REPORT TURNAROUND TIME OF DIFFERENT IMAGING MODALITIES AT KENYATTA NATIONAL HOSPITAL

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I, **Dr. Deborah Mocheche Osiemo,** do declare that this proposal is my original work, and that it has not been presented at any other academic institution in Kenya for award of Diploma or Degree, to the best of my knowledge.

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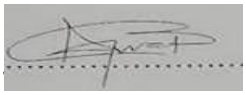
Signature..  **Date:** *2nd August 2023*

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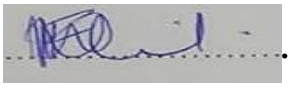
Signature.....  **.....** **Date:** *2nd August 2023*

DEDICATION

To my parents Justus and Joyce Osiemo who are my inspiration, whose love, sacrifice and encouragement has propelled me towards achieving my dreams.

To my brothers and sister who continue to stand with me.

To my lecturers and mentors who are continually encouraging me and pushing me to be the best that I can be.

I thank you all**.**

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I acknowledge the county government of Kajiado and the ministry of health for having sponsored me for the course of Master of Medicine in Diagnostic Imaging and Radiation Medicine and made it possible for me to be here today.

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LIST OF ABBREVIATIONS

CT-	Computed Tomography
HIS-	Health Information System
IR-	Interventional Radiology
KNH	Kenyatta National Hospital
KNH/UON- ERC –	Kenyatta National Hospital/ University of Nairobi Ethics and Research Committee
MRI-	Magnetic Resonance Imaging
OPG-	Orthopantomogram
PACS-	Picture Archiving and Communication Systems
RIS-	Radiology Information System
SPSS-	Statistics Package for Social Science
TAT-	Turnaround time
RTAT-	Report Turnaround time
UON-	University of Nairobi
VR-	Voice Recognition

ABSTRACT

Background

Diagnostic radiology plays a key role in the evaluation of patients seeking medical care as evidenced by the increasing demand of radiology services over the last few years. Referring physicians and patients are increasingly demanding expedited final reports to aid in clinical decision making and fast track patient care in both the inpatient and outpatient settings. Delays in reporting of results can lead to dissatisfaction among clinicians and their patients. The ultimate product of a radiology department is the final radiology report. Report turnaround time (RTAT) is a measure of the efficiency of a radiology department. Hospitals aim to achieve faster RTAT as it increases productivity of a radiology department and contributes to cost effectiveness of the hospital. Assessing turnaround times can help analyze workflow in the radiology department.

Objective

To determine the report turnaround time of different imaging modalities at Kenyatta National Hospital (KNH) and to highlight any gaps.

Materials and methods

A prospective cross-sectional study was carried out at KNH between 1st September and 30th November 2021. Consecutive sampling was done until the sample size was achieved. Every 3rd entry was recorded. The radiology reports generated were interrogated to measure the time taken from image acquisition to signing off of reports over the 3-month period. The modalities studied were plain radiography, PACS CT, non PACS CT scan and MRI. Each imaging study done was given a unique number and recorded for analysis. The date, time taken, requesting department and reporting time was recorded. Based on the data collected, the report turnaround time was calculated and data analyzed using SPSS package. The results were presented in tabular and graphical format.

Results

A total of 748 examinations comprising of 256 CT scans, 196 MRI scans and 333 plain radiographs were reviewed. Of the 256 CT scans 130 were done on the PACS system.The median time taken from image acquisition to generation of reports was lowest with the PACS CT at 8.8 hours, and highest with the non PACS CT which was at 115.6 hours(4.8 days). MRI studies had a RTAT of 71.5 hours (3 days). Plain radiographs had a RTAT of 24.9 hours (1 day). Emergency CT on PACS CT had RTAT of 6.1 hours while that on non PACS CT was 21 hours.

The median time taken from image acquisition to generation of reports for the inpatients was 28.6 hours, and that for the outpatients was 24.9 hours. Time from report completion to collection was shortest on PACS CT, collected in less than 1 day. MRI, Plain radiographs reports were collected within 1 day after report completion.

Conclusion

Findings from this study show that the turnaround time for emergencies on PACS CT was 6.1 hours, which was longer than the 1 hour expected in an ideal set-up. Reports from the non-PACS CT took 115 hrs (4.8 days). These were mainly non-emergency cases. MRI studies had a RTAT of 71.5 hours (3 days) while the plain radiographs took 24.9 hours (1 day). For the emergency cases, the reports were collected within the day. The rest of the reports were collected within 24 hours. The RTAT for CT reports from the PACS system was 13 times faster than those from the non-PACS system. PACS can lead to increased productivity by improving efficiency at many levels.

