VALIDATION OF A MODIFIED APACHE II SCORING SYSTEM IN PREDICTING MORTALITY IN PATIENTS IN THE INTENSIVE CARE UNIT AT THE UNIVERSITY TEACHING HOSPITAL, LUSAKA -ZAMBIA

BY

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A Dissertation Submitted to the University of Zambia in Partial Fulfilment of the Requirements of the Degree of Master of Medicine in Anaesthesia and Critical care

THE UNIVERSITY OF ZAMBIA, LUSAKA
2017
DECLARATION

I declare that this dissertation is my own work. It is being submitted for the Master’s degree in Anaesthesia and Critical Care at the University of Zambia, Lusaka. It has not been submitted before for any degree or examination at this or any other University.

Signed.......................................................
Student: Dr. Masuzyo Zymbo
BSc. HB, MB. ChB
CERTIFICATE OF APPROVAL

The dissertation of DR. MASUZYO ZYAMBO has been approved as partial fulfilment of the requirement for the award of MASTERS OF MEDICINE IN ANAESTHESIA AND CRITICAL CARE by the University of Zambia

Examiner 1 : __________________________
Signature : __________________________
Date : __________________________

Examiner 2 : __________________________
Signature : __________________________
Date : __________________________

Examiner 3 : __________________________
Signature : __________________________
Date : __________________________
ABSTRACT

The major challenge of intensive care in Zambia is limited availability of resources. With the increase in the number of intensive care units in the country, a tool to evaluate and compare the standard of care across these units could be used to help direct resources and provide quality assurance. Prognostic scoring systems may provide such a tool. Currently UTH has no specific data collection or prognostic scoring systems in place. Due to lack of facilities to directly measure oxygen partial pressure and arterial pH in many of Zambia’s intensive care units, the APACHE II (Acute Physiology and Chronic Health Evaluation II) scoring system, one of the most commonly used prognostic critical care scoring systems, may not be feasible to undertake countrywide. This study aimed at assessing how a modified APACHE scoring system excluding blood gas analysis (i.e. no pH and PO₂) compares to the full APACHE II scoring system. This was a prospective cohort study conducted at the UTH intensive care unit, where 51 patients were recruited with a mean age of 34 years. Clinical and physiological variables were collected in the first 24 hours of admission, and a score calculated for each scoring system. The primary outcome was mortality. Specificity and sensitivity for each scoring system was determined and compared. The area under receiver operating characteristic curve (AUROC) for the APACHE II was 0.78 (CI = 0.65–0.91, P = 0.01) and mAPACHE II 0.78 (CI = 0.66–0.91, P= 0.01). No significant difference between the two scoring systems was found. There was no significant difference between the areas under the two ROC curves for the standard APACHE II scoring system and mAPACHE II scoring system. This study suggests that the modified APACHE II may be an acceptable alternative to the full APACHE II scoring system.
DEDICATION

To my Father, who has taught me the importance of working hard,
may God bless him with many years.

To my siblings for the enthusiastic support, I love you.

Memory Mbale, thank you for the patience, love and support during the write-up
I love you.
ACKNOWLEDGEMENTS

I would like to thank my supervisors for their guidance throughout the whole journey from proposal stage until the completion of the dissertation. I wish to thank the staff from the main Intensive Care Unit, the TROPGAN team and my colleagues from the anaesthesia department who assisted me with the data collection and interpretation, Dr. Dylan Bould for his help with the analysis of the data, and lastly but not the least the patients who made it possible.
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<table>
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<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APACHE II</td>
<td>Acute Physiology and Chronic Health Evaluation II</td>
</tr>
<tr>
<td>mAPACHE II</td>
<td>Modified Acute Physiology and Chronic Health Evaluation II</td>
</tr>
<tr>
<td>ROC</td>
<td>Receiver Operating Curve</td>
</tr>
<tr>
<td>AUC</td>
<td>Area Under the curve</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive care unit</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Scale</td>
</tr>
<tr>
<td>UTH</td>
<td>University Teaching Hospital</td>
</tr>
<tr>
<td>UNZA</td>
<td>University Of Zambia</td>
</tr>
<tr>
<td>ERES Converge</td>
<td>Excellence in Research Ethics and science</td>
</tr>
</tbody>
</table>
CHAPTER ONE

