	Don't know
a) Do you have a quality assurance scheme in place for glucose meters ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) Do you have a quality assurance scheme in place for ketone meters ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) Have you audited the outcomes of your DKA patients the last past 12 months?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d) Do you monitor against performance indicators eg those listed in the DKA guideline?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e) Do you have a rolling educational programme for medical staff?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f) Do you have a rolling educational programme for nursing staff?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g) Are cases of DKA discussed at your diabetes team morbidity and mortality meetings ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
h) Is feedback given to junior doctors if errors in management occur?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
i) Is feedback given to nursing staff if errors in management occur?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Patients	Yes	No	Don't know
a) Do your patients have access to a specialist diabetes team within 24 hours of admission ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) Do your patients have the choice to self-manage their diabetes ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

APPENDIX 10: ORIGINAL JBDS DKA MANAGEMENT GUIDELINES

The Management of Diabetic Ketoacidosis in Adults

For young people under the age of 18 years use British Society of Paediatric Endocrinology and Diabetes (BSPED) guidelines: <http://www.bsped.org.uk/professional/guidelines/docs/DKAGuideline.pdf>

Diagnostic criteria: all three of the following must be present

- capillary blood glucose above 11 mmol/L
- capillary ketones above 3 mmol/L or urine ketones ++ or more
- venous pH less than 7.3 and/or bicarbonate less than 15 mmol/L

BOX 1: Immediate management: time 0 to 60 minutes

(To 0 at time intravenous fluids are commenced)
If intravenous access cannot be obtained request critical care support immediately

Action 1: Commence 0.9% sodium chloride solution (use large bore cannula) via infusion pump.
See Box 2 for rate of fluid replacement

Action 2: Commence a fixed rate intravenous insulin infusion (IIV) (0.1 units/kg/hr based on estimate of weight) 50 units human soluble insulin (Actrapid® or Humulin 50) made up to 50ml with 0.9% sodium chloride solution. If patient normally takes long acting insulin analogue (Lantus®, Levemir®) continue at usual dose and time

Action 3: Reassess patient
o Respiratory rate, temperature, blood pressure, pulse, oxygen saturation
o Glasgow Coma Scale
o Full clinical examination

Action 4: Further investigations
o Capillary and laboratory glucose
o Venous BG

Action 5: Establish monitoring regimen
o Hourly capillary blood glucose
o Hourly capillary ketone measurement if available
o Venous bicarbonate and potassium at 60 minutes, 2 hours and 2 hourly thereafter
o 4 hourly plasma electrolytes
o Continuous cardiac monitoring if required
o Continuous pulse oximetry if required

Action 6: Consider and precipitating causes and treat appropriately

BOX 3: 60 minutes to 6 hours

Aims of treatment:
o Rate of fall of ketones of at least 0.5 mmol/L/hr OR bicarbonate rise 3 mmol/L/hr and blood glucose fall 3 mmol/L/hr
o Maintain serum potassium in normal range
o Avoid hypoglycaemia

Action 1: Re-assess patient, monitor vital signs
o Hourly blood glucose (lab blood glucose if meter reading 14)
o Hourly blood ketones if meter available
o Venous blood gas for pH, bicarbonate and potassium at 60 minutes, 2 hours and 2 hourly thereafter
o If potassium is outside normal range, re-assess potassium replacement and check hourly. If abnormal after further hour seek immediate senior medical advice

Action 2: Continue fluid replacement via infusion pump as follows:
o 0.9% sodium chloride IV with potassium chloride over next 2 hours
o 0.9% sodium chloride IV with potassium chloride over next 2 hours
o 0.9% sodium chloride IV with potassium chloride over next 4 hours
o Add 10% glucose 125ml/hr if blood glucose falls below 14 mmol/L
More cautious fluid replacement in young people aged 18-25 years, elderly, pregnant, heart or renal failure. (Consider HDU and/or central line)

Action 3: Assess response to treatment
Insulin infusion rate may need review if
o Capillary ketones not falling by at least 0.5 mmol/L/hr
o Venous bicarbonate not rising by at least 3 mmol/L/hr
o Plasma glucose not falling by at least 3 mmol/L/hr
o Continue fixed rate IIV until ketones less than 0.3 mmol/L, venous pH over 7.3 and/or venous bicarbonate over 18 mmol/L

If ketones and glucose are not falling as expected always check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction).
If equipment working but response to treatment inadequate, increase insulin infusion rate by 1 unit/hr increments hourly until targets achieved.

