COMPETENCIES IN ECG INTERPRETATION AMONG NEWLY GRADUATED MEDICAL STUDENTS AT THE UNIVERSITY OF NAIROBI SCHOOL OF MEDICINE

DR. FREDRICK OLUGA

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DECLARATION

I understand the nature of plagiarism. I acknowledge the University policy on plagiarism. I declare that this thesis is an original work and has not been presented for the award of a degree in any other university.

Signed………………………………Date…………….

Dr. Fredrick Oluga, M.B.Ch.B.

APPROVAL BY SUPERVISORS

This dissertation has been submitted for examination with my full approval as supervisor.

Signed …………………………………………… Date ………………………..

Prof. E. N. Ogola, M.B. Ch. B, MMED, FACC

Consultant Physician & cardiologist.

Department of Internal Medicine and Therapeutics, University of Nairobi

This dissertation has been submitted for examination with my full approval as supervisor.

Signed………………………………………… Date………………………….

Prof. Joshua K. Kayima, M.B.Ch.B, MMED.

Consultant Physician & Nephrologist

Department of Internal Medicine and Therapeutics, University of Nairobi

DEDICATION

This research is dedicated to all the doctors who are passionate about passing knowledge and expertise from one generation to the next.

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ABSTRACT

Introduction: ECG is vital in screening, diagnosis and monitoring treatment of cardiovascular diseases. ECG interpretation accuracy influences the sensitivity and specificity of ECG utility in clinical practice. ECG interpretation competency has been studied in residents, physicians and cardiologists with varied results reported for each group. However, no study has evaluated ECG interpretation competency among newly graduated medical students in Africa.

Objective: The study determined ECG interpretation competency among newly graduated medical students at the University of Nairobi.

Methodology: Graduate medical students from the University of Nairobi were requested to participate in a web-based ECG survey containing 22 ECG strips. Initial survey questions concerned confidence in ECG interpretation and ECG training adequacy. The 22 ECG strips were derived from ECG Wave Maven – an ECG reference resource. A Participant could access the web-survey only once. 22 ECG strips were displayed successively for 90 seconds without any chance for revising a previous response. Data analysis was restricted to determining the proportion of participants who correctly interpreted 11 or more ECG tracings. This was reported as summative competency. Proportion of correct responses for each ECG tracing was determined and reported as Individual ECG Competency. The average for all Individual ECG Competencies calculated and reported as the Mean Competency Score. A multivariate analysis was done to correlate competency with self-reported confidence and self-reported adequacy of ECG training.

Results: 2.8% of participants were considered competent for correctly interpreting 50% or more of the 22 ECG strips used in survey. ECG tracing for Hyperkalemia was the most correctly interpreted at 61% while ECG tracing LAFB was the least correctly interpreted at 5.1%. The mean competency score was 4.24 (19.27%). Correlations between ECG Competency and self-reported Confidence and self-reported adequacy of ECG training couldn't be determined statistically because only 5 participants were found competent. Further, data on adequacy of training was insufficient.

Conclusions: Graduate medical students at the University of Nairobi have limited ECG interpretation competency. Further studies are necessary to determine effective ECG interpretation teaching methods.

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LIST OF ABBREVIATIONS

AHA	American Heart Association
ACC	American College of Cardiology
ECG	Electrocardiograph/Electrocardiogram
STEMI	ST Elevation Myocardial Infarction
LAFB	Left Anterior Fascicular Block

CHAPTER ONE

INTRODUCTION

Cardiovascular diseases remain the number one cause of mortality and morbidity worldwide accounting for up to 31% of all deaths (1). In Kenya, 25% of all hospital admissions are due to cardiovascular diseases (2). One study found that myocardial infarction, cardiomyopathy, pulmonary thromboembolism, subarachnoid haemorrhage, and hypertensive heart disease accounted for 18.7%, 17.2%, 15.7%, and 14.2% respectively of all cardiovascular disease related mortality confirmed at autopsy (3).

Electrocardiograms (ECGs) remain the key tool in the screening, diagnosis and monitoring the management of cardiovascular diseases (4) . The interpretation of ECGs has therefore been an important subject of study because interpretation accuracy determines the usefulness of the ECG in the evaluation of cardiac diseases (5). ECG interpretation competency has, therefore, been studied in residents, physicians and cardiologists in several settings with varied results on level of competency being reported.

ECG interpretation competency has been compared between cardiologists and automated ECG interpretation reports generated by computer software. The competency scores were comparable at 96% for cardiologists and 91% for computer generated interpretation at a confidence level of 0.01. A consensus panel of cardiologist has since remained the gold standard interpreter for ECGs.

ECG interpretation competency among final year medical students has not been studied in an Africa setting. An assessment tool that can be used to evaluate competency among newly graduated medical students was demonstrated to have construct validity.

No study on ECG interpretation competency has been conducted in Sub-Sahara Africa. Further, studies on ECG interpretation competency were conducted in settings where limited competency in ECG interpretation among graduating medical students did not affect patient outcomes because of the availability of and the access to cardiologists (6).

The American College of Cardiology (ACC) and the American Heart Association (AHA) developed consensus standards on ECG competency applicable in all practice settings and situations. The ACC/AHA recommends interpreting at least 500 supervised ECGs during initial training, using standardized testing in ECG interpretation to confirm initial competency and interpreting 100 ECGs yearly to maintain competency (7). The statement is, nonetheless, controversial for the lack of evidence on techniques for learning ECG interpretation, maintaining ECG interpretation competency, and evaluating competency in ECG interpretation among medical students.

Testing of ECG competency has formed part of standardized written and clinical qualifying undergraduate and post-graduate examinations in all medical schools. This emphasizes the consensus among education program directors on the significance of medical students acquiring ECG interpretation skills before students are qualified doctors.

Given that ECG interpretation doesn't form the bulk of these standardized written or clinical examinations for medical students, assessment of ECG interpretation competency remains unnoticeable and an insignificant part of the whole qualifying examination. Moreover, students do not compulsorily have to prove their ECG interpretation competency before being qualified as doctors. Some examinations have even been found subjective in assessment of ECG competency among undergraduate medical students (8).

The global burden of cardiovascular diseases necessitates that there is emphasis on the significance of ECG interpretation skills in the recognition and management of the cardiac diseases. It is therefore important to study the ECG interpretation competency of final year medical students. The outcome of this study could help in designing interventions that improve ECG interpretation competency among graduating medical students and practitioners

CHAPTER TWO

LITERATURE REVIEW

2.1. Clinical Significance of ECG Interpretation Competency

Cardiovascular diseases are a range of conditions affecting the heart and the blood vessels. The conditions are responsible for nearly one third of all deaths worldwide. While mortality from cardiovascular diseases are decreasing in western countries, developing countries are experiencing an increase in both morbidity and mortality from cardiovascular conditions (9).

Two methods for the prevention of morbidity and mortality from diseases of atherosclerotic origin have been explored. The first involves primary prevention by identification and control of the modifiable risk factors such as hypertension, dyslipidaemia, cigarette smoking and physical inactivity. The second strategy involves secondary prevention through early detection of heart disease. The principal tests used for this kind of screening are ‘Resting ECGs’ and ‘Exercise ECGs’, which can detect silent myocardial ischaemia among other cardiac abnormalities (10).

An Italian study found a 90% reduction in Sudden Cardiac Death when ECGs were included as part of screening test in a pre-participation examination for young athletes (11).