1.0 CHAPTER ONE: INTRODUCTION

Diagnostic radiology has become key in the wholesome evaluation of patients with different medical conditions, which are not clinically apparent. Referring doctors and patients are finding increased value from radiological services as shown by the tremendous growth in radiology demand over the last few years. The imaging studies done add value to the diagnosis and management of suspected clinical conditions. This underscores the role of radiology in the practice of evidence-based medicine in patient management (1).

The radiology examinations are divided into emergency and non- emergency. Emergency examinations are mostly those from trauma and non-traumatic life threatening conditions such as pulmonary embolism, cerebrovascular accidents, acute abdomen and obstetric emergencies. Non-emergency examinations are those from routine follow up, chronic conditions, comparison studies among others.

For many healthcare stakeholders, the final product of the radiology department is the final radiology report. They rely on the results of these imaging tests to make clinical decisions. Delay in relaying these final reports results in lack of satisfaction among referring doctors and their patients. Report turnaround time (RTAT) is a metric used to measure the efficiency of a radiology department [1,2].

From the review of literature, the commonest definition of report turnaround time was the time taken from the completion of acquisition of image until the final radiology report is made available[3]. In this study, RTAT will be defined as the time from the completion of image acquisition to when the final report is availed.

Several years ago in the United States of America, there were medical transcriptionists employed to type the report dictated by the radiologist. They then returned the report to the radiologist for proof reading. Edits were handwritten and the corrected report was submitted for signing. The signed reports were then delivered to the referring doctor by hand or mail. With the evolution of technology, transcribed reports were entered into the computer system and signed electronically by the radiologist. These were then transmitted via the health information system (HIS) and were immediately available to the referring doctors. Adoption of the PACS system and integration between radiology information system (RIS) and HIS have led to significant decrease in RTAT.[1]

Clinicians rely on fast turnaround times to be able to diagnose and treat their patients in a timely manner and to be able to discharge them from emergency departments or inpatient

appropriately. This according to previous publications has been defined as radiology reports within 1 hour for emergency department patients, up to 8 hours for inpatient studies and up to 24 hours for outpatient studies[4,5]

A number of hospitals have installed CT scanners and sometimes MRI to the emergency rooms to expedite patient care. Hospitals are demanding the scanning of in-patients as quickly as possible to help in cost cutting and fast track patient discharge [4].

Reducing TAT increases productivity of a radiology department and has been shown to reduce the duration of hospital stay of inpatients and therefore contributes to cost saving for the patient and the hospital. It also enables clinical decisions to be made faster and the required treatment to be commenced. Therefore, there is an increased need to make radiology reports available within the shortest time for imaging studies of both inpatients and outpatients[4,6.]

Kenyatta National Hospital (KNH) is the oldest and largest referral hospital in Kenya. It also serves as the teaching hospital for the University Of Nairobi College Of Health Sciences. It has an 1800 bed capacity. The radiology department has 17 full time employed radiologists, 8 UON radiologists and 35 residents from the UON who report the studies from different imaging modalities. On average 60-100 CT and 20-30 MRI and 150-200 radiographs studies are done in a day. Table 1 below shows the different imaging modalities and machines currently available at the KNH radiology department. The department is limited by lack of a RIS, HIS and PACS system although one new CT scan machine with a PACS system was recently installed. Most of the reporting is done manually and the reports delivered by hand to patients and different departments.

Table 1: List of imaging modalities in KNH as at November 2020

Imaging modality	Number of working machines
Plain radiography	2
Ultrasound	5
Ct scan	2
MRI	1
IR	1
Fluoroscopy	1
Mammography	1
OPG	2
Echocardiography	2

Despite increasing workload in the department and few radiologists, there was demand to have timely reports delivered to expedite patient management. KNH does clinical audits and turnaround time surveys every so often. No large volume study has been done on the report turnaround times. This study aims to fill this gap.

2.0 CHAPTER TWO: LITERATURE REVIEW

RTAT is an important metric used to measure the efficiency of a radiology department. With the adoption of PACS and speech recognition systems, RTAT has decreased over the last few years from several days to almost near real time (5).

According to a study by Bernhard et al in 2011, the most common definition of RTAT was that measured from when the imaging was completed to when the report was made available in the health information system (HIS)[3]. Other definitions found in his study included time from when the radiology request was ordered to when the imaging was done. Other papers reviewed defined RTAT as time from when request was ordered until the completion of the report. Time interval to the viewing of results by the requesting doctors were not found in the papers that were analyzed[3].