INTRODUCTION

1.1 Background
Intensive care medicine is a growing specialty in Zambia, evidenced by the recent commitment by the Zambian Ministry of Health to install Intensive Care units (ICUs) in the provincial headquarters of all ten provinces (Information from the ministry of health). The ability to expand Intensive Care services has been helped by the introduction of the Masters of Medicine Anaesthesia program in 2011 - which includes training in critical care - and the recently established Diploma in Critical Care Nursing.

The current challenges for Intensive Care in Zambia include limited availability of resources such as appropriate staffing levels and bed spaces - Lusaka’s University Teaching Hospital has 10 ICU bed spaces and Levy Mwanawasa has 4 ICU bed spaces that cater for a population of over 2 million people. Consequently, judicious allocation of this limited service is made very difficult.

With the increase in the number of ICUs in the country, a tool to direct care appropriately, evaluate and compare the standard of care across these units could be used to direct resources and provide quality assurance. Prognostic scoring systems may provide such a tool. One of the most commonly used prognostic critical care scoring systems is the Acute Physiology and Chronic Health Evaluation II (APACHEII), which uses 12 physiological variables (as shown below), age and chronic health parameters to inform a prognostic scoring system (Table 1)

1.2 The APACHE II and Modified APACHE II scoring systems
First introduced to the USA in 1985, the APACHE II system was an improvement on the original APACHE system in predicting mortality based on acute and chronic disease markers (85.5 % correct using a 0.5 predicted risk point) (Knaus et al., 1981). It has continued to be used and validated internationally (Wong et al., 1991). Though acknowledged that APACHE II is not fool-proof as a way of quality assurance and cost containment, APACHE II still improves the ability to predict in-hospital mortality even with the presence of newer scoring systems such as APACHE III and SAPS II (Simplified Acute Physiological Score) APACHE II may show a better ability to predict in hospital mortality than APACHE III and SAPS
II (Gilani et al., 2014). Currently in critical care at the University Teaching Hospital (UTH), there is no prognostic scoring system in place, and no specific data collection systems aimed at prognostic scoring.

Table 1: The 1985 APACHE II severity of disease classification system as documented by Knaus et al., 1981.

<table>
<thead>
<tr>
<th>Physiological Variable</th>
<th>HIGH ABNORMAL RANGE</th>
<th>LOW ABNORMAL RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+4</td>
<td>+3</td>
</tr>
<tr>
<td>Temperature (Celsius)</td>
<td>≥41</td>
<td>39-40.9</td>
</tr>
<tr>
<td>Mean arterial blood pressure (mmHg)</td>
<td>≥160</td>
<td>130-159</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>≥180</td>
<td>140-179</td>
</tr>
<tr>
<td>Respiratory rate (rpm)</td>
<td>≥50</td>
<td>35-49</td>
</tr>
<tr>
<td>Oxygen partial pressure (mmHg)</td>
<td>≥500</td>
<td>350-499</td>
</tr>
<tr>
<td>Arterial pH</td>
<td>≥7.7</td>
<td>7.5-7.59</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum Na+ (moll/l)</td>
<td>≥180</td>
<td>160-179</td>
</tr>
<tr>
<td>Serum K+ (moll/l)</td>
<td>≥7</td>
<td>6.0-6.9</td>
</tr>
<tr>
<td>Serum creatinine (mg/100ml)</td>
<td>≥3.5</td>
<td>2-3.4</td>
</tr>
<tr>
<td>Haematocrit (%)</td>
<td>≥60</td>
<td>50-59.9</td>
</tr>
<tr>
<td></td>
<td>HIGH ABNORMAL RANGE</td>
<td>LOW ABNORMAL RANGE</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>WBC x1000 total (mm$^3$)</td>
<td>≥40</td>
<td>20-39.9</td>
</tr>
<tr>
<td>Glasgow coma scale</td>
<td>Score=15-actual GCS score</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL ACUTE PHYSIOLOGICAL SCORE (ASP)**

sum of the 12 individual variable points

Venous HCO$_3^-$ (mmol)

