EVALUATING THE VALIDITY OF APACHE II AS A PREDICTOR OF ICU MORTALITY FOR THE CRITICALLY ILL PATIENTS AT KNH'SCRITICAL CARE UNITS

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DECLARATION

I declare that this Dissertation in part fulfilment of MSc. Nursing (Critical Care Nursing) is my original work, and has not been presented for a Degree in any other learning institution or for any other award.

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DEDICATION

I wish to dedicate this work to my wife and daughter for their endurance of the long hours of absence taken from home in preparing this work. My mum and late dad for always being a source of inspiration, and the entire family and friends for their constant support and encouragement.

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LIST OF ABBREVIATIONS/ ACRONYMS

A/E	Accident and Emergency department
AKI	Acute Kidney Injury
APACHE	Acute Physiology and Chronic Health Evaluation
APS	Acute Physiology Score
AUC	Area Under the resultant Curve
CASUS	Cardiac Surgery Score
GCS	Glasgow Coma Scale
ICU	Intensive Care Unit
KNH	Kenyatta National Hospital
MPM	Mortality Prediction Model
ROC	Receiver Operating Characteristic
SAPS	Simplified Acute Physiological Score
SOFA	Sequential Organ Failure Assessment
USA	United States of America

OPERATIONAL DEFINITIONS

Chronic health status

Organ insufficiency or immunocompromised state of a patient evident prior to this particular admission.

Critically ill patient

This refers to any person above the age of 16 who has come to seek healthcare services at Kenyatta National Hospital and has subsequently been admitted into the Critical Care Unit due to his/her deranged physiological status.

ICU mortality

These are deaths of patients admitted to the Critical care Unit occurring within the admission period.

Intensive care unit

This is a special department in the hospital set-up where the critically ill patients are taken care of. In this work, the term Critical care unit will be used interchangeably with intensive care unit (ICU).

Outcome

The end result of an admission into the Critical Care Unit. The consequences of interest in this case are either a death of a live discharge from the ICU.

Worst physiological variable

These are the most deranged recordings of the patients' health status during the first 24 hours of admission.

ABSTRACT

Introduction: Though most patients survive their critical illness after intensive care, another proportion are readmitted or die in hospital. While some of the risk factors for poor outcome are known, few are modifiable. It is now common to use tools that predict short term and long-term survival to guide care and cost management. The performance of these tools is quite variable especially when applied to different cohorts of patients. Acute Physiology and Chronic Health Evaluation (APACHE) II tool is most commonly used for audit and clinical purposes and to provide general measure of severity of disease.

Study Objectives: The objective of the study was to evaluate the validity of APACHE II scoring system as a predictor of mortality in KNH ICU.

Study Methods: This was a quantitative retrospective cross-sectional study. Stratified random sampling was used to select 180 files of patients admitted in ICU for the period January to December2017. The selected fileswere evaluated after approval from the Ethics and Review Committee. An APACHE II score was calculated by summing up the various diagnostic category weightings.

A binary logistics regression was done to examine whether APACHE II score correctly predicts mortality. Tests of Calibration to assess the correspondence between the expected probability of mortality and actual observed mortality was done using a Hosmer-Lemeshow goodness of fit test. The area under the resultant curve (AUC) of the receiver operating characteristic (ROC) curve was calculated to assess for discrimination.

Results: The mortality rate reported in this study was high at 31.1% with a mean APACHE II score of 20.58, the expected mortality rate also stood at 31.1%. Moreover, the mean APACHE II score was significantly higher in non-survivors when compared to survivors ($p < 0.001$). The study revealed that APACHE II score is an excellent predictor for mortality as ROC curve was found to be 0.889 with an optimum cut-off value of 20.5 with sensitivity 87.5% and specificity 79.0%.

Recommendations: The researcher recommends that APACHE II be used in stratifying patients according to their degree of severity of illness at admission to ICU.

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND INFORMATION

Critical care services have for the longest time, been a scarce resource that needs proper utilization. According to Murthy, Leligdowicz and Adhikari, (2015), most low-income countries do not have adequate ICU facilities, with those that have them, only being located in the large referral hospitals in major cities, and with more than half of these countries lacking any published data on ICU capacity. Identification of priorities and resources required for the management of the critically ill may be improved by knowing the characteristics and outcomes of the critically ill patients admitted in ICU's in low income countries (Kwizera, Dunser and Nakibuuka, 2012). It is therefore imperative to have tools to help in knowing these characteristics so as to help in resource allocation.

Severity assessment scores and tools are therefore important adjuncts of treatment in critical care nursing,for assessing characteristics of the critically ill patients and predicting their outcomes. Rapsang & Shyam, (2014) indicated that although theydo not form part of treatment, severity scores have an important role in the improvement of clinical decision making, in recognising patients with unanticipatedadverse clinical outcomes,in timely decision making, in explaining differences in mortalities and in decreasing the healthcare costs incurred by the hospital.Guimarães, Menezes, Alves, Rabelo, Lopes,et al.,(2017) demonstrated their wide use in research and in intensive care setups for severity of disease evaluation, benchmarking and best resource allocation. This is key, bearing in mind the huge resources allocated to intensive care units and therefore the need to use the most appropriate tool for each setting.

As with every tool, each severity scoring system is made for specific use and for use in a specific setting. Rapsang & Shyam, (2014) insisted that it was imperative to choose the

severity score or model precisely depending on the specific setting or application for that model, this is because a misapplication of the score was found to have adverse effects, such as misuse of resources for instance finances and time, unnecessary extrapolationsand poor science. Since existing scoring systems are made from a fixed set of patient data, Saha, Dewangan, Narasimhan, Sampath and Agarwal, (2014) argued that they perform poorly when applied to a population of patients with different characteristics and that they become suboptimal over time. These must be because of the differences in physiology between different age groups, gender and disease conditions as well as environmental adaptation. There is therefore a need for different types of severity scoring systems for different settings and population groups.

There are several types of scoring systems developed over the last three decades. The most commonly used scoring systems in adult patients in the ICUaccording to Sekulic, Trpkovic, Pavlovic, Marinkovic and Ilic, (2015) are Acute physiology and chronic health evaluation (APACHE) II and III, Glasgow coma scale (GCS), Simplified Acute Physiological Score (SAPS), Mortality Prediction Model (MPM), Sequential Organ Failure Assessment (SOFA), Multiple Organ Dysfunction Score (MODS), and Logistic Organ Dysfunction Score (LODS). In the first 24 h of stay in the ICU, APACHE, SAPS, LODS, and MPM are calculated, while repetitive scores such as SOFA and MODS are calculated daily during the ICU stay, they are primarily used for assessment of organ dysfunction of critically ill patients.Bouch and Thompson, (2008)classified severity scoring systems as follows; Anatomical scoring, therapeutic weighted scores, organ-specific scoring, physiological assessment,simple scales and disease specific scales.The APACHE II score is prognostic score which falls under the therapeutic weighted scores.

Among the severity assessment scores mentioned, APACHE II is the most commonly used. It is a severity of disease classification system which uses a point score based upon twelve

routine physiological measurements,patients age and any his/her chronic health status to provide a general measure of severity of disease(Knaus, Draper, Wagner and Zimmerman, 1985). It is the most widely used tool that uses the worst physiologic score obtained within the first 24 hours to predict the outcome of care with an increasing score (0 to 71) which correlates with the subsequent risk of death (Knaus et al., 1985).Sekulic et al., (2015) further stated that the APACHE score is the "gold standard" for the evaluation of critical care and is one of the most commonly used scoring systems in critical care medicine around the world. This is probably because APACHE score is based on routinely recorded values, can be used for all adult population and can be easily computed.Its ease of use allows for comparison in different settings.

1.2 STATEMENT OF THE PROBLEM

Critical care services are complex and therefore meant for those patients who are acutely ill but with reversible illnesses. In addition, many resources such as human resources, consumables, diagnostics, equipment and time are spent on patient care. It is therefore imperative that the patients admitted in any critical care unit benefit from the care. Prognostic indices are one way of determining the hospital mortality, and this information can be used to guide care and resource allocation.

The Acute Physiology and Chronic Health Evaluation (APACHE) II system is a one such prognostic indicator. It uses the worst physiologic variable to determine prognosis(Bouch & Thompson, 2008), with an integer score ranging from 0 – 71 calculated based on these physiologic data, in addition to age and chronic health status, a higher score infers a more severe disease and a greater risk of death. The estimated risk of hospital death is then calculated using logistic regression equation utilising specific beta coefficients made for this purposes.

Though such tools can be useful in guiding care decisions, they remain largely unused. In the USA only 10 to 15% of the ICU use the tools (Breslow & Pharmd, 2012), even though the data can be used to improve the quality of healthcare while reducing the operational costs. In Uganda, Kwizera, Dunser and Nakibuuka, (2012), determined that there is only one ICU bed per one million Ugandans (0.1 ICU beds/100000) with a poor uptake of prognostic scores. In the Kenyan setting, the ratio of ICU beds to the general population is very high (0.29 ICU beds/100000) according to Okech and Chokwe, (2015), with critically ill patients often having to wait for availability of an ICU bed before admission, the use of prognostic indicators can help reduce the operational costs by only admitting patients who will benefit from the care. Okech and Chokwe, (2015) further stated thatthere is a low ICU bed capacity compounded by a universal shortfall in human resource capacity and support set-up for the critical care services. Unfortunately, such tools are not used in Kenyan ICU's, this may be as a result of relative paucity in the utilisation of such information due to our socio-cultural backgrounds despite the few resources available.

Proper management of these resources, by use of a prognostic score as a basis for triaging ICU admissions, can ensure appropriate care is given to the critically ill, who have reversible illnesses, and therefore getting maximum benefit with little costs.Breslow and Pharmd, (2012) suggested that failure to implement an ICU scoring system was equivalent to not having any meaningful ICU outcome data, they strongly supported initiatives for ICU leaders to increase use of ICU scoring systems. Although cost and accuracy concerns have been raised as influences against the adoption of ICU scoring systems, numerous European countries have decided that these are insufficient excuses for not measuring the quality of ICU care and have directed their use. In Kenya, Marete, Wasunna and Otieno, (2011)used the Clinical Risk Index for Babies (CRIB) to determine prognostic scores in the management of neonates, while Michuki, (2014)used the Respiratory Index of Severity for Children (RISC).