ECG has remained a routine tool for use in the practice of emergency medicine, internal medicine, surgery, anaesthesiology, paediatrics, and primary care making ECG Interpretation competency one of the most useful clinical skills for doctors. (12).

The 12-lead ECG has been used for screening and diagnosis of cardiac conditions that are life-threatening (13) . Accurate ECG reading has been proven useful in cardiac arrest or acute myocardial infarction patients where identification of ECG signs determine appropriate and timely intervention (14).

The competency of doctors who are not cardiologists in interpreting ECGs remains unknown. ECG interpretation by non-cardiologists is often influenced by the clinical presentation of the patient and the automated computer interpretation reports (5).

Current literature on ECG interpretation by non-cardiologists makes conclusions on competency difficult. Assessments of ECG interpretation have non-cardiologists or trainees compared to an expert electro-cardiographer gold standard which is usually a consensus panel of cardiologists. The correctly identified diagnoses is recorded and reported as compared against the reference standard provided by the electro-cardiographer gold standard.

The clinical significance of the differences between cardiologists and non-cardiologists is uncertain because intra-interpreter reliability varies, even among cardiologists. As many trials test comprehensive detection of ECG abnormalities, the sensitivity of physicians' detection of any given disorder is often uncertain. Specificity and the implications of false-positive interpretations are infrequently reported.

Despite these variations in interpretation of ECG between cardiologists and non-cardiologists, interpretation errors that result in adverse patient outcome are minimal and have been demonstrated in only 1% of patients in developed countries where cardiologists can be easily accessed.

In the developing countries where cardiologists are not easily accessible and the most available doctors who review patients even in large teaching hospitals are medical residents or medical doctor interns, ECG Interpretation errors have been found to result in major adverse patient outcome due to inappropriate intervention or non-intervention (15). An estimated 20 – 50% discordance between initial ECG interpretation by a trainee or junior doctor and a final ECG interpretation by a senior cardiologist is documented (16).

A systemic analysis of 9 studies examining ECG interpretation competency among undergraduate medical students (4) found competency in ECG Interpretation to mean the ability of the medical student to::

1. Identify Abnormality on a 12- or 15-lead surface ECG
2. Synthesize a differential diagnosis for the common ECG abnormality (Class A).
3. Provide initial treatment if the patient is unstable or has a high risk ECG abnormality
4. Obtain assistance from a senior health care professional within a clinically appropriate time frame.

2.2 ECG Interpretation Competency.

The initial draft proposal for ECG interpretation competency was developed in Canada at Queen's University - Ontario. A list of ECG patterns and diagnoses which had been mentioned in literature was collected. Each ECG strip was then refined and organized into the following four classes (***See Tables 1 and 2***).

Class A

Represent ECG patterns that are common and are seen frequently in clinical practice in which accurate interpretation of the ECG within minutes is required for delivering intervention that is potentially lifesaving to the patient such as in ST-segment elevation myocardial infarction (STEMI).

Class B

Represent ECG abnormalities which are seen daily in patients who are not acutely sick and are not in an emergency state but the ECGs are vital in deciding the care of the patient in the appropriate clinical setting for example left ventricular hypertrophy.

Class C

These were classified as ECG findings encountered less frequently but for which an accurate interpretation is potentially lifesaving such as ventricular pre-excitation pattern. These ECG patterns are emergency type conditions that occur rarely.

Class D

Represent ECGs which are not common but may diagnostically contribute to patient care in a clinically appropriate setting such as right atrial abnormality.

ECG pattern recognitions were thus assigned to medical students and residents according to specific goals of training. Upon graduation, medical students were required to have the foundation for learning ECG interpretation in residency training, provide ECG interpretation and initial management for ECGs denoting emergencies, and be able to refer a patient or consult a more senior medical professional within a clinically appropriate time frame.

The training goal for a resident was to develop ECG interpretation that was useful for good patient outcomes in individual practice.

Table 1*: Competency Definition for medical students' ability to correctly identify ECGs in Class A and B* (4)

	Common	**Un-Common**
Emergency	Group A - Common Electrocardiographic Emergencies are patterns that require recognition within minutes to deliver potentially lifesaving care (Example: ST-Elevation MI)	Group C - Uncommon Electrocardiographic Emergencies are patterns that, if recognized, can prevent serious adverse patient outcomes (Example: Ventricular Pre-excitation) Non-Emergency
Non-Emergency	Group B - Common Non-Emergency patterns that are seen on a daily basis that may impact patient care (Example: Left Ventricular Hypertrophy)	Group D - Uncommon Non-Emergencies are Less common patterns that do not require urgent medical attention, but may impact patient care in an appropriate context (Example: Right Atrial Abnormality)

Table 2*. ECG patterns as Assigned to Training Levels, Medical Students and Residents (*italic*)* (4)

Class	**ECG Abnormalities**
A	1. Acute ST-Elevation Myocardial Infarction 2. Hyper-acute T-Waves 3. Ventricular Tachycardia (VT) 4. Differential Diagnosis for Wide Complex Tachycardia 5. Ventricular Fibrillation (VF) 6. Asystole • 3rd Degree AV Block 7. 2nd Degree AV Block Mobitz II 8. Hyperkalemia/Hypokalemia Pattern 9. Unstable Supraventricular Tachycardia 10. Long QT

B	1. Tachycardia Syndromes 2. Sinus Tachycardia 3. Atrial Fibrillation 4. Atrial Flutter 5. Atrial Tachycardia 6. Multifocal Atrial Tachycardia 7. Atrioventricular Nodal Re-entry Tachycardia 8. Non-sustained Ventricular Tachycardia 9. Atrioventricular Re-entry Tachycardia Bradycardia Syndromes 10. Sinus Bradycardia 11. Sinus Arrhythmia 12. 2nd Degree AV Block Mobitz I 13. Junction Rhythm Conduction Abnormalities 14. 1st Degree AV Block 15. Left Bundle Branch Block 16. Right Bundle Branch Block 17. Nonspecific Intraventricular Conduction Delay 18. Left Anterior Fascicular Block Ischemia/Injury 19. Pathological Q-Waves 20. ST Depression 21. T-Wave Inversion (post-ischemic) Other 22. Left Ventricular Hypertrophy 23. Pericarditis 24. Premature Ventricular Contraction 25. Electronic Pacemaker 26. Lead Misplacement and Common Artifacts 27. Left Atrial Abnormality 28. Interatrial Block 29. Benign Early Repolarization
C	1. Pre-Excitation 2. STEMI with pre-existing LBBB 3. Sinus Pauses 4. Brugada Pattern 5. Hypothermia 6. Drug Effects 7. Ventricular Aneurysm 8. Right Ventricular Hypertrophy
D	1. Right Atrial Abnormality 2. Left Posterior Fascicular Block 3. Low Atrial Rhythm *4.* Electrolyte Abnormalities (non-hyperkalemia)

2.3 Evaluation of Competency in ECG Interpretation

Structured assessments of ECG interpretation is derived by several techniques (17). The American Board of Medical Specialties certify residents to be internists, family physicians, and emergency medicine physicians after questions on ECG interpretation are satisfactorily answered (5). Advanced Cardiac Life Support programs initiated and run by the American Heart Association do provide additional instruction and testing on abnormal cardiac rhythm recognition in provision of emergency care before or within a hospital (14).