(Only used if ABG unavailable)

<table>
<thead>
<tr>
<th></th>
<th>&gt;52</th>
<th>41-51.9</th>
<th>32-40.9</th>
<th>22-31.9</th>
<th>18-21.9</th>
<th>15-17.9</th>
<th>&lt;15</th>
</tr>
</thead>
</table>

**AGE POINTS**

Age (Years) Point

if a patient has a history of severe organ insufficiency

OR

≤44          0

is immuno-compromised

Assign points as follows

45-54        2

a) for non-operative or emergency patient

55-64        3

5 points

65-74        5

OR

≥75          6

b) For elective postoperative patients

2 points

3
Total APACHE II SCORE ①+②+③

Due to lack of facilities to directly measure oxygen partial pressure and arterial pH in many of Zambia’s ICUs, the APACHE II scoring system may not be feasible to undertake countrywide. However, a modified APACHE II (mAPACHE II) score in which the arterial PH and oxygen partial pressure (PO₂) have been excluded has been used in Sudan and Nigeria to assess severity of illness (Adesunkanmi et al., 2003; Nibras et al., 2007).

This study was aimed at assessing how the modified APACHE II scoring system, excluding blood gas analysis (i.e. no pH and PO₂), compares to the full APACHE II scoring system (including blood gas analysis), at predicting mortality in patients admitted to ICU at the UTH in Lusaka.

1.3 Statement of the Problem

Currently at the university teaching hospital, no prognostic scoring is available for patients on the ICU. Prognostic Scoring is not only important in determining the disease severity and quality assurance, but also in comparing performance across intensive care units, especially now that the Zambian Ministry of Health has embarked on opening ICUs across the country.

One complicating factor is the lack of routinely available Arterial Blood Gas analysis; so included in the study is an evaluation of APACHE II minus PaO2 and pH.

1.4 Study Question

Is the modified APACHE II scoring system as good a predictor of mortality as the standard APACHE II scoring system in ICU patients at the UTH, Lusaka, Zambia?

1.5 Hypothesis

The Standard APACHE II scoring system is a better predictor of mortality in the intensive care unit at the university teaching hospital, Lusaka, Zambia than a locally modified APACHEII scoring system.

1.6.0 Objectives

1.6.1 Primary Objective:

To collect data to calculate APACHE II and mAPACHE II scores for intensive care patients admitted at the UTH, so that comparison can be made between these two scoring systems and mortality outcome.
1.6.2 Secondary Objectives

1) To determine the outcome of patients admitted to the main intensive care unit.

2) To determine the sensitivity, specificity, positive and negative predictive value of the mAPACHE II as a stand-alone scoring system.
CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of severity scoring systems and prognostic models