Salluh and Soares, (2014), implied that such severity assessment scores should be customised to the local setting to ensure accurate and constant update. However, despite the APACHE II being the commonly used tool worldwide, with high calibration and specificity, no studies have been carried out in the Kenyan setting. This study therefore addresses this evidence gap in the Kenyan setting. The purpose of this study was therefore to evaluate whether APACHE II severity score can correctly predict mortality while assessing how illness severity compares with the mortalities. The study also compares the APACHE II scores of patients admitted in medical ICU's and Main ICU with their outcomes.

1.3 STUDY JUSTIFICATION

Kenyatta National hospital, despite being a national referral hospital, securing a bed for a patient in the ICU remains a nightmare. Having a mortality prediction score whose validity has been tested in our setup would go a long way in ensuring that there is appropriate distribution of resources, including bed spaces for the patients who would benefit the most from ICU care. This would also inform policy on end of life care, further development and expansion of the hospital. It would also provide a roadmap for cost-benefit analysis for the provision of Critical care services.

Prognostic tools can be used in guiding care decisions. In most of Sub-Saharan Africa, there are no legal guidelines regarding brain death (Waweru-Siika et al, 2015), although such a condition is irreversible, you may find such patients admitted in ICU for prolonged periods of time. This leads to prolonged and futile interventions, suffering of families and poor allocation of the scarce critical care resources available in low resource settings. In Kenya there is no law on Advance directives, and where practiced, it is usually under institutional policy (Omondi et al, 2017). Since the need for intensive care exceeds its availability, having

a validated prognostic tool in use can help triage ICU admissions while reducing futility of care.

There is need to know whether a prognostic tool performs in a given population before it is adopted. Bouch & Thompson, (2008), indicated the need to determine performance of a score before adoption, after being developed in a different original population.Since they are derived from developmental cohortsGuimarães et al., (2017) believed that they may lose precision and accuracy, after extension of use to other populations overtime. Prognostic models should therefore go through external validation and constant update.

1.4 STUDY OBJECTIVES

1.4.1 Broad objectives

To evaluate validity of APACHE II scoring system in KNH ICU as a predictor of mortality among adult critically ill patients.

1.4.2 Specific objectives

1. To describe the APACHE II scores of adult patients admitted in KNH's ICUs.
2. To evaluate APACHE II ability to predict patients' outcome at KNH's ICUs.
3. To compare the APACHE II scores and mortalities between KNH medical and main ICU.

1.5 RESEARCH QUESTIONS

1. What are the APACHE II scores of patients admitted to KNH ICU's?
2. Does the APACHE II scoring system correctly predict outcomes in patients admitted at KNH ICU?
3. How does APACHE II scores of patients admitted at KNH ICUs compare with their mortalities between medical and Main ICU?

1.6 VARIABLES

1.6.1 Independent variables

- Apache II score

1.6.2 Dependent variables

- ICU mortality

1.6.3 Intervening variables

- Pre-referral management
- Time taken before arrival to hospital
- Quality of emergency care at the Accident and Emergency department.
- Quality of ICU care

CHAPTER TWO: LITERATURE REVIEW

In this section, we will discuss the current literature on scoring systems and have an in-depth analysis of the APACHE II score in terms of its development, its composition, its comparison with other scoring systems, its predictive power and limitations. Further we shall discuss the theoretical and conceptual basis of this study.

To achieve this, the researcher searched several literature databases including; The University of Nairobi library digital Repository, Google scholar, Springer and Hinari. Current literature and sources within the last five years were used as well as seminal literature. The following key search terms and combination of search terms were used; scoring systems, ICU scoring systems, APACHE II score, prognostic scores, outcome prediction scores, mortality prediction, ICU admission criteria and ICU admission.

2.1 INTRODUCTION TO SCORING SYSTEMS

Scoring systems have over time proven to be an integral part of Critical care service delivery. They been in use in critical care medicine for approximately 30 years, when they were introduced and developed(Breslow and Badawi, 2012). Before then there were no outcome prediction score in use for critical care units to compare mortalities. However their use has become common in critical care medicine. The scoring systems,as per Hosseini and Ramazani, (2015), quantify the severity of disease, guiding therapeutic interventions by helping in clinical decision making and providingan estimation of the likelihood of in hospital mortality as they assess the quality of ICU care, this is achieved by collecting routinely measured data on the patient, weights are given to each individual score, and a sum of the weights gives the predicted mortality score. Many severity scores have been developed

since, although only a small minority remain in use(Bouch& Thompson, 2008). Those in use however, are gaining popularity amongst intensivists.

Most of the scoring systems however, are being used for many purposes, some different from initial intended use. According to (Keegan & Soares, 2016), adjusted mortality rates, based upon the predictions provided by prognostic scores, are gradually being institutionalised for the comparison of the quality of care amongst different critical care units and different hospitals.. Mir, Patel, Khan, Furqan, Awan et al., (2012)inferred that the APACHE II score, together with other patient characteristics, should be considered in clinical decisions related to CPR administration, they demonstrated in their study that survival among patients with APACHE II scores more than 24 was significantly less than in patients who have a score less than 24. These allow different hospitals to benchmark or recognize institutional deficits in clinical outcomes and therefore, highlight areas for improvement

Though they are effective in prognosis prediction, severity assessment scores have several limitations. Bouch and Thompson, (2008) describes an ideal scoring system as one that fulfils a set of characteristics: based on routinely recorded variables, have a high level of discrimination, applicable to all patient populations, have good calibration, have the ability to predict functional status or quality of life even after discharge from the ICU, and be used in different countries or geographical locations. Predictably no single tool meets this criterion despite there being different types of severity scores available, they however, continue to be used as their applicability supersedes their limitations.

The different types of severity scoring systems and models available are either broad or disease specific, such that they may be used for case mix analysis or for specific patient assessment. Some are simple, while others are complex and centred on physiological derangements or resource allocation. In critical care medicine, themain categories that exists

according to Keegan & Soares, (2016)include: Organ failure scores which describe the severity of a patients physiologic disorders by organ system to give an objective assessment of the extent and severity of organ involvement, ranging from slight dysfunction to complete organ failure, they are often repetitive in nature. The other being a prognostic model which uses physiologic data, chronic health status and the history of present illness, often on day one of admission to give a probability of mortality. The organ failure scores include Sequential Organ Failure Assessment (SOFA), Organ System Failure (OSF) and Multiple Organ Dysfunction Score (MODS), while prognostic models includeAPACHE scoring models, Simplified Acute Physiologic Score (SAPS) scoring models and the Mortality Prediction Model (MPM) scoring systems(Keegan & Soares, 2016). The different types available help in their diverse application in the clinical set up.

The scoring systems can also be divided based on how they were developed. Bouch & Thompson, (2008) classified them as follows: subjective scoreswhich were derived by consensus opinion from a panel of experts which agrees upon specific variables and their individual weightings and objective scores which are generated by computer based multipurpose probability models which determines the variables to use and their specific weightings, it sources its data from large databases of clinical data collected from different ICU's.An example of an objective scoreis an orthogonal matching pursuit-based machine learning method that can learn a score system type prediction model from given patient data developed by Saha et al.,(2014). In the next sections, the focus will be on APACHE scoring MODEL.

2.2 APACHE SCORING SYSTEM DEVELOPMENT

The APACHE scoring system has undergone modification over time to its current use.The original APACHE tool was firstdeveloped in 1981 and evaluated three factors which influenced the acute illness outcome; patient's reserve- determined by age, pre-existing

conditions, and the physiologic derangements in the acute illness- determined by the Acute Physiology Score (APS) which is a sum of the weightings of the physiologic variables (Knaus et al., 1981). It had 34 physiologic variables which were later reduced down to 12 by removing those variables that were not measured routinely such as serum osmolality, lactic acid levels and skin testing for anergy as they were considered redundant by Knaus et al., (1985). The weightings for other variables were changed following recommendation by the team led by Knaus et al., (1985) as follows: the weighted scores for Glasgow Coma Scale and acute renal failure were increased, weights were added for end organ dysfunction and for emergency operations and medical admissions, and this led to the development of APACHE II. This formed part of the modifications done on the APACHE tool.

The reason for admission to the ICU remains an important factor and plays a major role in the determination of the final outcome. The reason for ICU admission according to Vincent & Moreno, (2010)is a significant variable in predicting mortality, even for patients with an equivalent acute physiological score and chronic health status. According to Breslow and Pharmd (2012), where multiple diagnosis are relevant during admission, the diagnosis with the worst prognosis should be used, it should reflect the main reason for the admission into the Critical care unit and should have been documented within the first day of admission to ICU. After completion of several validation studies, APACHE could be used to control for case mix, compare outcomes and evaluate new therapies while studying the utilization of ICUs.This brought about the commonly used APACHE II.

As with every scoring system, there is always a need to periodically validate and update it over time. Bouch & Thompson, (2008) found it imperative to refine the APACHE methodology in order to improve its statistical power and its capacity to predict individualizedpatients outcomes while identifying the factors that influence patient's outcomes in ICU care. This gave rise to APACHE III in 1991 which was further updated in

1998(Jean-Louis V., 2015). Data was collected prospectively on 17,440 ICU admissions in 40 USA hospitals. The variables analysed were; acute physiological abnormalities, age, chronic health limitations, medical and surgical disease diagnoses, major comorbidities and pre-admission locations. This gave rise to the current APACHE III.

Further updates ensued following the development of APACHE III. A similar study by Zimmerman, Kramer, McNair and Malila, (2006) with a larger study population of 131,618 consecutive ICU admissions in 45 USA hospitals was done with the aim of improving and refining the APACHE models. The predictor variables were similar to those of APACHE III but new variables were added and more refined statistical methods were used. The study suggested periodic retesting as the model's accuracy was deemed dynamic with deterioration in time (Zimmerman et al., 2006). This led to the development of APACHE IV severity score. In the next sections, we will focus on the APACHE II score.

2.3 APACHE II SCORE

Every tool requires a guideline for its proper utilisation. Knaus et al., (1985) developed the tool in figure 1 to help in the proper utilisation of the APACHE II score, it works as a guideline on the physiologic variables to use and the weights applied on each range of the findings of the variables. It further gives the definitions of the conditions listed as chronic health status. It is imperative to use the tool as it was designed so as to get the desired results of the authors.