Several studies revealed gaps in ECG interpretation by medical students and residents from different countries (5). The Polish Ministry of Science and Higher Education standards for medical faculties specify that medical graduates should be able to perform and interpret standard resting ECG (8).

In South Africa, emergency medicine physicians are evaluated on ECG skills as part of the general written and practical examination before being accredited by the Fellowship of the College of Emergency Medicine South Africa (FCEMSA) (15)

Many training programs still do not have a clear criteria to assess competency among medical students and medical practitioners. In 2000, a computer based ECG tutorial called ECG Wave Maven was founded. It was then established that the site was visited by 74% physicians and medical students in the United States of America for self-evaluation of ECG competency with an average 12 ECGs viewed per visit per user making the site a trusted reference resource for ECG Interpretation self-training and assessment (16).

Three main strategies are used in the evaluation of ECG Competency even though the methods are universal in all training programs (4). These are:

a) Longitudinal On-going feedback where learners are directly observed and point-of-care feedback is delivered such as in ward rounds. This evaluation is informal and is centred on case-presentations. The feedback may accompany an intervention such as teaching.
b) Formative Testing where tutors ask questions during lectures or use written instructional tools such log books to assess students.
c) Summative Testing in which the level of a proficiency of a learner is benchmarked against a reference gold standard.

Most investigators evaluating ECG interpretation competency among medical students, residents, physicians and cardiology fellows have used the summative testing strategy (7, 18).

Since the advent of the internet, the use of web-based ECG Interpretation programme for teaching and testing have increased. This is attributed to immediacy, better visualization, geographical independence and time flexibility for participants. Systemic review of 12 studies looking at teaching of electrophysiology now places delivery of tutorial and examinations using web-based methods at 52.9% and a further 58.8% run locally in computers of total tutorial and examinations done (18).

At Karolinska Institutet, a comprehensive web-based ECG interpretation programme was evaluated and ranked at 4.1 on a Likert scale of 1 equals bad and 5 equals very good by undergraduate students. When compared with traditional class methods in teaching, web-based methods were ranked at 9.1 vs 8.1 with p value 0.003 (19).

Even though web-based teaching and evaluation for medical image interpretation has received positive reviews in many studies, many differences still exist between settings to unambiguously attribute the effects to web-based or any technique alone (20).

2.4. Determinants of Competency in ECG Interpretation

a) ECG Interpretation Training and Exposure

A 'Polish Study' of ECG interpretation conducted among all undergraduate medical students found that students could estimate their ability to accurately interpret ECGs. No relationship was established by the same study between students attending regular ECG classes and the competency in ECG interpretation. A study reported that the overall accuracy of ECG interpretation is higher among students who report self-learning of ECG skills (21).

Many instructional strategies have been successfully piloted to train on ECG interpretation competency. These methods include regular class-based lectures, ECG puzzles and games, online-based tutorial programs, iBooks, and YouTube videos (5, 22, 23, 10).

A survey among Clerkship Directors of Internal Medicine Departments at four medical schools in the United States America found that 75% of clerkship programs taught ECG skills in a classroom lecture-based setting, 44% used clinical rounds, and only 17% utilized online or web-based pedagogy (24). 92% of the instruction for ECG skills occurred during the Internal Medicine clerkship.

In Canada, family medicine residency programs have a relatively measured mix amongst class -based, computer-based, and bedside teaching (25). Multiple small comparative studies favor an electronic teaching format because of the enhanced learner interaction and visual learning, but there does not appear to be a consistently large advantage of one teaching format over the others (26).

Literature emphasizes the importance of repetition and active engagement in learning ECG interpretation (27). These two qualities appear to be more important that any teaching strategy and are best delivered by computer-based training. The concept of repetition and active engagement is well supported by medical education evidence (28).

It is recommended that education programs choose teaching methods based on their available resources taking into consideration adequate teaching time that ensures defined objectives for ECG interpretation competency are met.

b) ECG Competency Assessment Method

Assessment drives learning by raising the stakes and thus boosting student efforts as already proven by medical education literature. Further, assessment method superseded the training format in determining ECG interpretation competency (28).

Summative Assessment method was found to be more effective in determining competency in ECG interpretation (29). Nevertheless, designing a formative assessment well can focus students on effective learning by identifying gaps and important information (30).

33% of family medicine post-graduate training and 71% of American clerkship programs have formal assessment of ECG interpretation skills (4, 24).

2.5. Errors in ECG Interpretation

Studies that examined extent to which ECG interpretation errors affect patient management and studies that have measured patient outcomes found that 4% to 33% of ECG interpretation errors are of significance to patient outcomes (8, 30, 31, 32, 33).

In instances where patient charts with ECG interpretation were subjected to expert cardiologists' consensus panels to determine whether a correct ECG interpretation would have changed patient management, the analysis revealed inappropriate management as a result of interpretation errors in up to 11% of cases.

Due to the difficulty in measuring probability of life-threatening disease in primary care settings, the impact of interpretation errors on patient outcomes may be overestimated by extrapolating from the existing evidence (35).

CHAPTER THREE

STUDY JUSTIFICATION

In spite of ECG being a routine diagnostic, screening and treatment monitoring test for cardiovascular diseases, the competency in the interpretation of ECGs among the unspecialized doctor remains unknown.

ECG misinterpretation or inability of a doctor to interpret an ECG increases the risk of misdiagnosis or delayed diagnosis of cardiovascular conditions. This may lead to adverse outcomes during care of cardiovascular patients. Cardiovascular diseases remain a leading cause of morbidity and mortality in most populations worldwide with the majority of patients first being attended to by the unspecialized doctors, mostly medical interns, in large or medium sized hospitals. These doctors often then make a decision on the appropriate treatment approach or referral to specialist physicians or cardiologists.

After graduation with an MBChB, no further evaluations are undertaken before graduates begin to attend to and make vital decisions concerning patients. It is important to assess the level of competency in ECG interpretation among the graduating medical students.

The outcome of this study would help establish gaps in competence in ECG interpretation and thus inform formulation of strategies towards improving competencies of graduating medical students in ECG interpretation.

3.1 Research Question

What is the competency of newly graduated medical students in ECG Interpretation?

3.1.2 Primary Objective

1. To determine the level of competency in the interpretation of ECGs among newly graduated medical students from the University of Nairobi.

3.1.3 Secondary objective

1. To correlate the level of competency in ECG interpretation among newly graduated medical students with self-reported confidence and self-reported adequacy of ECG interpretation training.

CHAPTER FOUR
METHODOLOGY

4.1 Study design

A medical school web-based descriptive cross - sectional study design.

4.2 Study setting

The study was conducted at The University of Nairobi's School of Medicine. The University of Nairobi is one of the 31 public universities in Kenya. It is the oldest medical school among the 9 medical schools in Kenya having graduated more than half of all doctors in Kenya. The School of Medicine has undergraduate, post-graduate and graduate fellowship programs. The undergraduate medical program is a six year program. The studies are undertaken in two Campuses. Chiromo Campus, where basic sciences of physiology, anatomy and biochemistry among other subjects are taught for the first two years and the College of Health Sciences where clinical clerkship are taught. In the first two years, the university curriculum has a two week instruction on performing an ECG and basic interpretation of a Normal ECG.

College of Health Sciences which is affiliated to the Kenya's biggest National Referral Hospital, Kenyatta National Hospital, and hosts all clinical education programs for the third years to the final sixth year.