The severity of illness in the critically ill patient can be assessed using scoring systems and prognostic models. This allows stratification of patients based on the severity of disease, often with a higher score representing more severe disease and greater risk of mortality (Capuzzo et al., 2008). These scoring systems have been used to estimate morbidity and mortality from a broad case mix, and to enable appropriate comparison in studies of critical care outcomes and therapies (Kalb et al., 1989; Civetta et al., 1990). As an example, the APACHE II and SOFA were used to stratify patients in a randomised control trial in which intermittent versus continuous renal replacement therapy was initiated for acute kidney injury in patients admitted to the intensive care unit (Lins et al., 2017). APACHEII can be used as a research tool for ensuring that the 2 arms of a comparative study have patients of equivalent sickness i.e. to match cohorts. Performance of different ICUs can also be compared efficiently. Many severity scoring systems have been developed within the past three decades to predict mortality, and the Acute Physiology and Chronic Health Evaluation (APACHE) and the Simplified Acute Physiology Score being the most widely used scoring systems (Sakr et al., 2008). Other scoring systems widely used include the Mortality Prediction Model (MPM) and Sequential Organ Failure Assessment (SOFA) scores (Herridge et al., 2017). The Acute Physiological and Chronic Health Evaluation (APACHE) was first developed in 1981 as a way to measure disease severity and evaluate resource allocation in intensive care units (Knaus et al., 1981). It consisted of 34 physiological variables. In 1985 it was revised into the APACHE II with the physiological variables reduced to 12 (Knaus et al., 1981). The APACHE II has shown to be very useful in predicting mortality and length of stay in the critically ill patients (Wong et al., 1991). The APACHE II model uses the most deranged value from the first 24 hours in the ICU of 12 physiological variables (scored from 0 to 4 points). The total scores vary from 0 to 71 points: up to 60 for physiological variables, up to 6 for age, and up to 5 for previous health status. The main reason for ICU admission has to be selected from a list of operative and non-operative diagnoses in order to transform the APACHE II score into a probability of mortality.
In Sudan a study by El Nibras et al., predicted mortality in patients suffering from severe acute variceal bleeding who were admitted to the ICU at the IbnSina Hospital using a modified APACHE II score (the measurement of pH and partial pressure of arterial oxygen were omitted). The results showed that the modified APACHE II score was an effective tool in predicting outcomes in patients with severe variceal bleeding (Nibras et al., 2007) Subgroup analysis showed it was accurate at estimating risk of death in patients with portal hypertension and acute variceal bleeding secondary to periportal fibrosis; however, it was shown to underestimate mortality two-fold in patients with variceal bleeding secondary to liver cirrhosis.

In Nigeria, a study by A.R.K Adesunkanmi et al assessed the severity of illness in African children with acute generalised peritonitis using a modified APACHEII score. The results showed that the scoring system was relatively accurate in predicting mortality but not morbidity (Adesunkanmi et al., 2003), though was not compared to full APACHE II score predictions.

In both the above studies modification made to the APACHE II score were as follows:

1) The measurement of the blood PH was omitted
2) Partial pressure of oxygen was not measured

The reason cited for not including these parameters was lack of facilities.

Despite the successful use of the modified APACHE II score in predicting mortality, a search of the literature shows no study that compares the strength of the modified APACHE II score at predicting mortality compared to the standard APACHE II scoring system.
CHAPTER THREE
METHODOLOGY

3.1 Study design
This was a prospective cohort study

3.2 Site
This study was conducted at the University Teaching Hospital Intensive Care Unit.

3.3 Study population:
All patients admitted to the main Intensive Care Unit who met the eligibility criteria. Physiological parameters for the first 24hrs following ICU admission were collected.

3.4 Inclusion criteria:
- Patients admitted to the intensive care unit
- Patients older than 16 years of age

3.5 Exclusion criteria:
- Patients who were discharged <24hrs after admission to ICU
- All patients readmitted to the ICU- only the first admission was considered.

3.6 Sample Size Calculation and Sampling Method:
All patients admitted to the UTHICU over a period of three months were screened for eligibility. We used MedCalc for Windows version 14.12.0 (Bruges, Belgium). Assuming a type I error of 0.05; a type 2 error of 0.8; an APACHE II receiver operating curve (ROC) area under the curve (AUC) = 0.828 (according to similar published data from Gilani et al., 2014) a mAPACHE II ROC AUC=0.7 which represents “fair” predictable value, and a moderate effect size (as a small effect size unlikely to be clinically significant); correlation between APACHEII and mAPACHEII to be 0.7 (likely high correlation as the variables of the modified APACHEII are identical to that of the APACHE II variables except for two omitted
physiological parameters); a mortality 50% (Jochberger et al., 2010); we estimated needing 54 deaths and 30 survivors for a total sample size of 84. However a total of 51 patients were recruited. The study was limited by the erratic supply of arterial blood gas analysis cartridges and the limited time frame allotted for data collection.

3.7 Data Management
Data was collected over a period of 3 months and entered on a standard APACHE II scoring sheet. Each included patient was assigned a study number to allow anonymized data to be transcribed into an electronic spreadsheet. No patient identifiable data left the hospital environment.