Physiologic Variable		+4	+3	+2	+1	0	+1	+2	+3	+4
Temperature - rectal (°C)		≥41	39-40.9		38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	≤29.9
Mean Arterial Pressure (mm Hg)		≥160	130-159	110-129		70-109		50-69		≤49
Heart Rate		≥180	140-179	110-139		70-109		55-69	40-54	≤39
Respiratory Rate (nonventilated or ventilated)		≥50	35-49		25-34	12-24	10-11	6-9		≤5
Oxygenation (mmHg) a. $FiO_2 > 0,5$ use $A\text{-}aDO_2$ b. $FiO_2 < 0,5$ use PaO_2	a	≥500	350-499	200-349		<200				
	b					> 70	61-70		55-60	<55
Arterial pH		≥7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	<7.15
Serum Sodium (mmol/l)		≥180	160-179	155-159	150-154	130-149		120-129	111-119	≤110
Serum Potassium (mmol/l)		≥7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		<2.5
Serum Creatinine (mg/dl, Double point score for acute renal failure)		≥3.5	2-3.4	1.5-1.9		0.6-1.4		<0.6		
Hematocrit (%)		≥60		50-59.9	46-49.9	30-45.9		20-29.9		<20
White Blood Count (in 1000/mm³)		≥40		20-39.9	15-19.9	3-14.9		1-2.9		<1
Glasgow-Coma-Scale (GCS)		Score = 15 minus actual GCS								
Serum HCO_3 (venous, mmol/l, use if no ABGs)		≥52	41-51.9		32-40.9	22-31.9		18-21.9	15-17.9	<15
A = Total Acute Physiology Score APS		Sum of the 12 individual variable points								
B = Age Points		**C = Chronic Health Points**								
≤44 years	0 points	If the patient has a history of severe organ system insufficiency or is immunocompromised assign points as follows:								
45-54 years	2 points									
55-64 years	3 points									
65-74 years	5 points	a. For nonoperative or emergency postoperative patients – 5 points								
≥75 years	6 points	b. For elective postoperative patients – 2 points								
APACHE II Score = Sum of A (APS points) + B (Age points) + C (Chronic Health points)										

(From: Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med 1985;13(10):818-29)

Figure 1APACHE II scoring system

APACHE II score is made up of three main components: Acute Physiological Score (APS), age and Chronic Health Status. The APS is made up of a sum of the weights of 12 variables, with each variable having a weight of 0-4, the higher the score, the greater the deviation from normal (Bouch and Thompson, 2008). However, the weight given to for the GCS score is different as it is calculated by subtracting the GCS score from 15 as shown in figure 1, giving the maximum weight for GCS as 12 and for the APS as 60. The weight for the age also

increase with increasing age giving a maximum of 6 for those above 75 years. For the Chronic Health status, non-operative or emergency post-operative patients score 2 points, while elective post-operative patients score 2 points.Bansal, Surve, Muthuchellappan, Rao and Philip, (2017), treated any missing values as normal and gave them a score of zero, this has also been the practice in similar studies. To get the final APACHE II score, one must sum up the points for all its three components.

The APACHE II however has several limitations. First, it uses the worst physiologic scores and laboratory data collected over 24 hours for prediction, collection of such data can be time consuming and tedious. The accuracy of the data is also dependent on the data collector as well as the accuracy of the data itself. To address this, concession has been made and the use of the admission data is accepted because it addresses these gaps. The use of this data is easier and results in less variability since comparison is not necessary. Secondly, during admission, it is more likely that the clinician makes decisions based on their perception on the survivability and long term outcome and quality of life of the patient. The APACHE II has not been applied to predict long term outcomes of such patients and therefore does not cover this shortfall. Despite its limitations, APACHE II remains largely accepted because its benefits outweigh its limitations.

2.4 COMPARISON OF APACHE II WITH OTHER ICU PROGNOSTIC SCORING SYSTEMS

In this section, we will have a side by side comparison of APACHE II amongst its peers. In 1984, an alternative for the APACHE score - the Simplified Acute Physiology Score (SAPS) was released. It was calculated from the deviation of 14 physiologic variables from their normal within the first 24 hours of admission. Unlike the APACHE, it did not take into consideration the pre-existing disease condition. Recent variations of the score- SAPS II and

SAPS III use 12 physiologic variables obtained within the first 24 hours of admission and further includes weightings for preadmission health status and age(Bouch & Thompson, 2008). From these, we can deduce that the APACHE model has a lot in common with the SAPS system of scoring. This can further be compared to other scoring systems.

The Mortality Prediction model is one such system. A probability of in-hospital death, rather than a severity score that needs to be further computed can be calculated byMPM which has two versions, this is done by summing up weightings for physiologic variables, acute diagnosis and chronic health status from data collected at admission and 24 hours post ICU admission. Its more recent version MPM II, utilizes age, therapeutic interventions and weightings for physiology, acute and chronic illness as variables from large populations by applying multiple regression analysis. Data is collected successively at 0, 24, 48 and 72 hours from admission to ICU (Bouch & Thompson, 2008).

APACHE II score is the most frequently used severity scoring system internationally.This is because, according to Naqvi, Mahmood, Ziaullaha, Kashif and Sharif, (2016)it has better discriminatory value across a range of diseases and better calibrationwhen compared to SAPS II and SOFA. Hosseini and Ramazani, (2016) stated that APACHE II and SOFA are the most validated and prevalent scoring systems all over the world. Although its accuracy is slightly superior, some users prefer MPM to APACHE due to MPM's simpler data collection.Hosseini and Ramazani, (2016) also argued that SOFA is simpler and easier to record data than APACHE II and therefore often chosen by institutions. Manual data collection burden remains lower in MPM and SAPS over APACHE according toBreslow and Pharmd, (2012).This shows that however much popular APACHE II is, its complexity may hamper its adoption in some settings.

Different settings should utilise different severity scores so as to be effective. Vincent and Moreno (2010), argued that the severity scores were developed for use in mixed cohorts of ICU patients and that they may not be accurate when used for in subgroups of patients. For this purpose, scoring systems for specific diseases and conditions are increasingly being developed such as the APACHE-HF developed by Okazaki et al., (2014) for predicting adverse outcomes in patients with acute heart failure. In a cohort of cardiac surgery patients, Cardiac Surgery Score (CASUS) and SOFA were found to be reliable ICU mortality risk stratification models for cardiac surgery patients – with CASUS being more accurate than SOFA in mortality prediction – in contrast, SAPS II and APACHE II performed poorly in terms of calibration and discrimination (Doerr, Badreldin, Heldwein, Bossert, Richter et al., 2011). Since the different scoring systems measure different parameters, and are developed for different purposes, they should therefore be seen as complementing each other, other than competing with one another.

A models' ability to differentiate between patientswho die and those who survive is known as discrimination and is assessed by examining the receiver operation characteristic (ROC) curves - a model with greater AUC (area under curve) is considered better and this can be used to compare different models. In a prospective study conducted by Sekulic et al., (2015), the area under the ROC for SAPS II was 0.690 which was slightly higher than of MPM II and APACHE II which was 0.654 and 0.623 respectively. However, the APACHE II was found to have the highest specificity (81.8%) and MPM II the highest sensitivity (85.2%).Zhou, Ben, Chen and Ni, (2015), in their study to compare APACHE II and Clinical Pulmonary Infection Score (CPIS) scores for the prediction of 30 day mortality for patients with Ventilator Associated Pneumonia in a Hospital in China, concluded that as opposed to CPIS, APACHE II showed good discrimination and Calibration with an AUC of 0.808. A model

with an AUC of 1 would be considered perfect, but we are yet to get there but are continuously working towards getting a model with better discrimination.

A newer model that shows better performance and predictive ability than the available models has since been developed although, this has been cited to be due to the small size of sample (36 participants) used to valid it. It was developed in single 27 bed ICU in Greece and recruited 400 participants, it therefore cannot be generalised. This novel model may be more flexible and easier to calculate, it uses 12 variables collected on day one of admission. In this study done by Fika, Nanas, Baltopoulos, Charitidou and Myrianthefs, (2018), they based the new model on the most widely used scoring systems in intensive care medicine, such as APACHE II, SAPS III and SOFA. Its AUC was 0.85 compared to 0.76 of both APACHE II and SAPS III. The predicted mortality was 41.63±31.61 with an observed mortality rate of 41.67%. There is need to validate this model in a large multicenter population.

2.5 PREDICTIVE POWER OF APACHE II

The discrimination of APACHE II remains quite high when put to test. In one study, Joe, Jo, Kim, Park, Hwang et al., (2012) used the tool on 37 patients with cardiomyopathy and found that the APACHE II score of 20 and above was associated with higher mortality.The mean APACHE II score in a study done by Hosseini and Ramazani, (2015)for immediate postoperative patients who died was 21.86 ± 6.91 compared with 12.19 ± 5.40 for survivors, $P< 0.0001$. In another study done by Naqvi et al., (2016) the average APACHE II scorein non-survivors (27.97+8.53) was higher than survivors (15.82+8.79) with statistically significant p value(<0.001).Patients with APACHE II scores less than 20 in a study done by Mir et al.,(2012)had 4.6 times higher odds of survival compared to patients with a score of >35. Despite the small differences in the study findings, it remains consistent that the odds of

survival remains higher with a lower APACHE II score and lower with a higher score. The score is therefore very reliable in predicting the odds for mortality.

However, the predictive value of APACHE II varies a lot depending on the cohort. According to Oliveira, Brauner, Filho, Susin, Draghettiet al., (2013)in a study done on transplant patients, there was significant overestimation of mortality of all the transplant patients with differing estimation in specific groups of the transplant patients and a gross underestimation among those who had undergone lung transplant (observed mortalities of 52% more than that predicted).In a study by Naved, Siddiqui and Khan(2011)on medical-surgical patients, the predicted mortality rates for different classes of patients based on their APACHE II score was slightly higher than the actual mortalities observed but with 100% mortality for those who scored above 40. In a study done to determine the risk stratification in cardiac surgery patients byDoerret al., (2011), APACHE II did not perform well in terms of calibration and discrimination statistics. This disparity may be attributed to overestimation of mortalities in high risk patients and underestimation in low risk patients. APACHE II scores therefore work best in mixed-cohort group of patients, its limitations are further discussed in the next section.

2.6 LIMITATIONS OF PROGNOSTIC SCORING SYSTEMS FOR CLINICAL USE.

The prognostic models cannot be used to determine the outcome of a single patient. They were not intended for prognosis of individual patients, rather they were established to give an indication of the risk of death of cohorts of ICU patients(Vincent & Moreno, 2010). These scoring systems give the best prognosis at a group level because their calibration and discrimination can never be perfect. Besides the uncertainty surrounding individual prognostic prediction, no single prognostic model, however clinically useful has an Area Under the resultant Curve (AUC) of the Receiver Operating Characteristic (ROC) greater

than 0.9, implying an imperfection of outcome prediction even at the cohort level (Keegan and Soares, 2016). This may explain why their uptake has been slow over time.