Additional measures
o Regular observations and Early Warning Score (EWS)
o Accurate fluid balance chart, maximum urine output 0.5ml/kg/hr
o Consider urinary catheterisation if incontinent or phasic, not passed urine by 60 minutes
o Nasogastric tube with airway protection if patient obstructed or persistently vomiting
o Measure arterial blood gases and repeat chest radiograph if oxygen saturation less than 92%
o Thromboprophylaxis with low molecular weight heparin
o Consider ECG monitoring if potassium abnormal or concerns about cardiac status

BOX 5: 12 to 24 HOURS

Expectation: By 24 hours the ketonaemia and acidosis should have resolved. Request senior review if not improving

Aim:
o Ensure that clinical and biochemical parameters are continuing to improve or are normal

Action 1 – Re-assess patient, monitor vital signs
o Continue IV fluid replacement if not eating and drinking
o If ketonaemia cleared and patient is not eating and drinking move to a variable rate IIV as per local guidelines
o Re-assess for complications of treatment e.g. fluid overload, central oedema
o Continue to treat precipitating factors
o Transfer to subcutaneous insulin if patient is eating and drinking normally

Action 2 – Review biochemical and metabolic parameters
o At 12 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose
o Resolution is defined as ketones <0.3 mmol/L, venous pH >7.3

Action 3
o If not resolved review fluid Box 4 Action 1 and insulin infusion Box 3

If DKA resolved go to Box 6

BOX 2: Initial fluid replacement

Restoration of circulating volume is priority

Systolic BP (SBP) below 90mmHg
Likely to be due to low circulating volume, but consider other causes such as heart failure, sepsis, etc.
o Give 500ml of 0.9% sodium chloride solution over 10-15 minutes. If SBP remains below 90mmHg repeat whilst requesting senior input. Most patients require between 500 to 1000ml given rapidly
o Consider involving the critical care team
o Once SBP above 90mmHg give 1000ml 0.9% sodium chloride over next 60 minutes. Addition of potassium likely to be required in the second liter of fluid

Systolic BP on admission 90 mmHg and over
o Give 1000ml 0.9% sodium chloride over first 60 minutes

Potassium replacement
Potassium level (mmol/L) | Potassium replacement mmol/L of infusion solution
o >5.5 | Nil
o 3.5-5.5 | 40 mmol/L
o <3.5 | 40 mmol/L, senior review – additional potassium required

BOX 4: 6 to 12 hours

Aims:
o Ensure clinical and biochemical parameters improving
o Continue IV fluid replacement
o Avoid hypoglycaemia
o Assess for complications of treatment e.g. fluid overload, central oedema
o Treat precipitating factors as necessary

Action 1: Re-assess patient, monitor vital signs
o If patient not improving by criteria in Box 3 seek senior advice
o Continue IV fluid via infusion pump at reduced rate
o 0.9% sodium chloride IV with potassium chloride over 4 hours
o 0.9% sodium chloride IV with potassium chloride over 6 hours
o Add 10% glucose 125ml/hr if blood glucose falls below 14 mmol/L

Reassess cardiovascular status at 12 hours, further fluid may be required.

Check for fluid overload

Action 2 – Review biochemical and metabolic parameters
o At 6 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose
o Resolution is defined as ketones less than 0.3 mmol/L, venous pH over 7.3 (do not use bicarbonate as a surrogate at this stage)
o Ensure referral has been made to diabetes team

If DKA not resolved review insulin infusion (see BOX 3 Action 3)
If DKA resolved go to BOX 6

Groups represented: Association of British Clinical Diabetologists; British Society for Endocrinology and Diabetes and Association of Children's Diabetes Clinicians; Diabetes Inpatient Specialist Nurse (DISN) Group; Diabetes UK; NHS Diabetes (England); Northern Irish Diabetologists; Society of Acute Medicine; Welsh Endocrine and Diabetes Society; Scottish Diabetes Group.