Different medical specialties within the healthcare system are increasingly relying on imaging to aid diagnosis and assess treatment outcomes. Various radiology stakeholders that includes patients, referring doctors and hospital managers are in need of more and faster access to imaging services. This has resulted in an increased workload which goes beyond imaging access alone due to the fact that referring doctors are under pressure to make time sensitive clinical decisions and therefore expect faster RTAT[7,8].

The radiology investigation offers little value until the requesting doctor gets the finalized radiology report. Therefore, the radiology report is the ultimate product of an imaging department [7].

There is intense competition in the outpatient imaging services in both CT and MRI. Doctors usually have a choice when referring patients for these services and they will often choose centers which they perceive to offer better radiology services. Once these patients are referred to the competition and they get what they perceive to be better services, it may be hard to get them back as clients [9]. This situation isn't ideal as they will be examined using different radiology equipment, protocols and will be interpreted by different radiologists. The images and reports will probably reside outside the hosts information system making it difficult for doctors to make comparisons with studies done earlier [7].

Many radiology departments including Kenyatta National Hospital are struggling with achieving a RTAT of less than 1 hour for emergency examinations and 8 hours for inpatient studies. This is partly due to having only 17 full time employed radiologists and 8 UON radiologists who verify reports to serve the whole hospital.

Radiologists sometimes say that a preliminary report is available but this isn't ideal as the final report is the ultimate both for medical care and medico-legal purposes. Medical decisions made on inaccurate preliminary reports may expose referring doctors and their patients who may receive the wrong care and opens room for litigation[4]. The problem is much bigger in departments that lack integration of three key information systems which are critical to a productive workflow. This are, the radiology information system (RIS), picture archive and communication system (PACS) and voice recognition technology (VR)(7).

In order to meet the demand for faster RTAT, radiologists have asked the organizations they work for to provide additional resources to increase their productivity such as typing staff. These initiatives may address some of the challenges but ultimately it is only through the implementation of integrated digital platform that they can truly meet stakeholders expectations (7).

A RIS monitors radiology workflow. It enables access to the patient's history and other radiological reports. When used together with a HIS it also enables access to the patient's lab works, surgical and pathology reports making the work of the radiologist easier(10). The RIS enables the following of the status of individual examinations from ordering to when the final report is signed off. This makes it possible to study workflow and assess modifications to the processes(11). It records the time of status change for each examination entry.

In a study by Luigi Lepanto [12], the incorporation of electronic signature into report management in RIS resulted in a significant decrease in median time from transcription to final signature from 11 days to 3 days for abdominal ultrasound and from 10 days to 5 days for chest radiographs. It increased timely delivery of radiology reports and increased efficiency compared to a paper based system. This finding was similar to studies published earlier [13,14].

Implementation of a voice recognition (VR) system has been shown to significantly reduce RTAT (15). With the voice recognition system, voice recognition (VR) software is installed and images reviewed on the PACS system are dictated by the radiologist. The radiologist is able to correct errors and verify the report and the report is immediately available for consumption. According to an article by Boland G.W(4), VR technology is advantageous because report signing off is done at the time of the dictation by the original dictator of the report which re-assures doctors and patients. Secondly, the reports are shortened most likely due to the fact that long reports consume a lot of time in dictation and editing. VR also enables structuring of reports into a standardized format[4].

In a study by Arun Krishnaraj et al, the implementation of a voice recognition software resulted in a RTAT from an average of 28 hours to an average of 12.7 hours during the study period. The volume of verified reports also increased by 5% between the study period [15)]

In another study by Luciano M. [16] in a community based hospital, the implementation of a speech recognition system resulted in a 24- fold improvement in radiology RTAT. In yet another study by Hammana [17], a systematic review of literature on the impact of speech recognition showed improvement in departmental productivity with decreases in RTAT varying from 35%-99% [18–20]

Implementation of a picture archive and communication system (PACS) has been shown to increase productivity in a radiology department. This is attributed to the elimination of manual tasks involved with the production of film and distribution to the various radiologists and referring clinicians. It then follows that a filmless environment reduces RTAT[21,22].

In a study by Luigi Lepanto et al, it was shown that PACS shortened dictation turnaround time and increased productivity. This was after studying dictation time in different imaging modalities in a 3 month period before implementation of a PACS , 3 months after and 1 year post PACS implementation[23].

In a study by David B, the implementation of a PACS and VR system significantly reduced RTAT. 86% of all examinations were reported within a 12-hour period compared to a 3% average before the implementation of the changes. It was also found to reduce clinician/radiologist dialogue [24].