Internal Medicine rotation is undertaken for 3 months each during the 4^{th} and the 6^{th} Level of MBChB studies. In each of the rotations, competency in clinical procedures and application to patientcare is assessed by observation and use of log books.

A final qualifying end of year examination is then administered and the MBChB degree is awarded for the students who satisfy the University's Board of Examiners.

4.3 Study population:

All the MBChB Graduating class of 2018.

4.4 Participant Selection:

A list containing all the names, registration numbers and phone numbers for Graduating Medical Students' Class of 2018 at the University of Nairobi was requested from the College of Health Sciences Academic Registrar and from which all study participants were selected.

4.4.1 Inclusion criteria:

- All 2018 graduating medical students who satisfied the Board of Examiners at the University of Nairobi for the award of MBChB degree.
- Agreement to participate in the study by signing the informed consent form for response to be used in Research.

4.4.2 Exclusion criteria

- There were no exclusions in this study.

4.5 Definition of Study variables

4.5.1 Dependent Variable

The dependent variable was Competencies in ECG Interpretation namely:

a) Summative ECG Interpretation competency defined as the proportion of participants who correctly interpret 11 (50%) or more of the 22 ECG images used.
b) Competency on Interpretation of Individual ECGs defined as the proportion of participants who correctly interpret an Individual ECG.
c) Mean ECG competency score defined as the average of Individual ECGs Competency scores.

ECG abnormalities were obtained from a validated study tool (Appendix 1). ECG strips showing abnormalities were derived from ECG Wave Maven, an online resource reference for ECGs and verified as representing the abnormality.

The ECG strips selected represented the following conditions.

1. Atrial fibrillation (case #266)
2. Hyperkalemia (case #36)
3. First degree AV block (case #280)
4. Left Ventricular Hypertrophy (case #378)
5. Long QT syndrome (case #1)
6. Acute pericarditis (case #3)
7. Sinus tachycardia (case #242)
8. Right Bundle Branch Block (case #239)
9. Myocardial ischemia (case #297)
10. Sinus arrhythmia (case #300)
11. Atrial flutter (case #188)
12. V-fib (case #333)
13. PAC's (case #492)
14. Left Anterior Fascicular Block (case #172)
15. Acute Myocardial Infarction (case # 355)
16. Third degree/complete heart block (case #219)
17. Torsades de Pointes (case #159)
18. Premature Ventricular Complexes's (bigeminy; case #272)
19. Left Bundle Branch Block (case #255)
20. Supra-Ventricular Tachycardia (case #323)
21. Ventricular Tachycardia (case #502)
22. Wolff-Parkinson-White Syndrome (case #299)

4.5.2 Independent Variables

The independent variables in this study was self-reported confidence and Adequacy of ECG Training on ECG Interpretation. These variables are explained as follows

Self-reported confidence: Single choice response on a Likert scale of Not at all confident, Somewhat Not Confident, Somewhat Confident or Very Confident
Adequacy of ECG Training: Defined as single choice answer from multiple choices one Adequacy of Training in ECG interpretation.

4.6 Sample Size

The study was conducted in the population of 250 Medical Students in the Graduating class of 2018.

4.7 Study Procedure

1. Subscription to a Web- Based Platform

The principal Investigator subscribed to a web-based platform designed to administer online examinations. The ECG survey questions, the ECG images representing only one abnormality and a corresponding Answer Key was uploaded onto the platform. A web link for the study was generated and then distributed via social media to participants.

2. Verification of Study Participant

University Registration Number and the corresponding phone number for the MBChB graduating class of 2018 was obtained from the Registrar, CHS.

Each study participant logged in to the web-based platform using the registration number as a user name and phone number as a password.

Participant verifier was not linked to their responses. Each participant logged in once without a chance to reuse the username or password.

3. Consent for Study

Study participants consented by checking a box. The consent information read as follows.

‘This survey is required for educational purposes with a goal of the Principal Investigator fulfilling part of requirements for the award of Masters’ Degree. The results may also be used for a research project but will not affect your academic or professional standing. If you would like for your responses NOT to be used for research, please check here:’

The consent statement prompted a participant to ***Proceed*** to other parts of the study or ***Opt Out*** of the study.

Participants who opt out ended the study without a chance to return to the study.

4. Study Flow

The Survey was divided into two Blocks. Block I contained general questions pertaining to self-reported confidence in ECG interpretation, ECG interpretation training sufficiency, resources, methods, attached significance of correct ECG interpretation to practice, future desired career options and the student's own comment on ECG interpretation training received. This section had 10 questions with choices and was not timed.

Block II comprised select ECG images each showing only one abnormality. Each ECG strip was timed at 90 seconds of display with no chance for participant to return to the previous ECG image. Each ECG image had below it 5 choices from a) to e), only one of which represented the abnormality corresponding to the correct ECG abnormality of image.

5. Response Submission

The study completed after last ECG image is interpreted or time has elapsed. The complete response automatically emailed to the principal investigator for analysis.
Unanswered questions due to time lapse were taken as incorrect interpretation.
Participants had the option of checking their ECG scores upon completion of the survey.

4.8 Data Management

Quality assurance activities were implemented during the process of data collection and management to ensure data quality. This included training of research assistants on the web-based study design and the study procedures including use of social media reminders and phone call or text follow-ups. The ECG items included in the study questionnaire for assessing competency in ECG interpretation were validated in previous studies.

In addition, standard operating procedures (SOPs) and data collection manual were prepared and used to guide data collection. Only a completed ECG survey tool were submitted for analysis.

Data was entered into password protected databases designed in MS Office Access (2007), and installed on the Principal investigator's personal computer (PC). The database was customized using the study questionnaire structure with data stored in numeric coded format, and text for open ended questions. Range and consistency checks were built into the database as a quality assurance measure aimed at reducing data entry errors. Data was transferred from Access databases to IBM SPSS (version 24) for data cleaning and analysis. Finally for quality control, data cleaning was conducted by inspecting each variable in the database to check for invalid entries, and inconsistencies using SPSS procedure for summarizing variables. Errors noted were corrected by referring back to the questionnaires to confirm that they are not data entry errors. Any discrepancy between the database and questionnaire was resolved by re-entry of data contained in the questionnaire.

Study questionnaires and data will be securely archived until period prescribed by the department of medicine and the journal that will accept publication of the scientific manuscript.

4.9 Statistical Analysis

Data analysis was performed using IBM SPSS (version 24). In the first stage, descriptive analysis was conducted for the characteristics of participating medical graduates. Means or medians were calculated for continuous variables (e.g. age) and these measures of central tendency are presented along with standard deviation or range, respectively. For categorical attributes including sex, the counts and percentages for each level of the variable are summarized using frequency distributions and presented as tables, charts and graphs.

After the descriptive analysis of the sample, the statistical analysis plan followed the study objectives. To determine the competency in interpretation of ECG tracing among newly graduated medical students, the 22 variables representing ECG tracings were used to calculate a summative competency score. The range of the score for each participant was between zero (0) and 22 with 0 representing inability to correctly interpret any of the ECG tracings and the maximum score of 22 representing correct interpretation of all the ECG tracings. Participants with scores of 11 or more (50% and above) were considered competent in interpreting ECGs. The proportion of participants showing competency in interpreting ECGs was calculated and reported along with the corresponding 95% confidence interval as the summative competency score.