3.8 Data Analysis
Analysis of APACHE II scores total Acute Physiological Score (APS) was calculated for both modified and standard APACHE II. Chronic health and age points were calculated. The dependent outcome variable, mortality (primary outcome measure), was defined as ICU inpatient death. The primary dependent variables were the APACHE II and the mAPACHE II scores. Other dependent variables (secondary outcomes) were the collected independent variables that constitute the APACHEII score: including temperature, mean arterial pressure, heart rate, and respiratory rate, partial pressure of oxygen, arterial PH, sodium, potassium, haematocrit, white blood cell count and Glasgow Coma Scale (GCS). Other variables collected were chronic health status, admission diagnosis, and patient demographics including age and sex. The primary analysis was a comparison of the predictive performance of standard and modified APACHE II scores for mortality in intensive care unit, which was assessed and compared using ROC curve analysis; specifically area under curve were compared for the two ROC curves using the method described by DeLong (DeLong et al., 1988).

3.9 Ethical Considerations
Approval was sought from ERES Converge, Zambia and the Department of Anaesthesia and critical care at UTH. All research leads were up-to-date with Good Clinical Practice and research was carried out adherent to the principles of the Declaration of Helsinki.
To clarify issues relating to this study specifically

1. No patient or persons directly or indirectly involved in the care of patients was identifiable in the final report.

2. Opinions and judgments required to allow categorizing of data was not biased by anyone outside of the research study, or by any prior or additional knowledge of individual cases out with what is held in medical records.

All electronic data were kept on encrypted data storage devices, and paper data will be archived for ten years. Informed consent was obtained from all participants that were conscious and for those that were unable to give consent; assent was obtained from the next of kin. They were informed that they could withdraw from the study at any time.
CHAPTER FOUR

RESULTS

4.1 General characteristics of the patients

A total of 58 patients were recruited for the study, and 51 were successfully included in the study. 4 did not give consent and 3 had missing data and so could not be included in the study. Data was collected from February 2016 to June 2016. Inclusion and exclusion criteria was based on same criteria used in the original model development, (Knaus et al., 1981). The outcome measure was survival or death after adjustment for case mix using the mAPACHE II and APACHE II scoring system.

Table 2: General characteristics of the Patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Survivor</th>
<th>Non-Survivor</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>45.8%</td>
<td>15</td>
</tr>
<tr>
<td>Male</td>
<td>13</td>
<td>54.2%</td>
<td>12</td>
</tr>
<tr>
<td>ARF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>14</td>
<td>58.3%</td>
<td>12</td>
</tr>
<tr>
<td>YES</td>
<td>10</td>
<td>41.7%</td>
<td>15</td>
</tr>
<tr>
<td>Chronic disease &amp; immunosuppression</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>18</td>
<td>75.0%</td>
<td>15</td>
</tr>
<tr>
<td>Yes</td>
<td>6</td>
<td>25.0%</td>
<td>12</td>
</tr>
<tr>
<td>HIV status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>22</td>
<td>91.7%</td>
<td>18</td>
</tr>
<tr>
<td>Positive</td>
<td>2</td>
<td>8.3%</td>
<td>9</td>
</tr>
<tr>
<td>APACHE II (mean, SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17.04</td>
<td>5.31</td>
<td>23.63</td>
</tr>
<tr>
<td>mAPACHE II (mean, SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.63</td>
<td>6.25</td>
<td>21.37</td>
</tr>
<tr>
<td>Age (mean, SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34.89</td>
<td>15.47</td>
<td>34.22</td>
</tr>
<tr>
<td>GCS (mean, SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.79</td>
<td>3.78</td>
<td>7.67</td>
</tr>
<tr>
<td>Length of stay ( days)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Of the 51 patients studied, 25(49 %) were male and 26(51 %) were female with a mean age of 34.53. The observed mortality was 54 % with 55.6 % of these being females and 44.4 % males. The mean age was 34.2 years for those that died both male and females. The average mAPACHE II score for survivors was 14.6 and non-survivors 21.3, while for the APACH II, survivors17.0 and for non-survivors 23.3, the average score being significantly higher in non-survivors for both scoring systems. The P-values of the variables was calculated using the fishers exact test.