Several factors have hindered the adoption of these severity scores. The cost of information technology and infrastructure required when using some of these prognostic models to acquire and analyse data is quite high, forming a barrier to their use and widespread acceptance. APACHE III and IV were introduced as proprietary tools and only recently have the algorithms been made freely available(Breslow and Badawi, 2012). Other barriers according to Keegan and Soares (2016), included resistance from the health workforce due to their focus on prediction of mortality as opposed to functional outcome such as the quality of life, their perceived superiority of their clinical judgement on prognosis and their disregard for the relevance of the model to their patients. These can be mitigated by sensitization of the healthcare workforce on the use of these scores, doing more studies on them and working on any biases posed by the tools.

Several biases have been identified to hamper the proper utilisation of these tools. A lead-time bias can develop due to variations of care and duration of care provided prior to ICU admission,Breslow and Pharmd (2012), suggested that this affects severity-adjusted mortality prediction rates. While some Emergency departments may have accurate triage and transfer to the appropriate care setting promptly as their primary objective, others may focus on optimum early treatment and management to stabilize the patient. The former approach may lead to patients being admitted into the ICU with more deranged physiologic variables (such as, alkalosis or acidosis, higher respiratory rates) hence giving a higher mortality prediction with a lower actual to predicted ratio, with the latter approach having more ‘normal’ findings hence a lower mortality prediction and consequently a higher actual to predicted ratio. Bias may also develop as a result of the case mix, quality of care offered and the institutional policies, a small sample size may also gravely affect the calibration power of the model,

Hosseini and Ramazani, (2016) suggested that this could be mitigated by doing studies in large multicenter populations.In a study done by Fuchs, Novack, McLennan, Celi, Baumfeld et al.,(2014), the findings suggested that outcomes in critically ill elderly patients may not be influenced by an ICU admission and further that increasing the ICU bed capacity to deal with an increasing age of the population may not be effective. It is evident that these scores come with their load of biases and limitations and that these can be sorted out by customizing the severity scores to specific cohorts or using only the scores designed for those cohorts.

2.7 THEORETICAL FRAMEWORK

The theory of uncertainty in illness is applicable in this conceptual framework by Mishel (1990). According to Neville, (2003) the theory of uncertainty in illness is best utilised among patients in the acute phase of illness or those who are deteriorating. He further stated that adaptation - psychosocial behaviour within the person's normative level of functioning - is proposed as the end state achieved after coping with the uncertainty. In this case, the outcome of illness is an uncertainty of which, if accurately predicted in this case with APACHE II, would lead to adaptation of the patients, relatives and the healthcare workers.

There are two appraisal processes that can be adopted by the patient, their social resources and the healthcare provider, these are; inferences which refers to the evaluation of uncertainty based upon similar experiences and illusions which are constructions of beliefs that have a generally positive outcome, in this case recovery. Illusions are generated in situations with progressively negative outcomes. If personal evaluation of the event is interpreted as to have a positive outcome, then the uncertainty will be seen as an opportunity. Whereas, if interpreted as to have a negative outcome, they will be interpreted as a danger, in this case ICU mortality (Neville, 2003).

Practices and Hannay (2013), argued that uncertainty functions differently in chronic illnesses in comparison to acute illnesses. They stated that uncertainty decreases with time but returns with recurrence or exacerbation of illness, they also said that uncertainty was highest and most distressing when awaiting a diagnosis. It is at this time that APACHE II comes into play as it is accessed only within the first 24hours of admission. It therefore would not cater for uncertainties that develop later during the ICU stay and organ dysfunction scores would then be of help.

The association of post-traumatic stress and uncertainty has been reported in most populations dealing with illness. Studies of coping with uncertainty in acute illness have resulted in consistent findings for the relationship between uncertainty and emotion-focused-coping (Practices & Hannay, 2013). Having a prognostic tool such as the APACHE II model would go a long way in alleviating this uncertainty and hence help patients, their relatives as well as healthcare workers to better cope.

2.8 CONCEPTUAL FRAMEWORK

The following is a diagram of the conceptual framework that guides this study. It depicts how the APACHE II prognostic score, is used to determine the probability of death or recovery, and how this can help one to cope with the illness.

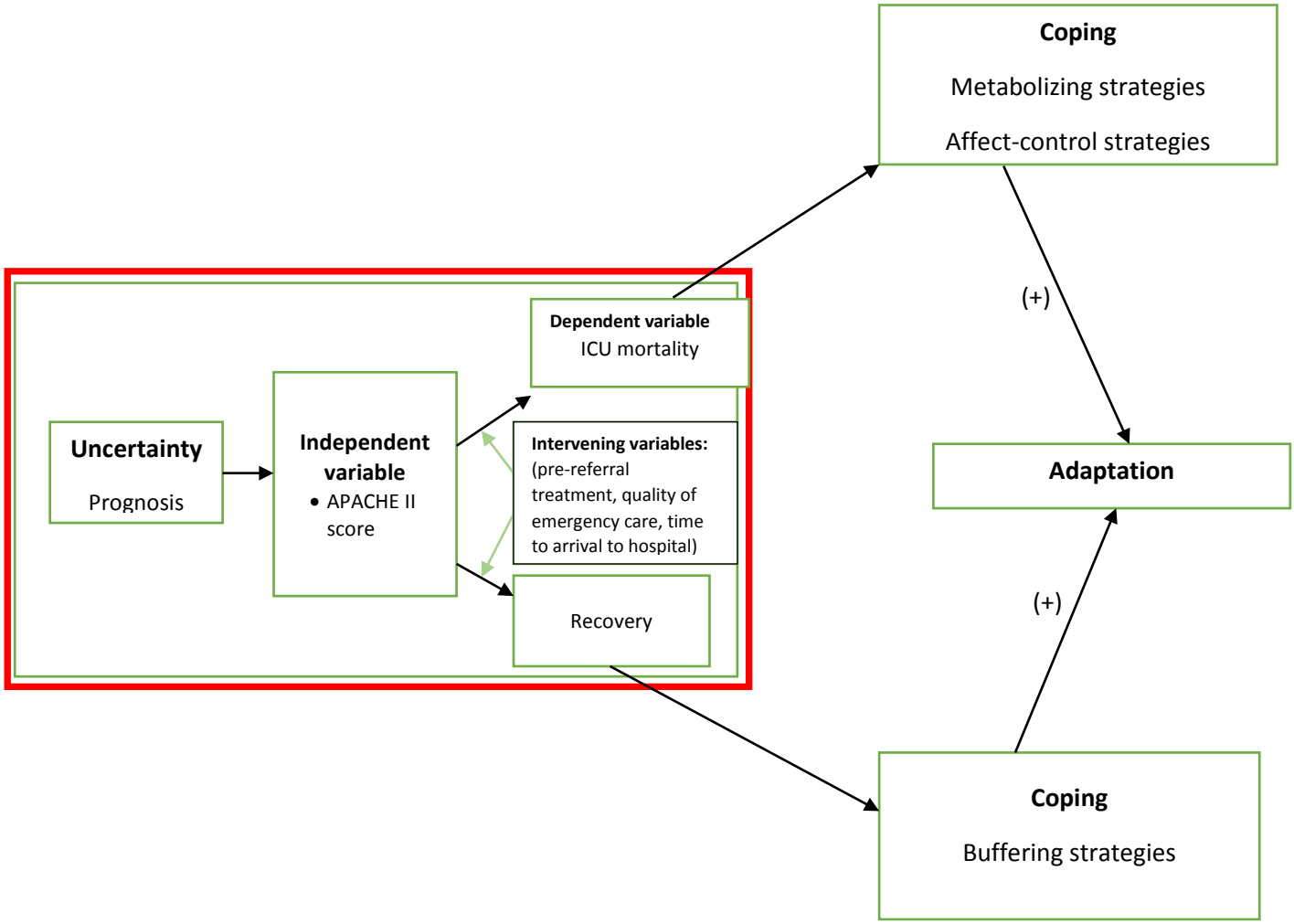

Figure 2: Conceptual Framework

Adopted from M. H. Mishel., 1990. Reconceptualization of the Uncertainty in Illness theory. Journal of Nursing Scholarship.

The red bold box in figure 2 above defines the area directly being studied in this research. Whereas the other parts are not being directly studied, they cannot be ignored as they are the reason and purpose for this particular study. The uncertainty of the acute illness of patients admitted in the critical care unit (Prognosis), can be resolved by the APACHE II score which consists of age, Acute Physiology Score and the Chronic Health Status of that patient. This can either predict anICU mortality or Recovery from illness.

The prediction of either an ICU mortality or Recovery from illness both lead to coping mechanisms by both the Patient, relatives, health care workers and the institution albeit in different ways, both lead to an adaptation. The prediction of an ICU mortality will lead to metabolizing and affect control Coping strategies whereas the prediction of an ICU recovery will lead to buffering strategies of coping. These are however not the subject of this study but should also be studied.

CHAPTER THREE: RESEARCH METHODOLOGY

The purpose of this study was to evaluate the validity of APACHE II scoring system as a prognostic tool in our set up.

3.1 STUDY DESIGN

The study was a retrospective cross-sectional study.This was because of the limitations in time and resources only allowing the study to be done post-hoc.

The data collected during the study covered a one year period (January 2017 – December 2017). The one year period was toensure adequatecoverage for variabilities in seasons, human resource and other resources for every month, for example, from the month of January through mid-March, the main ICU was undergoing fumigation and renovations and therefore only had an admission capacity of 10 as they had been moved to another smaller location.Data from the central registry department showed a total of 786 admissions; 186 and 600 admissions from medical and mainICU respectively in the year 2017.

3.2 STUDY AREA

The area of study was Kenyatta National Hospital (KNH). This is one of the National Teaching and referral hospitals in Kenya. It is located in the Kenyan capital city, Nairobi. It receives patients from all other hospitals across the country and neighbouring East African Countries. It also serves as a non-referral hospital mainly for Nairobi County and neighbouring counties. It serves as a teaching hospital for The University of Nairobi, College of Health Sciences as well as other Universities across the country. It has a total bed capacity of 2034 beds with a percentage occupancy rate of 82.4% in the year 2017. The facility has various specialities and departments in its 10-storey building. Kenyatta National Hospital had 74,580 total admissions in the year 2017 with an average of 8.3 days length of stay.