Secondly, correct interpretation for an Individual ECG by a participant was scored one mark. Incorrect interpretation was marked as zero. Scores for each individual ECG were computed and presented with a measure of variation (standard deviation). Competency in interpreting each of the 22 ECG tracings (Competency in Interpretation of Individual ECGs) was determined by calculating the proportion of correct interpretations for each ECG tracing. Individual ECGs were ranked from the most correctly interpreted to least correctly interpreted ECG abnormality.

Lastly, the mean competency score was then determined as an average from the Individual ECG Competency scores.

In the second stage, bivariable analysis was conducted for the variables: self-reported confidence and self-reported adequacy in ECG Interpretation training. Using logistic regression, each of the independent variables namely self-reported confidence and adequacy of ECG interpretation training were correlated against the dependent variable Mean ECG competency scores. Odds ratios and 95% CI were presented and statistical significance determined using a p value of 0.05. Variables showing statistically significant association with competency in ECG interpretation in the bivariable analysis were subjected to a multivariable logistic model.

4.10 Dissemination plan of study findings

The findings of the study will be disseminated through scientific presentations at the departmental and college level. The results will also be presented at national and international scientific conferences. The results of the final analysis will be published in a peer reviewed scientific journal.

4.11 Ethical considerations

Ethical approval to conduct this study was sought from the KNH/ UON Ethics Review Committee. Participation in the study was voluntary and based on recorded informed consent. Participants were adequately briefed regarding the objectives of the study; and how the information collected will be used. The investigators reassured potential participants that participation or non-participation in the study had no direct bearing on academic progression or professional standing for each graduate. No conceivable harms directly related to participation in the study was noted. The potential benefits of participation in the study included acquisition of essential skills in interpretation of common and abnormal ECG tracings.

CHAPTER FIVE

RESULTS

The web-based ECG Competency survey was administered to Graduating Medical Students from the University of Nairobi's School of Medicine. The University's College of Health Sciences Academic Registrar, upon request, supplied the investigators with a list of the 250 students who had satisfied the University Board of Examiners and were awaiting University Senate approval for the award of Bachelors of Medicine and Bachelors of Surgery Degree for the year 2018. The graduating medical students used a link sent as short text message by study assistants to join in an internet based social media social messaging platform (whatsapp) as a group. All the 250 joined the internet-based social media group message platform. The ECG survey web-link was messaged to the group using the platform. Reminders were done once every week by the study assistant until the close of the survey and the ECG survey website. The study was open between 14th February 2019 and 15th March 2019.

Out of a population of 250 graduates, 211 participants voluntarily enrolled in the study. Of the 211, 5 participants did not consent for their data to be used for research purposes and did not therefore proceed to the ECG survey while 206 participants who consented proceeded to respond to ECG survey questions and images.

During data cleaning, responses for 29 participants were removed as descriptive data sets such as age and gender were not complete and all the 22 ECG images automatically timed out without attempted interpretation.

Responses for 177 participants were analysed as per framework detailed in the study methodology section 4.9.

A summary of the study flow is represented in the chart below.

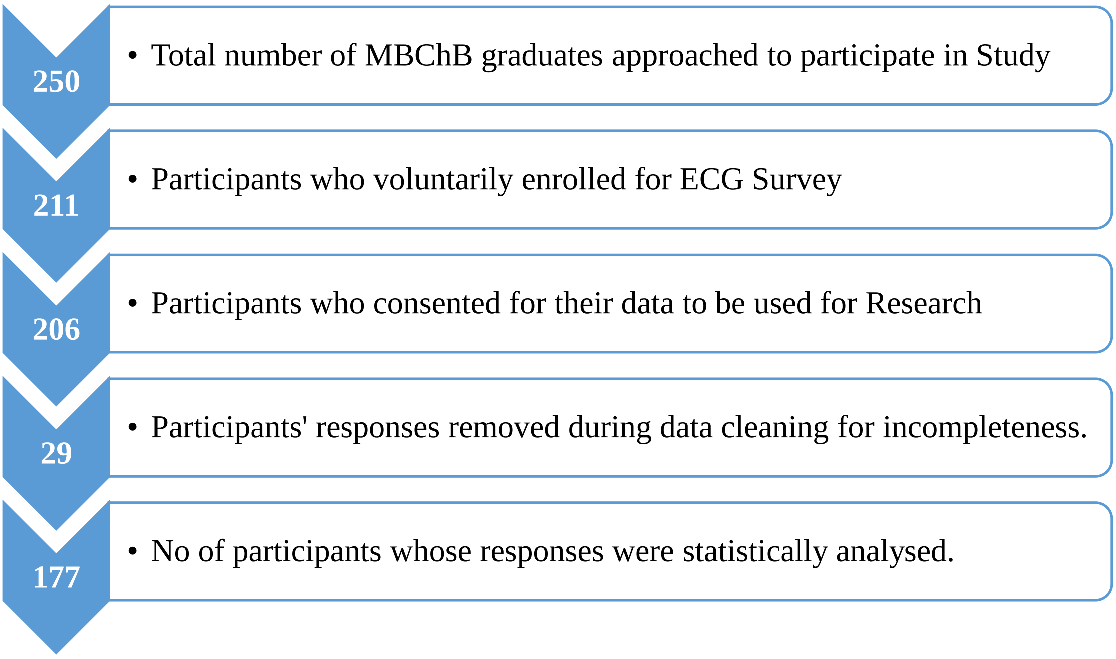

Figure 1: Flow Chart

5.1 Characteristics of the Study Population

One hundred and seventy seven (177) graduates, 89 (50.3%) male and 88 (49.7%) female completed our web-based ECG survey. The participants' age ranged from 23 years to 32 years with a median age of 24 years and a mean age of 24.8 years. Characteristics of the study group are summarized in Table One (Table 1).

Table 1: Characteristics of Study Participants

Characteristic	Frequency (n); N=177	Percentage	
Gender			
Male	89	50.3%	
Female	88	49.7%	
Age			
23 years	9	5.08%	Average Age
24 years	47	26.55%	
25 years	94	53.10%	24.8 years
26 years	17	9.60%	
>26 years	10	5.64%	

5.2 Competency in ECG Interpretation

5.2.1 Summative Competency in ECG Interpretation

Participants interpreted between zero and twelve ECGs correctly out of twenty two ECGs used for assessment in the survey. Only five participants (2.8%) correctly interpreted ≥11 (≥50%) of the twenty ECG tracings assessed and were considered competent in ECG interpretation. 97.2% of the participants were incompetent. Figure 1 illustrates the summative ECG Interpretation competency score for Graduating Medical Students Class of 2018 at the University of Nairobi's School of Medicine.