### 4.2 Mortality and predictive values of the two scoring systems

Table 3: Mortality rates according to age and percentages

<table>
<thead>
<tr>
<th>Age range</th>
<th>Number of patients</th>
<th>Number that died</th>
<th>Percentage of patients that died</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>5</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>20-39</td>
<td>31</td>
<td>19</td>
<td>61.2</td>
</tr>
<tr>
<td>40-59</td>
<td>12</td>
<td>4</td>
<td>33.3</td>
</tr>
<tr>
<td>60-79</td>
<td>2</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>≥ 80</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
</tbody>
</table>

The majority of the patients were between the age of 20 and 30 with a 61.2 percent mortality rate in this age
Table 4: Comparison of the predictive values of the two scoring systems

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>APACHE II</th>
<th>mAPACHE II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>70.3</td>
<td>74</td>
</tr>
<tr>
<td>Specificity</td>
<td>62.5</td>
<td>70.8</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>67.8</td>
<td>74</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>65.2</td>
<td>70.8</td>
</tr>
<tr>
<td>Area Under the curve</td>
<td>0.78</td>
<td>0.79</td>
</tr>
<tr>
<td>Cut off point</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>95% confidence level</td>
<td>0.65 to 0.91</td>
<td>0.66 to 0.91</td>
</tr>
</tbody>
</table>

The table above shows the cut off giving the best sensitivity, specificity, positive and negative predictive values for the two scoring systems.

Table 5: Case mix of the 51 patients included in the study

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of admission</strong></td>
<td></td>
</tr>
<tr>
<td>No surgery</td>
<td>37</td>
</tr>
<tr>
<td>Elective surgery</td>
<td>6</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>8</td>
</tr>
<tr>
<td><strong>Types of surgery</strong></td>
<td></td>
</tr>
<tr>
<td>Cardiac surgery</td>
<td>2</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>2</td>
</tr>
</tbody>
</table>
Gastrointestinal surgery  8
Trauma surgery  1
ENT surgery  0
Others  1

The 38 patients listed under “No surgery” admitted were medical and surgical patients with various conditions, including tuberculosis(5), organophosphate poisoning(3), Diabetes Mellitus(1), severe malaria(7), traumatic brain injury treated conservatively(10) and sepsis(4).

4.3: Area under the operating curve and median GCS at the time of admission

<table>
<thead>
<tr>
<th>Test Result Variable(s)</th>
<th>Area</th>
<th>Std. Error$^a$</th>
<th>Asymptotic Sig.$^b$</th>
<th>Asymptotic 95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>APACHE II</td>
<td>.78</td>
<td>.065</td>
<td>.001</td>
<td>.65</td>
</tr>
<tr>
<td>mAPACHE II</td>
<td>.78</td>
<td>.064</td>
<td>.000</td>
<td>.66</td>
</tr>
</tbody>
</table>

Figure 1: The receiver operating curve showing the discriminative capabilities of the APACHE II and the modified APACHE II

Figure 2: Shows the average GCS at admission
Figure 3: Box plot showing the median GCS of Survivors and Non-Survivors

Figure 4: Box Plot showing the APACHE II and mAPACHE II Scores comparing the scores for survivors and non-survivors

The Box plot above shows the modified APACHE II and APACHE II scores, comparing the scores for survivors and non-survivors. The Black Bar is the median value; the shaded area above and below the Black Bar represents the 25th-75th percentile. The circles, outliers; the black lines represent the most extreme data points that are within 1.5 times the interquartile range from the 25th -75th percentiles.
Figure 5: Shows the frequency of the modified APACHE II
Figure 6: Showing the frequency of the mAPACHE II
CHAPTER FIVE

DISCUSSION

5.1 Validation of the modified APACHE II

The main aim of this study was to validate the use of the mAPACHE II score against the standard APACHE II scoring system (the model whose performance has been evaluated the most) at predicting mortality. The study was necessitated by the fact that the ICU at the UTH, Lusaka, as well as other ICUs around the country, are unable to consistently perform the full APACHE II due to lack of reagents to carry out blood gas analysis; a parameter which is an integral part for calculating the APACHE II score. In this study, blood gas investigations were only done once in the first 24 hours because of the high cost of repeated investigation. However, the worst physiological parameters in the first 24 hours were still used.