**APPENDIX 11: ADULT DIABETIC KETOACIDOSIS EMERGENCY CARE
PATHWAY**

(Based on the Joint British Diabetes Societies DKA Guidelines 2013)

DKA DIAGNOSTIC CRITERIA

Established diabetes or new diagnosis of diabetes mellitus **and one or more of**

Capillary blood ketonaemia of $>3\text{mmol/L}$

Or ketonuria ++or more

AND Venous bicarbonate $<15\text{mmol/L}$ **OR** Venous/Arterial pH <7.3

DKA RESOLUTION CRITERIA

Resolution of ketonaemia $<0.6\text{mmol/L}$ **and**

Arterial/Venous pH >7.3

Venous bicarbonate $>18\text{mmol/L}$ **and**

Diabetes controlled with subcutaneous insulin, with glucose $<11\text{mmol/L}$ **and**

Patient eating and drinking **and**

OR Exit from pathway has been recommended by the diabetes team

ESSENTIAL INITIAL RESULTS, ALL MUST BE DOCUMENTED

Blood ketones.....mmol/L

Blood glucose.....mmol/L

Venous bicarbonate.....mmol/L

Venous (or arterial pH).....

Potassium.....mmol/L

Creatinineumol/L

EARLY MANAGEMENT – 1st hour fluids/potassium/insulin

INTRAVENOUS FLUID

- If systolic BP < 90mmHg:
- Give 1 litre of 0.9% sodium chloride solution over 15 minutes
- If systolic BP remains < 90mmHg repeat and call senior medical colleague for advice
- Consider septic shock / heart failure as a potential cause
- Consider calling the critical care outreach team from HDU/ICU

Do NOT use plasma expanders

- If the systolic BP is > 90mmHg

The rate of fluid replacement depends on the age / fitness / dehydration of the patient.

Plan fluid replacement and use clinical judgement

Typically though:

- 0.9% sodium chloride 1L with potassium chloride over next 2 hours
- 0.9% sodium chloride 1L with potassium chloride over next 2 hours
- 0.9% sodium chloride 1L with potassium chloride over next 4 hours

- Add 5% glucose given at 125ml/hr if the blood glucose falls below 14mmol/L

More cautious fluid replacement should be considered in young people aged 18-25 years, elderly, pregnant, heart or renal failure. (Consider HDU and/or central line)

Reduce the rate of fluid replacement in the elderly / cardiac disease / mild DKA (bicarbonate >15mmol/L). More rapid infusion increases risk of respiratory distress syndrome and cerebral oedema

POTASSIUM

Serum potassium is often normal or high initially but total body potassium is low

• Add potassium as follows:

>5 mmol/L - none

4.1 - 5.0mmol/L - 20mmol KCl per litre

3.1-4.0mmol/L – 30mmol KCl per litre

<3mmol/L – 40mmol KCl per litre

For potassium <3.5mmol/L, senior advice is required. In addition the patient **MUST** be looked after in a High Care Area

Anticipate a fall in potassium and replace, once the first plasma potassium result is known

Care must be taken to assay potassium levels and to supplement as per guidelines.

INSULIN

DO NOT STOP subcutaneous NPH insulin (Insulatard®, Humulin I®, Insuman Basal®), or analogue (Lantus®, Levemir® or Tresiba®).

DO disconnect Continuous Subcutaneous Insulin Infusion (CSII) pump and DO NOT attempt to use it without diabetes specialist team input under any circumstances.

A Fixed Rate Intravenous Insulin Infusion (FRIVII) is to be used at 0.1 U/Kg of patient weight

Add 50 units of soluble insulin made up to 50ml with 0.9% sodium chloride solution in a 50ml syringe

Weigh or estimate patient weight in Kg, if pregnant, use their current pregnant weight

Infuse intravenous insulin using approved syringe driver

Paradigm / ethos is to drive ketones down aggressively by at least 0.5mmol/L per hour. A variable rate intravenous insulin infusion is NOT to be used until blood ketones are < 0.6mmol/L

OTHER IMPORTANT NOTES AND MEASURES

Call the diabetes specialist team or diabetes inpatient specialist nurse as soon as possible

If ketone and / or glucose levels do not fall as expected, call for senior advice

High Care Area (HDU or dedicated beds) care is needed if:

- Hypokalaemia is present on admission ($K^+ < 3.5\text{mmol/L}$)
- Young (18 - 25 years old)
- Pregnant. Call for urgent senior obstetric involvement. **KETONES KILL BABIES, NOT GLUCOSE**
- GCS < 12
- Shocked: pulse $> 100\text{bpm}$ or systolic BP $< 90\text{mmHg}$

Consider urinary catheter if no urine passed after 2 hours or incontinent

Consider naso-gastric tube and aspiration if the patient does not respond to commands (NB protect airway)

Consider thromboprophylaxis with low-molecular weight heparin in elderly or high risk patients unless it is contraindicated.