The Medical ICU is located on 8th floor, side A and 7th floor side A with a 10 bed capacity, though geographically separated, they are treated as one department. However, in the year 2017, the 7A side had not been operationalised and therefore the medical ICU only had a bed capacity of 5 in 8A. The Main ICU is located on 1st floor with 21 bed capacity, it is opposite the Burns Unit, and in close proximity with the Theatres and Renal Unit.The medical ICU recorded 186 admissions in the year 2017 averaging 15.5 admissions per month, there were122 discharges against 66 deaths averaging a death rate of 35.1%, the average length of stay was 8.6 days with 91.2% bed occupancy. The main ICU recorded 600 admissions averaging 50 admissions a month, there were 208 deaths against 383 discharges with an average death rate of 35.2%, the average length of stay was 10.8 days with an 83.6% bed occupancy. The data available for specific months showed a huge variabilities on admissions and deaths within the units.

3.3 STUDY POPULATION

The study population included all the adult patients admitted to medical and main ICU at the Kenyatta National Hospital.

3.4 SAMPLE POPULATION

This included the files of adult patients admitted to Kenyatta National hospital medical and mainICU between the months of January and December in the year 2017 and additionally those met the eligibility criteria for the study.

3.5ELIGIBILTY CRITERIA

3.5.1 Inclusion Criteria

This included all the adult patients admitted to Kenyatta National Hospital Medical ICU and MainICU during the period January to December 2017, it includedpatients who were above the age of 16 years. This was togive the study a focus on the adult patient as well as to be in

sync with the recommendations from the founders of the prognostic model (Knaus et al., 1985).

3.5.2 Exclusion Criteria

The study excluded all the patients who were admitted before or after the period of January to December 2017, it also excluded all the admissions who were below the age of 16 years to give a consistency in the physiological findings. Files with a lot of missing data were also excluded from the study.

3.6SAMPLE SIZE DETERMINATION

The sample size was calculated using the (Daniel, 1999) formula for estimating sample size for a survey in a finite population

$$\boldsymbol{n = \frac{Nz^2p(1-p)}{e^2(N-1) + z^2P(1-p)}}$$

Where

n = Sample size

z = z statistic for a two-tail level of significance (alpha) value of 0.05 z=1.96

p = Expected proportion (estimated at 86%, from a study conducted by Knaus et al., (1985) found 86% of the population under study were correctly classified by the tool.)

e = Precision (in this case the precision used was 5%, therefore d = 0.05)

N = the estimated patient population during the study period (Jan – Dec 2017) was 786

Using these parameters the minimal sample size was 150.

This value was inflated by 20% to cater for incomplete data and the final sample size was set at a minimum of 180.

Table 1: Sample size determination, selection and adjustments per strata

Month (Strata)	Medical ICU	Main ICU	estimated proportion	Adjusted by 20% for missing data
Jan	12	2	2.672	3
Feb	4	3	1.336	2
Mar	7	27	6.489	8
Apr	20	56	14.504	17
May	19	56	14.313	17
Jun	14	65	15.076	18
Jul	18	56	14.122	17
Aug	12	67	15.076	18
Sep	18	68	16.412	20
Oct	20	70	17.176	21
Nov	23	65	16.794	20
Dec	19	65	16.031	19
Total	186	600	150	180

Table 1 shows how the sample was selected for every month of the year, the number of admission for each month per ward and the adjusted sample size for every month of the year.

3.7 SAMPLING METHOD

Stratified random sampling method was used, with the total population divided into twelve strata with each strata being the twelve months of the year as shown in table 1. Simple random sampling was used for each strata, to select the files of patients admitted in every month of the year.

For every month, each file admitted was coded, the codes were written in pieces of paper equivalent to the total number of admissions in the two wards for that month (for example; 34 pieces of paper with codes for the month of March). The pieces of paper were folded and put in one jar, mixed and a number equivalent to the sample size for that month as indicated in table 1 picked up randomly (for example; 8 pieces of paper picked from the 34 in the jar for the month of march 2017).

3.8 ETHICAL CONSIDERATIONS

Approval was sort from KNH-UON Ethics and Research Committee and from the Head of Department KNH Health Information and Records Department for collection of data and analysis.

There was no direct contact between the researcher and the patients. Any information gotten from the patients' files was treated with utmost confidentiality. The names of the patientsplus any personal identifiers were not collected from the patients' files and no information on individual patientswas shared to anyone not involved directly with this study.

No files were carried out the Central registry department and all the data collection was conducted within the department.

3.9 PRETESTING OF DATA ABSTRACTION TOOL

Prior to conducting the study, the study toolwas pretested in the same area to determine its validity. The views of the researcher on the structure of the data abstraction tool and its quality was considered in reviewing and restructuring. The files of patients used in the pretesting exercise were not recruited to participate in the actual study. 10% of the sample population (18 files) were used, these were retrieved from the year 2016.

It is during this that it was noted that the researcher had left out a section on the outcome of the patients admitted, the date of admission into the ICU was also added as in some instances it was different from the date of admission into the hospital.

3.10 DATA MANAGEMENT

3.10.1Data collection

Files of patients admitted between the dates of 1st January 2017 and 31st December 2017 were sourced from the Health Information and Medical Statistics department of KNH. The

requisite Search and Retrieval fees were paid as per the Departments Service Charter. The retrieval rate ranged from 5 to 35 files per day.

For every month, files were selected randomly from the daily bed return (DBR) register from the statistics section of the Health information records department. The sample size for each month was further inflated by 20% to cover for those files that were lost, traced elsewhere in the hospital or could not be traced. The files of those who were discharged from ICU and those who died were traced separately as they were stored in different locations, with those that were alive being traced first. Once the sample size for the month was reached as shown in table 1, retrieval of files from the second month was initiated.

All the relevant data was collected from the sampled files and filled into the data abstraction form shown in appendix III. The raw data was then entered into a secure data entry excel sheet on a personal computer.

3.10.2 Data cleaning, coding and handling

Any unavailable data on the physiologic score was treated as a normal value with a score of 0. This was based on the practice in similar studies (Bansal et al., 2017).

3.10.3Data analysis & presentation plan

The data was exported into IBM SPSS Statistics 24 software. Data cleaning and screening for outliers, accuracy and missing values was done.

Frequencies and percentages of the demographic data was calculated to describe the study population and other variables of interest. Bivariate analysis was then conducted to determine unadjusted factors associated with accurate predictions of APACHE II. To examine the research questions, a binary logistics regression was done to examine whether APACHE II score predicted mortality.The binary logistic regression is an appropriate statistical analysis

when the purpose of research is to assess if a set of independent variables predict a dichotomous dependent variable (Stevens, 2009).

Calibration defined as the degree ofcorrespondence between predicted and observedmortality, was assessed using theHosmer-Lemeshow goodness of fitC statistic. If the predicted mortality is close to the observed mortality, then the calibration is said to be good.Points of 25 or less denote less than 50% mortality, while points of 35 or more denote more than 80% mortality (Hosseini and Ramazani, 2015).

Model discrimination was assessed to determine the ability of the model to discriminate between the patients who die from those who survive based on the predicted mortalities. The area under the resultant curve (AUC) of the receiver operating characteristic (ROC) curve was calculated to assess the discrimination. An ROC of 0.5 is no better than chance such as a coin toss, whereas values of 0.7, 0.8, and 0.9 are considered acceptable, excellent, and outstanding, respectively. Perfect discrimination will give rise to an AUC of 1(Breslow and Badawi, 2012).Finally a cut off valuewas calculated, sensitivity, specificity and overallcorrectness of prediction was determined and a comparison among survivors and non-survivorswas done using odds ratio.

The results were presented as graphical representations and in tables as deemed fit.

3.10.4Data storage

The filled data abstraction forms used to collect the data from the patients' files have been kept in a locked cabinet by the principal investigator. This will be done for a period of one year after completion of the research before being destroyed. Data from the abstraction forms was extracted and entered into a secure data entry platform on a computer owned by the principal investigator.

3.10.5Data dissemination plan

The study findings were presented as a dissertation in partial fulfilment of the requirements for the award of the Master of Science in Nursing (Critical Care Nursing) Degree of The University of Nairobi. The dissertation was uploaded onto the repository and website of the UoN. In addition the study findings were presented and to the School of Nursing Sciences faculty as well as published in a refereed scientific journal. Moreover, the study findings will be presented in scientific conferences and seminars as well as presented to members of staff working in Medical and mainICU, Kenyatta National Hospital and to the relevant authorities at KNH in order to inform decisions and policies that will lead to improvement and management of the Critically Ill.

3.11 STUDY LIMITATIONS

The study was a retrospective study and therefore the study variables gotten from the files were limited to the data available and recorded in the files. This was overcome by excluding the files without enough data from the study as outlined in the exclusion criteria, however files with only single missing values were not excluded but the missing values were treated as normal values as stated in section 3.10.2. The researcher recommends a prospective study on the same to overcome this limitation.

The study involved only a small sample size of 180 files of patients in two ICU's in KNH, this does not provide a statistically significant sample to allow for generalizability to the rest of ICU's in the country. Further research is recommended to be done in more Intensive Care Units from both private and public hospitals across the country to cater for this.

The data collection process was hampered and slowed down by huge gaps in documentation in the files. For example, in most files the nursing notes, lab reports and the doctors' notes were not arranged in a chronological manner and in some instances one could not tell the

records for the first 24 hours of admission. Further, even though the time was always recorded in the nursing notes, rarely were the dates recorded, leaving the researcher to only the assume the dates followed each other chronologically.

CHAPTER FOUR: RESULTS

4.1 INTRODUCTION

This chapter presents the findings of the study. The results are presented and interpreted based on the objectives and conceptual framework. These include socio-demographic characteristics among adult participants admitted in KNH's ICUs, description of the APACHE II scores among those participants, and an evaluation of the scores with the outcome. The results are presented in frequency distribution tables and figures.

4.2 RESPONSE RATE

One hundred eighty (180) files of adult participants admitted in KNH's ICUs in the year 2017 were included in the study.

4.3 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS

The researcher sought to determine the socio-demographic characteristics of the 180 participants included in the study. A majority of the participants were aged 45 years and above (33.9%, n=61) followed by those aged between the age 18 to 24 years (17.8%, n=32). More than half of the participants were males (58.3%, n=105). Concerning the county of residence, a majority of the participants (52.8%, n=95) were from Nairobi County.These findings are as shown on table 2.