Presence of an in-house emergency radiologist has been shown to significantly reduce RTAT. In a study by Leslie Lamb et al in 2015, it was determined that the presence of an in house radiologist in addition to a radiology resident dedicated to the emergency department significantly reduced RTAT. Out of the 1624 reports reviewed, there was a statistically significant decrease in final RTAT. Median final report times decreased from 5 hours to 2.75 hours during the study period. This resulted in improvement of patient care [25].

In a study by Eric et al (5), the implementation of a required 1 hour RTAT for emergency department studies resulted in fewer studies being dictated by residents and this negatively impacted on the quality of their education in a teaching hospital. Tele radiology has also decreased RTAT and improved service levels in the emergency set-up. This is especially important in life threatening conditions such as acute stroke, pulmonary embolism, aortic dissection, ruptured aortic aneurysm in which delay in diagnosis can be catastrophic (26)

In the recent past, there has been an increasing trend of sub specialization in radiology with certified radiologists working in their fields of specialization. This is yet to be fully achieved in Kenyatta National Hospital (KNH). In a study done by Smith et al(27), a survey was done regarding sub specialization in radiology. It was found that 62.9% of practicing radiologists reported expansions of sub specialization within their practices, 91.5 % of radiology residents intended to pursue fellowship and 89.9% had plans of sub specialization (27)

In a study done by Cristoph Stern et al in 2018, it was found that change from general reporting to sub specialized reporting reduced RTAT from a median of 17.04 hours during the period of general reporting to 3.38 hours for the period of sub specialized reporting resulting in a 4.7-fold improvement. The fraction of reports available within 24 hours increased by 22% from 65.2% to 87.2%. The productivity of radiologists also improved. This improved the efficiency of the radiology department and resulted in faster management of patients [(6)].

In a study by Boland carried out at a teaching hospital, the introduction of pay for performance measures significantly reduced RTAT during the study period. It reduced the time taken to sign off a preliminary report to a completed report by the radiologist (28).

In June 2020 KNH conducted a pilot study to determine the average reporting time and average TAT for CT, MRI and ultrasound procedures. In the survey, the TAT recorded were those from registration to finance, queuing time, procedure time and reporting time. The average turnaround time from registration to reporting was also recorded. 49 patients were monitored where 18 were ultrasound patients, 17 MRI and 14 CT patients. The ultrasound mean reporting time was 21.3 minutes. The CT mean reporting time was 3 hours 9 minutes with a median of 3 hours 24 minutes. The MRI mean RTAT was 2.5 days with a median of 1.9 days.

The radiology workflow in the department is once the images are acquired, the radiology resident first does a preliminary report which is then validated by a consultant radiologist and printed then signed off by the radiologist. Once this is done, it is recorded in the reporting room and the reports taken to the reception from where they will be picked by the patient or the ward. During the night, there is a radiologist on call and the radiology residents provide a preliminary report for the emergency cases. Only emergency cases are reported at night.

2.1 Study Justification

Kenyatta National Hospital which is the largest referral hospital in Kenya receives approximately 500-700 new patients from across the country on a daily basis. Radiology is increasingly being used to aid in patient management. In the year 2018 86,363 imaging

investigations were ordered. In the year 2019, 95,257 imaging investigations were ordered. This was a 10% increase from the previous year. In the year 2020, 98,563 studies were done. 15,989 were CT scans, 2,893 were MRI scans and 49,145 were X-rays. The referring clinicians have expressed the need to have final reports produced in the shortest time possible to aid in clinical decision making and expedite management. For inpatients, faster RTAT has been shown to reduce length of stay in hospital.

One of the markers of efficiency in a radiology department is the time taken to produce a final report. With the increased workload, radiologists have reported being overwhelmed by the numbers. There is also increased demand from stakeholders to have shorter RTAT.
This study aims to find out the report turnaround time in different imaging modalities in the radiological investigations done at KNH radiology department. KNH does turnaround surveys every so often but no large volume study has been done on the RTAT of different imaging modalities. Data obtained from this study can be used to formulate policy on required turnaround times for different imaging modalities. Additionally, the data may be used to lobby for the need to digitize the department by introduction of a PACS and RIS to improve radiologists efficiency and to also increase the number of radiologists. This will improve services at the hospital and improve customer service experience. No local or regional studies have been done on RTAT. This study aims to fill that gap.

2.2 Objectives

2.2.1 Main Objective

To determine the report turnaround time of different imaging modalities at Kenyatta National Hospital.

2.2.1 Specific Objectives

a) To determine time taken from image acquisition to generation of reports in CT, MRI and plain radiograph modalities.

b) To determine time taken from completion of report to collection by the patient /clinician.

c) To determine the difference in RTAT between the PACS CT scan and non- PACS CT scan.