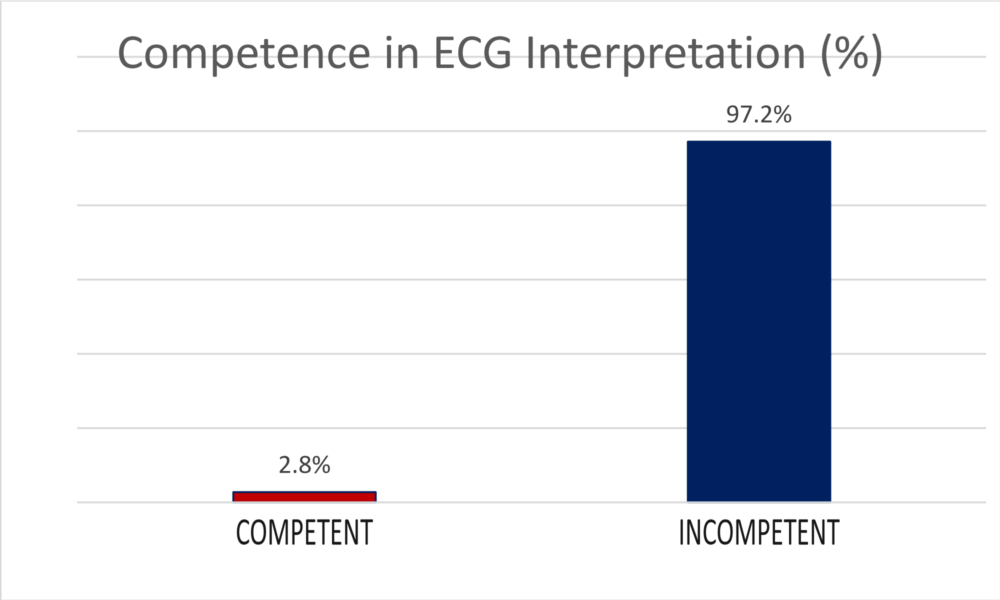

Figure 1: ECG Interpretation Competence (score ≥50%) for graduating medical students

5.2.2 Competency in Interpreting Individual ECGs

Hyperkalaemia was the most correctly interpreted on ECG tracing with a 61.0% of participants interpreting it. Atrial fibrillation (36.1%) and Left Ventricular Hypertrophy (31.6%) were the second most correctly interpreted on ECG tracings. Complete (Third degree) AV block and Left Anterior Fascicular Block were the least correctly interpreted ECG tracings at 6.2% and 5.1% respectively.

Table 2: Competency in Interpretation of Individual ECGs

Medical Condition	Correct Interpretation	
	n	%
Hyperkalaemia	108	61.0
Atrial Fibrillation	56	31.6
Left Ventricular Hypertrophy	56	31.6
ST Elevation Myocardial Infarction	50	28.2
Ventricular Fibrillation	47	26.6
Myocardial Ischemia	46	26.0
Premature Ventricular Complexes	38	21.5
First Degree Heart Block	35	19.8
Atrial Flutter	35	19.8
Left Bundle Branch Block	35	19.8
Sinus Tachycardia	28	15.8
Sinus Rhythm with Premature Atrial Complexes	26	14.7
Long QT syndrome	25	14.1
Torsade de Pointes	25	14.1
Wolff-Parkinson-White (WPW) pre-excitation	25	14.1
Right Bundle Branch Block	22	12.4
Paroxysmal Supraventricular Tachycardia	20	11.3
Sinus Arrhythmia	18	10.2
Ventricular Tachycardia	17	9.6
Acute Pericarditis	13	7.3
Third Degree (complete) AV Block	11	6.2
Left Anterior Fascicular Block	9	5.1

5.2.3 Mean Competency Score

The mean score of participants (N=177) for correct interpretation of 22 ECGs was 4.2 (SD=3), which was equivalent to an overall competence of 19.2%.

5.3 Competence Correlation with Confidence and Training Adequacy

5.3.1 Self-Reported Confidence and Adequacy of ECG Interpretation Training

Most participants (66.6%) perceived themselves to be somewhat confident in the Interpretation of ECGs. Only fourteen (8.0%) participants self-reported as not at all confident in the Interpretation of ECGs.

Self-reported adequacy of ECG training was linked to participants' satisfaction with ECG Training. Nearly all (92%) of the one hundred and seventy seven participants perceived their training on ECG as satisfactory (adequate). Table 3 details the participants' self-reported Confidence and self-reported adequacy in ECG Training.

Table 3: Study Characteristics for Study Participants

		n	**%**
Confidence in ECG Interpretation	Not at all confident	14	8.0
	Somewhat unconfident	42	23.7
	Somewhat confident	118	66.6
	Very confident	3	1.7
Satisfaction with ECG Training	Yes	163	92.0
	No	14	8.0
Need for More ECG Training	Yes	38	21.6
	No	139	78.4

5.3.2 Competence by Self-Reported Confidence and Adequacy of ECG Interpretation Training with the Mean ECG Interpretation Competence Scores

There were no correlations observed between Self-Reported Confidence in ECG Interpretation. However, participants who self- reported as very confident had a Mean ECG Score of six (27.2%) out of twenty two ECGs which was higher than the Mean Competency Score of 18.2% reported for other categories of Confidence.

Additionally, no correlations were observed between self-reported adequacy of ECG Training and Mean Competency Scores.

Table 4: Competence vs Confidence in Interpreting ECGs and Self-Reported Adequacy in ECG Training

		N	**Mean**	**Competence (%)**	**P**
Confidence in interpretation of ECGs	Not at all confident	14	4	18.2	0.83
	Somewhat unconfident	42	4	18.2	
	Somewhat confident	118	4	18.2	
	Very confident	3	6	27.2	
Satisfaction with training	Yes	163	4	18.2	0.93
	No	14	4	18.2	

DISCUSSION

5.4 Competency in ECG Interpretation

ECG Interpretation competency amongst doctors determine patient outcomes. Our study found a low level of competency among graduating medical students at the University of Nairobi. Only 2.8% of students could correctly interpret at least 50% of the twenty ECGs used in the competency survey. Individual ECGs were interpreted variedly with participants being only competent in the interpretation of ECG tracing for Hyperkalemia at 61% which was correctly interpreted by more than 50% of the Graduating Medical Students. Left Anterior Fascicular Block (LAFB) was the least interpreted ECG abnormality at 5.1%. The mean competency score was equally low at 19.2%.

Jablonover and others found ECG Interpretation Mean Competency at 37% with an average 8.2 of the 22 ECGs being correctly interpreted by graduating medical students at George Washington University (21). Alikor and others (36) found a summative competency score of 0.9% with only 24% of final year medical students capable of interpreting a Normal ECG strip. A normal ECG tracing the most correctly interpreted ECG in their study. None of the students correctly interpreted critical ECG abnormalities such as ST segment elevation myocardial infarction, ST segment depression myocardial infarction, ventricular tachycardia, ventricular fibrillation, atrial fibrillation and atrial flutter. Our study did not include a normal ECG tracing and participants were informed that all ECG strips showed one abnormality. However, our study methodology and tool was varied.

Individual ECG Interpretation competency scores for Hyperkalaemia at 61%, ST segment Elevation Myocardial Infarction at 28.2%, Atrial Fibrillation at 31%, Left Ventricular Hypertrophy at 31% and Left Anterior Fascicular Block 5% in our study were not consistent with study findings by Kopec and others (8) and Jablonover and others (21) for which individual scores for ST Elevation Myocardial Infarction; Atrial Fibrillation; Left Ventricular Hypertrophy; Left Bundle Branch Block and Atrial Flutter were 88% and 74%; 46% and 69%; 34% and 26%; 75% and 26% and 82% and 79% respectively. ECG competency score for Hyperkalemia at 24% by Jablonover and others was much lower than in our study. Moreover, Individual ECGs scores that were higher are those for critical ECGs. In particular, it has been established by Salerno and others (5) that graduating medical students interpret ECG tracings for critical conditions better than non-emergency conditions. However, Jager and others (15) carrying out a study in South Africa among Emergency Medicine post-graduate students found a low level of competency in the interpretation of critical ECGs. Our study didn't categorize ECGs as critical or non-critical.