Table 2 Socio-demographic characteristics of participants

Attributes	Frequency	Percent (%)
Age in years		
18 to 24	32	17.8
25 to 29	16	8.9
30 to 34	24	13.3
35 to 39	27	15.0
40 to 44	20	11.1
45 years and above	61	33.9
Total	**180**	**100.0**
Gender		
Male	105	58.3
Female	75	41.7
Total	**180**	**100.0**
County of residence		
Nairobi	95	52.8
Kiambu	12	6.7
Machakos	11	6.1
Kajiado	7	3.9
Muranga	7	3.9
Nyeri	7	3.9
Others	41	22.8
Total	**180**	**100.0**
Occupation		
Unemployed	83	46.1
Self-employed	65	36.1
Salaried	16	8.9
Student	16	8.9
Total	**180**	**100.0**
Religion		
Christian	165	91.7
Muslim	15	8.3
Total	**180**	**100.0**
Outcome		
Died	56	31.1
Survived/discharged	124	68.9
Total	**180**	**100.0**

Regarding occupation, a majority of the participants were unemployed (46.1%, n=83). A large percentage (91.7%, n=165) were Christians with the rest (8.3%. n=15) being Muslims. Concerning the outcome status, majority of the participants (68.9%, n=124) were discharged alive from the ICU's while the rest (31.1%, n=56) died in ICU as shown in table 2.

4.4 DESCRIPTION OF THE APACHE II SCORES OF ADULT PARTICIPANTS ADMITTED IN KNH'S ICUS

The ICU mortality was calculated based on the diagnostic categories. About one third of the adult participants died and the risk of death was calculated using APACHE II method. In this method, each score was calculated for each patient based on the 12 physiologic scores with a maximum score of 60, the age with a maximum score of 6 and the chronic health status with a score of 5. The sum of the scores was the APACHE II score. This was compared to the observed mortality as shown in table 3. The predicted mortality score was the same with the observed mortality score. This indicates that the tool has an excellent calibration to predict mortality.The overall mean of APACHE II score was found to be 20.58 ranging between 7 and 40.

Moreover, as a measure of calibration from the model, the Hosmer and Lemeshow goodness-of-fit statistics revealed $\chi^2 = 0.000$ (p value=1.000) indicating strong agreement between observed and expected ICU mortality as indicated in table 3. A good calibration is considered to be consistent with a small chi squarevalue for the Hosmer and Lemeshow test statistic.

Table 3 Description the APACHE II scores of adult participants admitted in KNH's ICUs

APACHE SCORE	Number of participants, n(%)	Participants died, n(%)	Participants discharged, n(%)	Observed mortality	Expected mortality
3 - 10	11(6.1)	0(0.0)	11(6.1)	0	0.0
11 - 20	94(52.2)	7(12.5)	87(70.2)	7	7.0
21 - 30	49(27.2)	29(51.8)	20(16.1)	29	29.0
31 - 40	26(14.4)	20(35.7)	6(4.8)	20	20.0
Total	**180(100.0)**	**56(31.1)**	**124(68.9)**	**56**	**55.9**
Hosmer and Lemeshow goodness-of-fit test: Chi-square value = 0.000; p value = 1.000					

4.5 DISCRIMINATORY PERFORMANCE OF APACHE II TO PREDICT PARTICIPANTS' MORTALITY AT KNH ICUS

The receiver operating characteristic (ROC) curve for APACHE II score and observed death/mortality is depicted in Figure 3. The curve is created by plotting the true positive rate (sensitivity) against the false positive rate at various threshold points. The ROC curve is far above the diagonal line, this shows that it is an appropriate predictor for mortality/death. Further the figure shows that the optimum cut-off value is 20.5 with sensitivity 87.5% and specificity 79.0%. The closer the ROC curve is to the upper left corner, the higher the overall accuracy of the test.

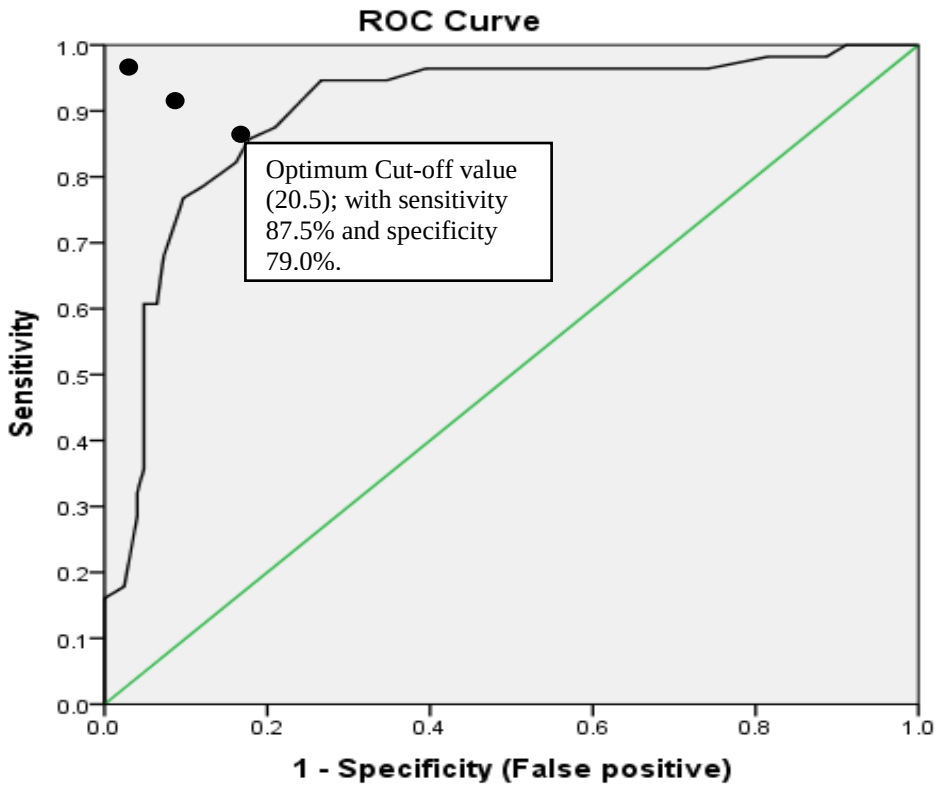

Figure 3: Receiver operating characteristic curve (ROC) for APACHE-II score

The discriminatory performance of the APACHE II model revealed the Area under the curve (AUC) was 0.889. It was statistically significant with $p<0.001$ and 95%CI of 0.82 and 0.95.

This indicates that the model has good ability to distinguish between participants with a high risk of mortality and those with a low risk of mortality.

4.6 APACHE II SCORES BETWEEN KNH MEDICAL AND MAIN ICU

The researcher sought to compare between illness severity and APACHE II scores between KNH Medical and Main ICUs. There was statistically significant differences in mean score of APACHE II between Main and Medical ICU (p=0.004) where the score was more among medical ICU participants (22.85) compared to 19.38 among main ICU participants. Table 4 shows the mean and standard deviation of the APACHE II score from the two ICUs.

Table 4: APACHE II scores between KNH medical and main ICU

Variable	Main ICU, (n=118)		Medical ICU (n=62)		Independent t test (p value)
	Mean	Std. deviation	Mean	Std. deviation	
APACHE II Score	19.38	7.86	22.85	7.20	**0.004**

This shows that the participants admitted in the Medical ICU had more severe illness as described by the APACHE II score of 22.85 as compared to that of Main ICU (19.38).

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents the discussion of the findings, conclusion and recommendations based on the findings.

5.2 DISCUSSION

Among critically ill patients, several scoring systems have been introduced and developed over the last 30 years. Though many factors and scoring systems have been identified to diagnose and predict mortality, the acute physiology and chronic health evaluation (APACHE) II is one of the most widely used scoring systems (Desai et al., 2013). Higher scores correspond to more severe disease and a higher mortality (Wong et al., 1995; Gupta and Arora, 2004). This system consists of three components: Twelve physiological variables along with previous state of patient's health and age. The performance of APACHE II as prognostic score must be evaluated prior to being used. Its use in the Kenyan setting has not been validated, though its performance has been evaluated in other countries with variable results. Prediction of patient prognosis admitted in intensive care unit always remains an area of great concern for physicians as well as for patient's families. The aim of the study was therefore, to evaluate the predictive ability of hospital mortality of acute physiology and chronic health evaluation score among participants admitted to intensive care units of Kenyatta National Hospital, Kenya.

In regard to demographic data of the participants, the mean age was 41.85±18.0 years, varying between 18 and 91 years. This was lower compared with 56.9±19.2 years varying between 19 and 97 years (Cardoso and Chiavone, 2013) 51.26±17.9 ranging from 15 to 84 years reported from Pakistan (Naved et al., 2011), 50±19 ranging from 13 to 91 years reported from Brazil (Chiavone and Sens, 2003), 53(±19.5) reported from Hong Kong (OH et al., 1993) and 56 (±15.9) reported from Netherland (Polderman et al., 2001). Similarly it was

lower compared to those reported by El-Shahat et al. (2015), by Tonnelier et al. (2011), and Mansoura et al. (2013). The lower mean age in this population may have been attributed to the high percentage of youths admitted with severe head injuries secondary to Road traffic accidents in that lower age group, the KNH ICUs are also multidisciplinary admitting all kinds of patients. Most of the other studies were done among older participants. However, it is known that as age increases the morbidities and mortalities also increases among critically ill participants which could be associated with physiological changes.

The study has revealed that the observed mortality during the ICU stay at the hospital was 31.1%. This was comparable to the findings by Saleh et al. (2015), Hosseini and Ramazani, (2016), and Jarrell et al. (2018) which reported the overall mortality rate of 27.3%, 27.3% and 33.9% respectively. However, it was higher compared to the study findings reported from USA, Canada, and Japan (17–25%) (Chen et al., 2001, Sirio et al., 1992). Studies conducted by Cardoso and Chiavone. (2013), Freire et al. (2010) and Mbongo et al. (2009) showed much lower ICU mortality 11.0%, 8.2% and 5.3% respectively compared to the findings of this study. But it was lower than the studies reported by El-Shahat et al. (2015) which was 40.9% and reported by Alves et al., 2010 which was 62.8%. These difference could be attributed by availability of human resources, better medical equipment and other resources in the hospitals in USA, Canada and Japan as compared to the other settings. The high mortalities in the other studies may have been due to the different cohorts where El-Shahat et al recruited only mechanically ventilated participants and Alves et al recruited only geriatric participants above the age of 60 years. The different sample sizes and cohorts may be attributed to the other minor differences.