In a Hong Kong study on critical patients admitted to the resuscitation room using the same modifications made in this study to the APACHE II, they showed a moderate prognostic value for 14 day-all cause mortality. However, it was noted in the study that the emergency department being a busy area with a high turnover of patients, the tools applicability was limited by its complexity (Man et al., 2007).

In a Sudanese study using the same mAPACHE II scoring system to predict mortality in patients admitted with variceal bleeding, the results showed patients with a mAPACHE II of > than 15 points had a high mortality rate, with 42.6% of the patients with scores above 15 points died (Nibras et al., 2007).

Our study shows that the mAPACHE II scoring is comparable to the standard APACHE II scoring system at predicting mortality in patients in the ICU at the UTH, Lusaka. This was assessed by using the method by DeLong (DeLong et al., 2008). Comparing the area under the receiver operating curves of both scoring systems. The AUC for the modified and the standard APACHE II were 0.788 and 0.783 respectively. This represents a fair predictive ability for both scoring system on our patient in intensive care unit. The discriminatory capabilities of the two tests are comparable, with a marginally better discriminatory ability for the mAPACHE II score.

The prognostic capabilities of a scoring system model is based on discrimination and calibration; discrimination being the ability of a scoring system to correctly identify the patients that survive and those that die, while calibration refers to the ability of a
scoring system to describe a group of patients accurately (this refers to prognostic accuracy at different levels of risk). Discrimination can be obtained by studying the area under the ROC curve, with 0.5 representing the null hypothesis and 1 used to describe perfect discrimination.

5.2 Other physiological and diagnostic factors that were noted to significantly increase mortality

The other significant finding is that the GCS at the time of admission was a predictor of mortality. The lower the GCS at admission, the higher the mortality rate. Most of the patients admitted with low GCS in our study had a traumatic brain injury. This is consistent with earlier studies (Iba et al., 2014; Lingsma et al., 2017). Of interest, a study by Hicham et al., 2014 in Morocco, the APACHE II showed better discriminative power than the SAPS-II for early accurate prediction of outcome of moderate to severe brain injury.

Patients with compromised immunity had a high ICU mortality. Of the 11 patients included in the study who tested positive for HIV, 9 died. Factors possibly contributing to the high mortality in this group of patient are that most had sepsis at the time of admission to the ICU, and the lack of available invasive monitoring. These findings are comparable to a South African study to validate the use of the APACHE II score in a tertiary South African ICU. The mortality among the immunocompromised patients in their study was found to be 62%. Patients that had a diagnosis of sepsis had a 59.4% mortality compared to 25% for those without this diagnosis (Town et al., 2005).

5.3 Study Limitations

One of the major limitations of the study is the sample size, so further research may be required with a larger sample size. The erratic supply of the reagents to measure blood gases and the fact that blood investigations were only done once in the first 24 hours may have affected the results.

Since this study was only done in the ICU at the UTH, caution must be used when considering these findings and applying recommendations to other ICUs.

Not all patients admitted to the intensive care unit were included in the study mainly due to non-availability of blood gas reagents.
CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion
This study suggests that mAPACHE II can be used for predicting mortality in adult patients admitted to the ICU at the UTH in Lusaka. The mAPACHE II may be suitable for predicting mortality in any ICU where reagents are not always available to perform the full APACHE II. The study also suggests that immunocompromised patients and patients admitted with a low GCS have a significantly high mortality rate.