Screen for infection and give antibiotics if clinical evidence of infection (NB The WBC is not helpful because it may be markedly raised from DKA alone)

Continue the Fixed Rate Intravenous Insulin (FRIII) Infusion and fluids until the acidosis is reversed and the Variable Rate Intravenous Insulin Infusion (VRIII) until the patient is ready to eat and drink

Discontinue the VRIII 30-60 minutes after the subcutaneous insulin has been given

BICARBONATE ADMINISTRATION

In most cases bicarbonate is **NOT** helpful and is potentially dangerous

If bicarbonate is being considered, the patient should be in a level 2 (HDU / ICU) environment

Only consider if $\text{pH} < 7$ and after discussion with the consultant in charge of the patient's care.

RESTARTING SUBCUTANEOUS INSULIN

Re-start subcutaneous insulin as follows (firstly ensure that the long acting analogue, if the patient was previously on it, was not stopped):

- Allow the patient to eat
- If no sickness, inject normal meal time insulin and stop intravenous insulin 30-60 minutes later

Get the input of the diabetes specialist team

APPENDIX 12: DETAILS OF KEY INFORMANTS INTERVIEWS

Item	Yes	No	Notes
Guidelines:			
Presence of DKA treatment pathway	7	1	1 general ward did not have a DKA treatment pathway
Accessibility of guidelines to all health care workers	4	4	In 3 general wards and at the medical ICU the guidelines were not accessible to all health care worker
Presence of an Integrated Care Plan (ICP) for DKA	3	5	3 general wards had an integrated care plan (ICP) for DKA
Guidelines current and valid	4	4	In 2 general wards, the medical ICU and the A&E, guidelines were current and valid.
Staffing:			
Presence of trained health care professional to measure urine ketones 24 hours per day in all clinical areas	2	6	1 general ward and the A&E had health care professional to measure urine ketones 24 hours per day
Presence of dedicated inpatient diabetes specialist nurses	2	6	2 general wards had dedicated inpatient diabetes specialist nurses
Presence of a clinical lead responsible for the implementation and audit of DKA guidelines	2	6	1 general ward and the A&E had a clinical lead responsible for the implementation and audit of DKA guidelines
Management/Monitoring:			
Availability of insulin infusion pumps	2	6	Both the medical ICU and A&E had insulin infusion pumps
Availability of facility to measure urine ketones at the bedside	4	4	3 general wards and the medical ICU had the facility to measure urine ketones at the bedside
Availability of blood glucose meters at the bedside	7	1	1 general ward did not have blood glucose meters at the bedside

Item	Yes	No	Notes
Audit/Education:			
Availability of quality assurance scheme for glucose meters	3	5	3 general wards had quality assurance scheme in place for glucose meters
Availability of quality assurance scheme for ketone meters	1	7	1 general ward had quality assurance scheme in place for ketone meters
Audit of DKA outcomes in the past 12 months	3	5	3 general wards had audited outcomes of DKA patients in the past 12 mo
Monitoring against performance indicators eg those listed in the DKA guidelines	3	5	2 general wards and the medical ICU monitored against performance indicators
Presence of rolling educational program for medical staff	1	7	1 general ward had a rolling educational program for medical staff
Presence of rolling educational program for nursing staff	4	4	4 general wards had a rolling educational program for nursing staff
Discussion of DKA cases at diabetes team morbidity and mortality meetings	4	4	4 general wards discussed DKA cases at their diabetes team morbidity and mortality meetings
Feedback given to junior doctors if errors in management occur	3	5	2 general wards and the medical ICU gave feedback to junior doctors if errors in management occurred
Feedback given to nursing staff if errors in management occur	7	1	1 general ward did not give feedback to nursing staff if errors in management occurred
Patients:			
Patient access to a specialist diabetes team within 24 hours of admission	5	3	Patients in 5 general wards had access to a specialist diabetes team within 24 hours of admission

APPENDIX 13: KNH-UON ETHICS AND RESEARCH COMMITTEE APPROVAL



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Dr. Daphne Kerubo Abunga
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Dept. of Clinical Medicine and Therapeutics
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13th December, 2017

Dear Dr. Kerubo

RESEARCH PROPOSAL – ASSESSMENT OF THE MANAGEMENT OF DIABETIC KETOACIDOSIS AT THE KENYATTA NATIONAL HOSPITAL (P566/10/2017)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above proposal. The approval period is from 13th December 2017- 12th December 2018.

This approval is subject to compliance with the following requirements:

- Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
- All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
- Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
- Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
- Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
- Submission of an *executive summary* report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

For more details consult the KNH- UoN ERC website <http://www.erc.uonbi.ac.ke>

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