Different study settings, different study methodologies and lack of standard applicable guidelines (5) have been attributed to the variations in ECG competency scores in many studies. For example the study by Kopec and others in all Polish Medical schools included identification of normal ECG parameters such as Heart Rate, Rhythm and Axis which could have influenced higher the competency scores. Kopec et al attributed the higher scores to potential bias in selection of study participants with interest in ECG without which we can confirm with our findings that graduate students have limited competency in ECG interpretation. Students could have retaken tests several times or used external resources until correct responses are achieved as reported by Kopec and others in the limitations within their study.

Summative assessment methods for ECG interpretation yield the most results in driving students to acquire ECG interpretation skills (4). Other ECG interpretation studies administered by internal medicine departments, clerkship directors and compulsory interventional studies on ECG interpretation (19) have reported higher competency scores. Our study was a web-based cross-sectional study, was unsupervised and participation was voluntary which could explain the lower ECG interpretation competency mean of 19.2%.

Self- Reported Confidence in ECG Interpretation Competency & Adequacy of ECG Training

Even though we had secondarily set to correlate Self-Reported Confidence and Competency in ECG interpretation, this was not statistically possible because only 5 participants were competent in ECG interpretation. We could not, therefore, establish the ability of graduating medical students to predict their own competency.

Few studies examining the competency of graduating medical students on the interpretation of ECGs have correlated ECG Interpretation Competency and Self-Reported Confidence. Kopec and others (8) found that students could estimate their ECG interpretation ability but there was no relationship between attending regular ECG classes with ECG competency. At the George Washington University, Graduating Medical Students could predict their ability to interpret ECGs at 37% which correlated statistically with ECG competency at 37% as reported by Jablonover and others.

No study has determined adequate amount of training that determines ECG interpretation competency. Our study and Jablonover and others estimated students 'satisfaction with their training in ECGs. Determination of adequacy of Training would review the content of the ECG training curriculum together with the training resources and training methods. The consensus recommendations for the American Heart Association/American College of Cardiology states that ECG competency is acquired by interpretation of at least 500 ECGs and maintained by exposure to at least 100 ECGs per year (37). These guidelines are prescribed for cardiologists and physicians but the standards are recommended to apply in all practice settings where ECG interpretation competency is part of patient care (38).

The University of Nairobi Curriculum covers ECG competency teaching in physiology classes of Level 1 (HMP 100), physiology classes of Level 2 (HMP 200), Internal Medicine 1 rotation in Level 4 (HME 400) and Internal Medicine rotation 2 in Level 6 (HME 600). However, the curriculum does not define competency in ECG interpretation. Neither is the curriculum explicit on particular ECG skills students are expected to attain at the end of their teachings. Kenya's Ministry of Education has no guideline for medical students and medical schools on specific ECG skills students must obtain as compared to Ministry of Science and Technology in New Zealand and Poland which have defined performing ECGs and interpreting prescribed ECG abnormalities as competency skills necessary before a student is qualified to be a doctor (8). The Kenya Medical Practitioners and Dentists Board has not defined competency in ECG interpretation nor listed ECG as part of the skills interns must acquire before being registered as doctors to practice in Kenya. These factors may play a role in de-emphasizing ECG competency skills among medical students and lead to low competency as we found out in our study.

Self-learning and being in clinical years have been found to be the two most consistent determinants of higher ECG interpretation competency among medical students (8). Our study found that 92% of all students reported self-learning using YouTube while only 6.6% used ECG Textbooks. Self-learning correlated positively with competency though the finding is not significant statistically.

Providing a patient's clinical narration to accompany an ECG image has been found to influence competency for practicing physicians. Our study did not narrate a clinical scenario for the 22 ECG images for participants that would otherwise influence their choices. ECG competency evaluations should avoid the clinical scenario and computer generated reports accompanying ECG images (5).

5.5 Study Strengths and Limitations

This study had the strength of adequate response rate from participants thus eliminating the selection bias where only participants interested in ECG interpretation enrol for a study. Secondly, we used a survey tool demonstrated to have construct validity without modification in order to keep up with global guidelines and recommendations not only on ECG interpretation competency but on good clinical practice principles in cardiovascular disease management. Third, our study was voluntary for students without the threat or coercion of consequences that may obtain if they did not participate. Lastly, our study was web-based which increased efficiency and reduced bias and leakages that accompany physical administration of competency tests.

Several limitations to this study that should be highlighted. First, the study was conducted in only one medical school in Kenya and even though the response rate was high, it may not represent all graduate medical students. Secondly, the study was conducted after students had completed medical school and were awaiting the start of their internship for which period they could have been less interested about taking an academic test. However, because the study was voluntarily, we believe that students provided the best responses as per their knowledge. Third, some respondents had challenges with internet access or power access given that the study was web-based methodology. As a result 29 responses were incomplete and were not analysed.

Lastly, the ECG survey tool was validated for use in a set-up outside of Africa and the participants may have had little exposure to some ECGs thereby lowering cumulative competency scores.

CONCLUSIONS

Our study found that newly graduated medical students at the University of Nairobi have limited competency in the interpretation of ECGs. Only 2.8% of graduate students score 11 (50%) or more out of the 22 ECGs.

However, the mean competency score of 19.27% is consistent with similar studies evaluating ECG interpretation competency among graduating medical students which range from 17% to 63%. This wide variation can be attributed to different methodologies used by the different studies in different settings.

To the best of our knowledge, the study was the first in Africa evaluating ECG interpretation competency among graduate medical students.

Even though Mean ECG interpretation competency scores are consistent with findings in other studies, there was significantly poor scores on Atrial Fibrillation, Ventricular Fibrillation, Ventricular Tachycardia, ST elevation Myocardial Infarction, and Complete Heart Block. These six ECG abnormalities have been considered critical ECGs.

RECOMMENDATIONS

Standard ECG competency skills should be defined by the Medical Schools, Education Ministries, Medical Professionals regulators and such defined skills be taught and tested to medical students and medical practitioners. Further, studies are needed to determine effective training modalities that can improve ECG Interpretation competency among graduating medical students.

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APPENDIX 1: STUDY TOOL

EKG Survey for Newly Graduated Medical Students at the

University of Nairobi - Kenya

1. This survey is required for educational purposes with a goal of improving the principal investigator fulfilling requirements for Masters of Medicine in Internal Medicine. The results may also be used for a research project but will not affect your academic and professional standing. If you would like for your responses NOT to be used for research, please check here:
   ______________ Proceed   _______________ opt out

2. How confident are you in your ability to interpret common, critical EKG rhythms? Please circle one response.

1	2	3	4
Not at all confident	Somewhat unconfident	Somewhat confident	Very confident

3. Do you feel you received sufficient training in EKG interpretation during medical school in order to be prepared for your internship? Please check one response.
   ____ Yes
   ____ No

4. Would you have liked more training in EKG interpretation during medical school? Please check one response.
   ____ Yes
   ____ No

5. If yes, what method(s) of training would be the most helpful for you? Please check one or more response.
   ____ Lecture
   ____ Small group
   ____ Online
   ____ Practice on the wards
   ____ Quizzes
   ____ Simulated patients
   ____ Other; please specify: ____

6. What medical field/specialty do you plan or prefer to practice? Please check one response.

____ Surgery	____ Neurology	____ Pathology
____ Internal Medicine	____ Family Practice	____ Orthopedics
____ Pediatrics	____ Anesthesiology	____ ENT
____ Ob-Gyn	____ Radiology	____ Urology
____ Psychiatry	____ Emergency Medicine	____ Ophthalmology

____ Other; please specify: ________________

7. How important to your future work as an intern do you rate the ability to accurately interpret EKG's? Please circle one response.