6.2 Recommendations
The ICU has no admission policy, so it is very important that it is not perceived as a terminal ward, but patients should have relative prospects of recovery. Even when patients have an acute reversible condition, their chronic health status may significantly affect their outcome, so the modified APACHE II may provide a tool to identify the patients with realistic prospects of recovery.

Other recommendations include the following:

1. UTH management to consider using the mAPACHE II scoring system as a tool for prognostic scoring.
2. The Ministry of Health to consider using the mAPACHE II scoring system as a tool to compare performance across the various ICUs in the country
3. The local ICU team should conduct further research on other scoring systems that maybe used in resource poor intensive care unit.
REFERENCES


APPENDICES

Appendix A

CONSENT FORM

I, ___________________________ hereby confirm that the nature of this clinical study has been explained to me, I am aware that the personal details of my relative will be kept confidential and I understand that I may voluntarily, at any point withdraw the participation of my relative without suffering any consequence. I have been given sufficient time to ask questions and seek clarifications, and have agreed participation of my relative in this research.

I have received a signed copy of this agreement.

_________________________  ___________________________  ___________________________
Name of participant (PRINT)  Relative (signature or thumbprint)  Date

_________________________  ___________________________  ___________________________
Name of participant (PRINT)  witness (signature or thumbprint)  Date
Appendix B

**DATA COLLECTION SHEET**

Date____/____/______  Diagnosis at admission_______

**Chronic organ insufficiency or Immunocompromise**

- Yes (emergency surgery) +5
- Yes (elective surgery) +2
- Yes (but not post-op) +5
- No

**Sex______**

**Acute renal failure**

<table>
<thead>
<tr>
<th>Yes+1</th>
<th>No 0</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>Potassium</th>
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</thead>
<tbody>
<tr>
<td>years</td>
<td>mmol/L</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Creatinine</th>
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</thead>
<tbody>
<tr>
<td>°C</td>
<td>µmol/L</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean Arterial Pressure</th>
<th>Hematocrit</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm Hg</td>
<td>%</td>
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<table>
<thead>
<tr>
<th>pH</th>
<th>White Blood Cell Count</th>
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<tbody>
<tr>
<td></td>
<td>µL/L</td>
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</table>

<table>
<thead>
<tr>
<th>Heart Rate/Pulse</th>
<th>Glasgow Coma Scale</th>
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<tbody>
<tr>
<td>beats per minute</td>
<td>points</td>
</tr>
<tr>
<td></td>
<td>PaO2</td>
</tr>
<tr>
<td></td>
<td>kPa</td>
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</table>

<table>
<thead>
<tr>
<th>Sodium</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>mmol/L</td>
<td></td>
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</tbody>
</table>
Appendix C

Information sheet

VALIDATION OF A MODIFIED APACHE II SCORING SYSTEM IN PREDICTING MORTALITY IN PATIENTS IN THE INTENSIVE CARE UNIT AT THE UNIVERSITY TEACHING HOSPITAL, LUSAKA –ZAMBIA

Introduction
I am Dr. Masuzyo Zymbo an anaesthetic registrar in the department of anaesthesia and critical care medicine at the University Teaching Hospital. I am currently pursuing a Masters degree in anaesthesia and critical care medicine with the University Of Zambia. This study is part of the fulfilment for the Masters degree. I would like to explain to you the nature of my study before you decide whether to allow your relative to participate or not in the study. If you allow your relative to participate in the study, you will be asked to sign a consent form in the presence of a witness.

Nature and Purpose of the Study
The study intends to come up with a tool that is well suited for our environment that will be able to compare the performance of the various intensive care units around the country without bias

Procedure of the Study
If you agree to participate in this research, I will take some laboratory results of the patient and demographic data that will be recorded on a data sheet.

Your relative will not be exposed to any additional risks by participating in this study. The patient will receive the standard care by their attending doctor. No extra procedures will be performed on your relative due to this study.

Possible Benefits
Possible benefits will be an improvement in the intensive care unit care in the long term and judicious use of limited resources.

Confidentiality
All the data collected in this study will be strictly confidential. Your name will not be included in the data that will be collected, analysed and reported on.