5.2.1 Discriminatory performance of APACHE II to predict participants' mortality

When examining the discriminatory performance of the APACHE II score, the overall mean of APACHE II score was found to be 20.58 ranging between 7 and 40, this is related to the

various conditions and severity of cases admitted in the ICU ranging from participants admitted postoperatively only for observations and monitoring to very severely ill participants. This finding was similar with the mean of 20.84 reported from Pakistan (Naved et al., 2011), 20 reported from Hong Kong (OH et al., 1993), 20.1 reported by Naqvi et al. (2016), 22.6 reported by Loh et al. (2017), 23.8 reported by El-Shahat et al. (2015) and 17.46 reported by Sánchez-Hurtado et al. (2016). This may be attributed to similar cohorts of participants, a similar sample size and study design used hence similar findings. However, it was lower than those reported by Hosseini and Ramazani, 2015 as 32.39 which examined participants in Post-Anaesthesia Care Unit and it was higher compared to 15.4 reported by Ho et al. (2006), 10.7 and 16.5 reported from United States (Chiavone et al., 2003) and 12.87 reported from India (Gupta and Arora, 2004). The discrepancies of these findings could be due to strict institutional admission policy because of limited ICU beds, the use of different principles of measuring the scoring system (APACHE II), the different cohorts of the participants or the study design used. Generally, the APACHE IImean from this study indicate that the participants were more severely ill at the time of admission in the ICU.

The study also showed that in each successive APACHE-II score interval of 10, the mortality rates were higher than that of the preceding interval. The mortality has increased from 3.4% to 53.4% to 78.6% with APACHE II score of less than 10, 20 to 29 and 30 to 40 respectively. These findings are expected from the model of Knaus et al, (1985) and comparable to a study carried out in Pakistan (Naved et al., 2011). These findings confirmed the capability of APACHE II scoring system to stratify participants according to the degree of severity of their disease.

The predicted mortality score was the same as to the observed mortality score. This indicates that the tool has an excellent calibration to predict mortality. Moreover, as a measure of

calibration from the model, the Hosmer and Lemeshow goodness-of-fit statistics revealed a strong agreement between observed and expected ICU mortality

The APACHE II score as per the study can be an appropriate predictor for mortality/death as ROC curve is far above the diagonal line. The area under the ROC curve was found to be 0.889 which implies an excellent predictor of mortality. Normally the area under the curve (AUC) of 0.5 (a diagonal line) is equivalent to random chance, AUC >0.7 indicates a moderate prognostic model, and AUC >0.8 (a bulbous curve) indicates a good prognostic model (Metz, 1978). Similarly, an observational prospective study conducted by Hosseini and Ramazani, (2015) revealed the area under ROC of 0.857. Different study demonstrated varying result of area under the ROC curve for instance Gursel and Demirtas. (2006) in a prospective observational cohort study showed 0.81 and Qiao et al. (2012) found 0.76, this may be attributed to the study design used. However, very few studies for example Adam et al. (2013) found no statistically significant association between APACHE II scores and mortality. The sample's profile, in addition to the characteristics themselves of the care and the service in different countries, may explain the difference in the area under the ROC curve, and consequently the difference in the index's discriminatory capacity.

Moreover, studies show different results in relation to the capacity to predict death using the APACHE II (Zanon et al., 2008; Doerr et al., 2011). Generally speaking, the literature points to the APACHE II's good performance when used in general ICU (Chiavone and Sens, 2003). When compared to indices developed for specific groups of participants, its capacity to predict mortality reduces (Fernandes et al., 2009), except when modifications in the structure occur, with the inclusion of new variables which improve its performance (Mercado-Martínez et al., 2010).

Further the study showed that the optimum cut-off value is 20.5 with sensitivity 87.5% and specificity 79.0%. This result on the cut-off score were consistent with the findings of Grmec and Gasparovic (2001), Cho and Wang (1997) and Yoon et al. (2018), at 17, 19 and 20.1 respectively. However, the cut-off score was lower according to the study conducted by Tsai et al., (2012) and Hosseini and Ramazani (2015) at 13 and 13.5 respectively.

5.2.2 APACHE II scores and participants outcomes between KNH medical and main ICU.

When the researcher compared the APACHE II score between the participants from the Medical and the Main ICU, there was significant differences in mean score of APACHE II between main and medical ICU where the mean score was more among medical ICU participants22.85 compared to 19.38 among main ICU participants.This may be because of the small ICU bed capacity of 5 beds in the medical ICU as compared to a bed capacity of 21 in the Main ICU, hence only the very severely ill medical patients given priority for admission. This is in line with the study done in Australian ICU following acute exacerbations of COPD that indicated in-hospital mortality during the study period was 18.7% and ICU mortality was 11.5% (Brown et al., 2018). A similar result was also reported that a considerable number of participants die on the wards after discharge from the ICU (Oliveira et al., 2010; Freitas, 2010). The ICU mortality rates recorded from previous studies were between 6% and 29% (Ai-Ping et al., 2005; Alaithan et al., 2012 and Ongel et al., 2014) and hospital mortality ranging from 11% to 48% (Ai-Ping et al., 2005; Alaithan et al., 2012; Conti et al., 2015; Ongel et al., 2014).

This is also likely to be related to higher standards of care and improved management of co-existing chronic illnesses in the main ICU or the fact that post-operative surgical participants admitted in Main ICU may have a better prognosis than chronic Medical participants admitted to the Medical ICU. Although the occurrence of death after discharge from ICU

may be related to the natural progression of the illness, when all the therapeutic possibilities have been exhausted, it may also be the result of factors such as the limitation of human resources and availability of equipment, principally in services where intensive care units are not available (limited support set-up for the critical care services) (Daly et al., 2001). For this reason, it becomes highly important to identify high risk participants who could benefit from either a longer period of treatment.

5.3 CONCLUSION

The mean APACHE II score higher in non-survivors when compared to survivors as expected, the higher the APACHE-II score was, the higher the risk of mortality. The overall mean of APACHE II score was found to be 20.58 ranging between 7 and 40.

The study also revealed that the APACHE II score is an excellent predictor for mortality/death with the predicted mortality same as the observed mortality.

There was statistically significant differences in mean score of APACHE II between main (19.38) and medical ICU (22.85)(p=0.004).. The results of this study showed usefulness of APACHE-II scoring system to classify participants according to their disease severity.

5.4 RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

- APACHE II can be useful to stratify the patients according to the degree of severity both at admission and before discharge from the ICU
- Special attention should be given to those critically ill patients admitted to the medical ICU and there is need that the medical ICU to be well equipped with standard care and technology

5.5 FURTHER RESEARCH

A prospective study design (cohort) is recommended to shed more light on the use of APACHE II to predict mortality. Though APACHE II in this study was found to be an excellent predictor for mortality/death, further studies are necessary to ascertain whether these same variables are also appropriate to be measured when the patient admits or leaves ICU

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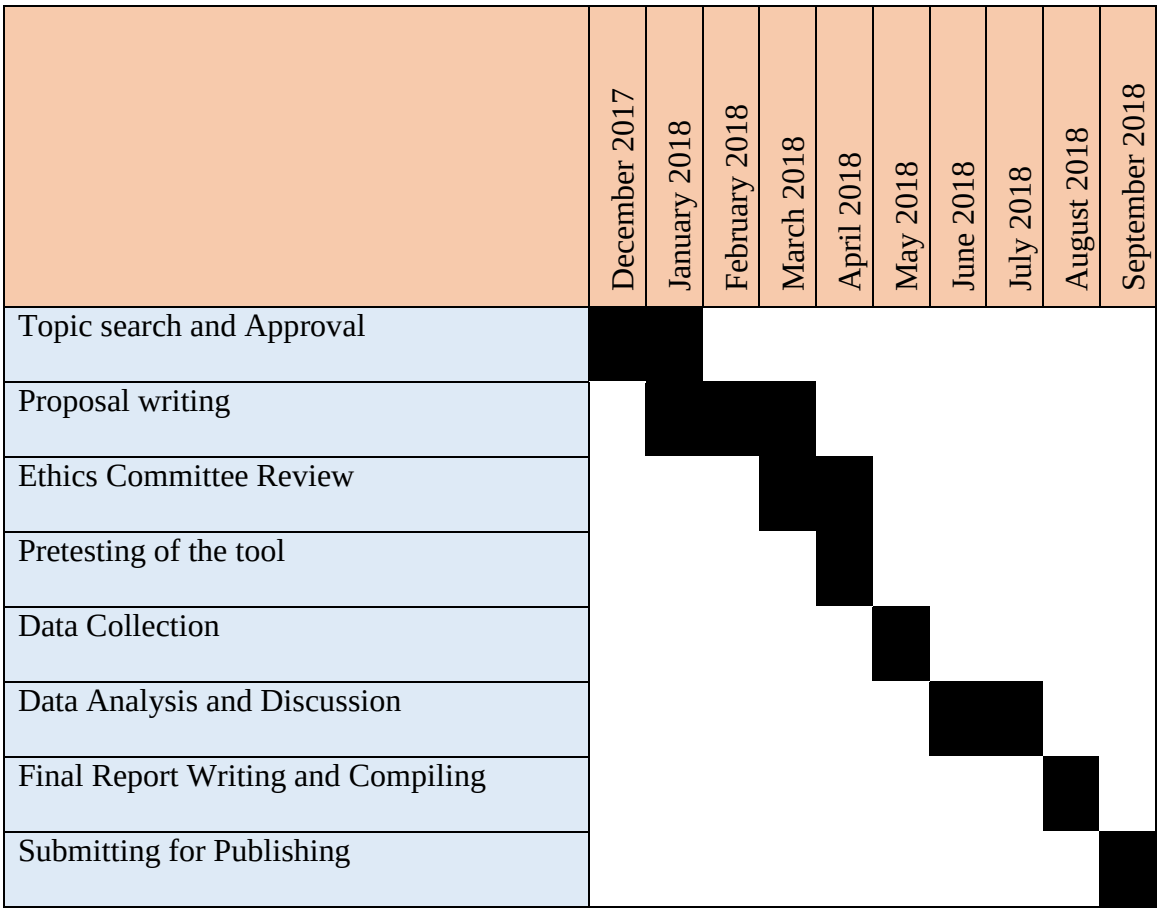
APPENDICES

APPENDIX I: WORK PLAN FOR THE PERIOD DEC 2017 –SEPT 2018



APPENDIX II: BUDGET

ITEM	NO. OF UNITS	COST PER UNIT (KSHS)	TOTAL COST (KSHS.)
A. STATIONERY			
Pens	20	10	200
Pencils	10	10	100
Rubbers	4	15	60
Folders	4	75	300
Flash disc	1	1500	1500
Sub Total			**2,160**
B. **SERVICES**			
Internet subscription	4 months	3000	12000
Proposal printing	50 pages x 1	5	250
Proposal Photocopying	50 pages*10	2	1000
Proposal binding	3 copies	100	300
Report printing	100 pagesx6	5	3000
Report binding	5 copies	500	2500
Data abstraction form printing	5 pages	5	25
Data abstraction form copies	5 pages*200	2	2000
KNH Central Registry statistics fee	once	500	500
KNH Central Registry Search and Retrieval of files fee	once	1500	1500
Ethics Committee Fee	1	2000	2000
Research assistants	2	10,000	20,000
Statistician fee	1	30,000	30,000
Publishing fee	One journal	50,000	50,000
Sub Total			**125,075**
Cumulative Sub total			**127,235**
Contingencies (10% of total cost)			**12,723**
GRAND TOTAL			**139,958**

APPENDIX III: DATA ABSTRACTION SHEET/FORM

DATA ABSTRACTION FORM TO EXPLORE OUTCOMES AND APACHE II PREDICTIONS FOR THE CRITICALLY ILL PATIENTS: A STUDY OF KNH CRITICAL CARE UNITS

This data abstraction formwill be used as a study instrument to collect data retrospectively from patients files admitted to KNH mainICU and Medical ICU within the period January 2017 to December 2017 for the Central Registry Departments and the Wards for those still admitted by the time of Data Collection.