1	2	3	4
Not at all important	Slightly important	Very important	Extremely important

8. How important to your future work as a practicing physician do you rate the ability to accurately interpret EKG's? Please circle one response.

1	2	3	4
Not at all important	Slightly important	Very important	Extremely important

9. Please check all that you have completed during medical school:
____ An elective/teaching on EKG interpretation
____ A textbook on the rapid interpretation of EKG's
____ Any other source for self-teaching on EKG interpretation; please specify: ______________

10. How many times have you been asked to interpret an EKG on the wards? Please circle one:

0 times   1-5 times   6-10 times   11-15 times   >15 times

11. If desired, please provide any comments in reference to your training in EKG interpretation at the University of Nairobi.

____

____

____

____

____

____

12. Each of the following EKG's has an abnormal finding. Please indicate your specific interpretation of each EKG tracing by writing the single most significant abnormality on the line provided:

APPENDIX 2: ANSWER KEY

Answer Key for ECG Competency Survey for Newly Graduated Medical Students Used at The University of Nairobi: (Cases obtained from ECG Wave Maven)

1. Atrial fibrillation (case #266)
    a. Atrial flutter
    b. Sinus Rhythm
    c. Atrial Fibrillation
    d. First degree heart block
    e. I do not know
2. Hyperkalemia (case #36)
    a. Hyperkalemia
    b. Pulmonary Embolism
    c. Long QT syndrome
    d. Right Bundle Branch Block
    e. I do not know
3. First degree AV block (case #280)
    a. Second degree heart block
    b. Third degree heart block
    c. Intraventricular junctional rhythm
    d. First degree heart block
    e. I do not know
4. Left Ventricular Hypertrophy (case #378)
    a. Left Ventricular Hypertrophy
    b. Right Ventricular Hypertrophy
    c. Left Bundle Branch Block
    d. Right Bundle Branch Block
    e. I do not know
5. Long QT syndrome (case #1)
    a. Wolf-Parkinson-White syndrome
    b. Hypothyroidism
    c. Hypokalemia
    d. Long QT syndrome
    e. I do not know
6. Acute pericarditis (case #3)
    a. ST-segment Elevation myocardial infarction
    b. Acute Pericarditis
    c. ECG Artifacts
    d. Left Bundle Branch Block
    e. I do not know
7. Sinus tachycardia (case #242)
    a. Ventricular Tachycardia
    b. Supraventricular tachycardia
    c. Sinus Tachycardia

d. Atrial Fibrillation
e. I do not know

8. Right Bundle Branch Block (case #239)
   a. Right Bundle Branch Block
   b. Complete Heart Block
   c. Left Anterior Fascicular Block
   d. Right Atrial Deviation
   e. I do not know
9. Myocardial ischemia (case #297)
   a. Acute Pericarditis
   b. Myocardial Ischemia
   c. Aortic dissection
   d. Tension Pneumothorax
   e. I do not know
10. Sinus arrhythmia (case #300)
   a. Ectopic atrial rhythm
   b. Sinus Rhythm with AV Wenckebach
   c. Sinus Arrthymia
   d. Atrial Premature beats
   e. I do not know
11. Atrial flutter (case #188)
   a. Atrial Fibrillation
   b. Bilateral Atrial Enlargement
   c. Atrial Flutter
   d. Parkinson tremor artifact
   e. I do not know
12. V-fib (case #333)
   a. Ventricular Tachycardia
   b. Ventricular Fibrillation
   c. Asystole
   d. Torsade de pointes
   e. I do not know
13. PAC's (case #492)
   a. Sinus Rhythm with Premature Atrial Complexes
   b. Premature Ventricular Beats
   c. Respiratory Sinus Arrthymia
   d. Left Axis Deviation
   e. I do not know
14. LAFB (case #172)
   a. Incomplete Left Bundle Branch Block
   b. Right Bundle Branch Block
   c. Indeterminate QRS axis
   d. Left Anterior Fascicular Block
   e. I do not know

15. Acute Myocardial Infarction (case # 355)
    a. Acute anterior ST elevation/Q wave myocardial infarction
    b. Acute pericarditis
    c. Left Bundle Branch Block
    d. Acute Left Pneumothorax
    e. I do not know
16. Third degree/complete heart block (case #219)
    a. Sinus Rhythm with isorhythmic AV dissociation
    b. Mobitz 1 second degree AV block
    c. Mobitz II AV block
    d. Third degree (complete) AV block
    e. I do not know
17. Torsades de Pointes (case #159)
    a. Myocardial Infarction
    b. Ventricular Tachycardia
    c. Paroxysmal Atrial Fibrillation
    d. Torsade de pointes
    e. I do not know
18. Premature Ventricular Complexes's (bigeminy; case #272)
    a. Premature Atrial Complexes
    b. Left Axis Deviation
    c. Apnea
    d. Premature Ventricular Complexes in Bigeminy pattern
    e. I do not know
19. Left Bundle Branch Block (case #255)
    a. Left Bundle Branch Block
    b. Wolff-Parkinson-White pre-excitation
    c. Left Anterior Fascicular Block
    d. Left Posterior Fascicular Block
    e. I do not know
20. Supra-Ventricular Tachycardia (case #323)
    a. Sinus Tachycardia
    b. Ventricular Tachycardia
    c. Atrial Fibrillation
    d. Paroxysmal Supraventricular Tachycardia
    e. I do not know
21. Ventricular Tachycardia (case #502)
    a. Atrial Tachycardia with right bundle branch block
    b. Ventricular Tachycardia
    c. AV reentrant tachycardia
    d. Sinus Tachycardia
    e. I do not know

22. Wolff-Parkinson-White Syndrome (case #299)

   a. Left Bundle Branch Block
   b. Anteroseptal Myocardial Infarction
   c. Right Bundle Branch Block
   d. Wolff-Parkinson-White (WPW) pre-excitation
   e. I do not know

APPENDIX 3: KNH ETHICAL APPROVAL LETTER

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/30

29th January, 2019

KENYATTA NATIONAL HOSPITAL
APPROVED
29 JAN 2019
KNH/UoN-ERC
P. O. BOX 20723 - 00202 NAIROBI

Dr. Fredrick Oluga
Reg. No. H58/75338/2014
Dept. of Clinical Medicine and Therapeutics
School of Medicine
College of Health Sciences
University of Nairobi

Dear Dr. Oluga,

RESEARCH PROPOSAL – COMPETENCIES IN ECG INTERPRETATION AMONG NEWLY GRADUATED MEDICAL STUDENTS AT THE UNIVERSITY OF NAIROBI SCHOOL OF MEDICINE (P828/12/2018)

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 29th January 2019 – 28th January 2020.

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

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 Dean, School of Medicine, UoN
The Chair, Dept. of Clinical Medicine and Therapeutics, UoN
Supervisors: Prof. Joshua K. Kayima, Prof. E.N. Ogola