Data will be collected only from those patients' files that meet the inclusion criteria: the patient must be aged 16 years and above. Must not have been sedated or paralysed by the time of admission.Any unavailable data will be treated as a normal value with a weight of 0 on the Apache II Score.

ICU: MainICU ☐ Medical ICU ☐

Serial No: ☐ Date of Admission: _____/_____/2017

A. Demographic Data

1) Age in years : _____
2) Gender: Male ☐ Female ☐
3) County of residence: _____
4) Occupation:
   a) Unemployed ☐
   b) Self-employed ☐

c) Salaried ☐

d) Business ☐

e) student ☐

5) Religion:

a) Christian ☐

b) Muslim ☐

c) Others ☐

6) Admitted to ICU from:

a. Other ward in KNH ☐

b. Accident site ☐

c. Home ☐

d. Private clinic ☐

e. Public referral centre ☐

7) Estimated time in hours from referral to KNH casualty: _____

8) Hours from arrival to A/E to admission to ICU: _____

9) Duration of Mechanical Ventilation in days: _____

10) Length of stay in ICU in days: _____

B. Acute Physiology Score

The most deranged variable recorded within the first 24 hours of admission will be recorded.

And missing data will be noted.

1. Temperature (◦c): _____
2. Mean Arterial Pressure (mmHg): _____
3. Heart Rate (b/min): _____
4. a. Was the patient Intubated? Yes ☐ No ☐

   b. Respiratory Rate (breaths/min): _____

5. Fraction of inspired air (FIO_2): _____
6. Partial Pressure of Carbon dioxide (PCO_2): _____
7. Partial Pressure of Oxygen (PaO_2): _____
8. Arterial pH: _____
9. Serum Sodium (Na) (mMol/l): _____
10. Serum Potassium (K) (mMol/l): _____
11. Serum creatinine (Cr) (mg/100ml): _____
12. Haematocrit /Packed Cell Volume (PCV) (%): _____
13. White blood cell count ($x10^3$ mm^3): _____
14. Glasgow Coma Scale: _____

C. Chronic Health Status

1) Admission Diagnosis: Specify:_____
   a) Cardiovascular disorder ☐
   b) Neurological Disorder ☐
   c) Pulmonary disorder ☐
   d) Post arrest patient ☐
   e) Immediate patient ☐
   f) others ☐
2) History of any of the following:
   a) Biopsy proven cirrhosis: ☐
   b) Documented portal hypotension: ☐
   c) Hepatic failure/ encephalopathy / coma: ☐
   d) Diagnosed New York Heart Association heart failure class IV: ☐
   e) Chronic hypoxia: ☐
   f) Chronic hypercapnia: ☐

g) Severe pulmonary hypertension >40mmHg: ☐

h) Ventilator dependence: ☐

i) Receiving Chronic Dialysis: ☐

j) Patient on any immunosuppressant therapy: ☐

k) Patient has HIV/leukaemia/lymphoma: ☐

3) Is the patient a readmission to ICU?

a) Yes ☐

b) No ☐

4) Any complications arising In ICU?

a) Yes ☐

b) No ☐

5) If yes in 4 above, specify:_____

6) Was the patient operated on?

a) Yes ☐

b) No ☐

7) If yes to 6 above, was it an emergency operation?

a) Yes ☐

b) No ☐

8) If yes to 6 above, when was the surgery done?

a) Immediately prior to admission to ICU ☐

b) Admitted to the ward first ☐

c) At a referral facility ☐

d) During admission to ICU ☐

APPENDIX IV: LETTER TO KNH/ UON RESEARCH AND ETHICS COMMITTEE

Benjamin Kamau Munyua,
School of Nursing Sciences,
University of Nairobi.
Reg. No.: H56/87198/2016

April 3rd, 2018

The Chairman,
UoN/KNH Ethics and Research Committee,
P.O. Box 20723-00202,
Nairobi.

RE: RESEARCH PROPOSALAPPROVAL

As part of Master of Science in Nursing (MSc. N.) program, I am required to carry out research and compile a project report. I hereby present this proposal '**APACHE II predictions for the critically ill patients at KNH critical care units'** for review and approval. The study will be retrospective study carried out at the KNH ICU.

I look forward to your comments and suggestions for improvement of the proposed study.

Yours faithfully,

_____

Benjamin Kamau Munyua

+254 723 004 702

bkamau08@gmail.com

APPENDIX V: LETTER OF PERMISSION FROM DEPUTY DIRECTOROF CLINICAL SERVICES KNH

Benjamin Kamau Munyua
School of Nursing Sciences,
University of Nairobi.
Reg. No.: H56/87198/2016

April 3rd, 2018

The Deputy Director Clinical Services,
Kenyatta National Hospital,
P.O. Box 20723-00202,
Nairobi.

Dear Sir/Madam,

RE: PERMISSION TO CONDUCT A RESEARCH IN ICU, KNH

I am a second year postgraduate student at School of Nursing Sciences, University of Nairobi. I am kindly requesting for permission to carry out a research study on '**APACHE II predictions for the critically ill patients at KNH critical care units'**

Enclosed is a copy of our research proposal and copy of my student identification card.

Your assistance will be highly appreciated. Thank you in Advance.

Yours sincerely,

_____

Benjamin Kamau Munyua

+254 723 004 702

bkamau08@gmail.com

APPENDIX VI: LETTER OF PERMISSION FROM THE HEAD OF DEPARTMENT, CENTRAL REGISTRY, KNH

Benjamin Kamau Munyua
School of Nursing Sciences,
University of Nairobi.
Reg. No.: H56/87198/2016

April 3rd, 2018

The Head of Department,
Central registry Department,
Kenyatta National Hospital,
P.O. Box 20723-00202,
Nairobi.

Dear Sir,

RE: PERMISSION TO ACCESS FILES OF PATIENTS ADMITTED TO KNH ICU IN THE YEAR 2017

I am a second year postgraduate student at School of Nursing Sciences, University of Nairobi. I am kindly requesting for permission to carry out a retrospective research study on '**APACHE II predictions for the critically ill patients at KNH critical care units'**

Enclosed is a copy of our research proposal and copy of my student identification card.

Your assistance will be highly appreciated. Thank you in Advance.

Yours sincerely,

_____

Benjamin Kamau Munyua

+254 723 004 702

bkamau08@gmail.com

APPENDIX VII: APPROVAL LETTER FROM KNH/UON ERC

KENYATTA NATIONAL HOSPITAL APPROVED 11 JUL 2018 KNH/UoN-ERC P.O. Box 20723-00202 NRB

081303

Access to Records 1500/-

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/272

July 11 2018

Benjamin Kamau Munyua
Reg.No.H56/87198/2016
School of Nursing Sciences
College of Health Sciences
University of Nairobi

Dear Benjamin

RESEARCH PROPOSAL – APACHE II PREDICTIONS FOR THE CRITICALLY ILL PATIENTS AT KENYATTA NATIONAL HOSPITAL CRITICAL CARE UNITS (P241/04/2018)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above research proposal. The approval period is from 11th July 2018 – 10th July 2019.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH-UoN ERC before implementation.
c) 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.
d) 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.
e) Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f) 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*).
g) 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.

Protect to discover

Attn Ms. Coding
Please INV
Mbugua
13/7/2018

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

Yours sincerely,

PROF. M. L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Director, CS, KNH
The Chairperson, KNH-UON ERC
The Assistant Director, Health Information, KNH
The Director, School of Nursing Sciences,UON
Supervisors: Dorcas W. Maina, Hannah Inyama

Protect to discover

APPENDIX VIII: APPROVAL FROM KNH

KNH/R&P/FORM/01

KENYATTA NATIONAL HOSPITAL
P.O. Box 20723-00202 Nairobi

Tel.: 2726300/2726450/2726565
Research & Programs: Ext. 44705
Fax: 2725272
Email: knhresearch@gmail.com

Study Registration Certificate

1. Name of the Principal Investigator/Researcher
   BENJAMIN KAMAU MUNYUA
2. Email address: bkamau08@gmail.com Tel No. 0723004702
3. Contact person (if different from PI).....
4. Email address: ..... Tel No. .....
5. Study Title
   APACHE II Prediction for the Critically Ill patients at KNH's CRITICAL CARE UNITS
6. Department where the study will be conducted Health Records department
   (Please attach copy of Abstract)
7. Endorsed by Research Coordinator of the Department where the study will be conducted.
   Name: ..... Signature ..... Date .....
8. Endorsed by KNH Head of Department where study will be conducted.
   Name: MARGARET MBULWA Signature [signature] Date 13/7/2018
9. KNH UoN Ethics Research Committee approved study number P241/04/2018
   (Please attach copy of ERC approval)
10. I Benjamin Kamau Munyua commit to submit a report of my study findings to the Department where the study will be conducted and to the Department of Research and Programs.
    Signature [signature] Date 21st June 13th July 2018
11. Study Registration number (Dept/Number/Year) H1 /31/ 2018
    (To be completed by Research and Programs Department)
12. Research and Program Stamp

KENYATTA NATIONAL HOSPITAL 13 JUL 2018 P.O. Box 20723 - 00202 Nairobi Research Resource Centre

All studies conducted at Kenyatta National Hospital must be registered with the Department of Research and Programs and investigators must commit to share results with the hospital.

APPENDIX IX: MAP OF KNH