3.0 CHAPTER THREE: METHODOLOGY

A prospective cross sectional study was carried out at the KNH radiology department both at the imaging rooms and reporting area. KNH does over 90,000 radiological examinations per year. 15,989 CT scans, 2893 MRI and 49,145 plain radiographs were done in the year 2020. Data collection was done from Monday to Friday including night time. Turnaround time of reports from CT, MRI and plain radiographs were recorded by the principal investigator. The data was collected from the departmental computers and from the records department. Waiver of consent was sought from KNH/UON- ERC. To maintain confidentiality, the patient's name, hospital number, age and gender was concealed. Each imaging request done was given a unique identifier and recorded for analysis. The date imaging was done including time (day or night) was recorded. The requesting department, whether accident and emergency, outpatient, inpatient or clinics was recorded. The examinations were also grouped into emergency or non-emergency. For CT scans, they were grouped into the PACS and non-PACS system.

3.1 Study Design

Cross-sectional institutional based study.

3.2 Study Setting

Kenyatta National Hospital (KNH), Department of Diagnostic Radiology, imaging rooms, records and reporting room.

3.3 Study Population

Ct scans, MRI scans and plain radiographs done and reported at KNH radiology department.

3.4 Sample Size

Sample size is calculated using Fisher's formula [29]

$$\boldsymbol{n = \frac{(Z_{1-\propto/2})^2\, SD^2}{d^2}}$$

n = Desired sample size

$\boldsymbol{Z_{1-\frac{\alpha}{2}}}$ = value from standard normal distribution corresponding to desired confidence level (Z=1.96 for 95% CI)

$\boldsymbol{SD}$ = Standard deviation taken from a previous study done Andrea Nitrosi et al that showed an average turnaround time of 38.4 (SD 28.5) hours for MRI scans, 29.6 (SD 32.4) hours for CT scan, and 33.9 (SD 56.3) hours for radiographs [21].

$\boldsymbol{d}$ = Precision (acceptable difference), i.e. 4 hours for CT scan and MRI, and 6 hours for Radiographs

For CT scan:

$$\boldsymbol{n = \frac{(1.96)^2\ 32.4^2}{4^2} = 253}$$

For MRI:

$$\boldsymbol{n = \frac{(1.96)^2\ 28.5^2}{4^2} = 196}$$

For radiographs:

$$\boldsymbol{n = \frac{(1.96)^2\ 56.3^2}{6^2} = 339}$$

3.5 Sampling Technique

Consecutive sampling was done until the sample size was achieved. Every 3rd entry was recorded.

3.6 Study Duration

The study was a cross-sectional study carried out over a period of 3 months, which began on 1st September 2021 to 30th November 2021.

3.7 Inclusion Criteria

Reports generated in the radiology department from images acquired in CT, MRI and plain radiographs.

3.8 Exclusion Criteria

Reports generated from images acquired from centres outside KNH

3.9 Data Collection, Entry and Storage

Data collection was commenced only after obtaining approval from KNH/UON ERC. Unique arbitrary numbers were allocated to each examination. Findings for each modality were recorded in the data collection tool and stored. The data was collected by the principal investigator by looking at records from the departmental computers and from the records department During data capture, patient identifiers including name and hospital numbers were not captured. This was done to uphold confidentiality. Likewise, reporting radiologists names were not captured. All the examinations and reporting times were analysed on a daily basis by

the principal investigator. Data was extracted and fed into a password protected excel spread sheet and the file was stored on a password protected personal computer. Backup copies of the file were saved on two separate external data storage devices under encryption and were only accessible to the principal investigator. Data will only be stored for the duration of the study and all data will be destroyed at the end of the study.

3.10 Data Analysis

Data collected in the data collection tool was entered into the International Business Machines Statistical Products and Service Solutions (formerly known as Statistical Package for Social Sciences (SPSS)) for Windows software version 22.0 which was used for data analysis. Data verification was done by checking for consistency. Missing entries were discarded. The examinations done were grouped by time done (day or night), requesting departments- whether from wards, outpatient, clinics or accident and emergency and whether they were emergency or non-emergency studies. For CT scans, data was divided into the 2 systems, one of which uses PACS and the other doesn't. The time taken to collect the reports from the reception was also recorded. The report turnaround times were analysed and presented in tabular and graphical format.

3.11 Ethical Considerations

The study was conducted after approval by the Kenyatta National Hospital/University of Nairobi Ethics and Research Committee (KNH/UON – ERC) and permission was sought from KNH Administration. All information obtained from the study was held in utmost confidence and used solely for the purpose of the study. Patient confidentiality was upheld during and after the study period. Waiver of consent was sought before commencement of the study. To prevent Covid-19 disease transmission, wearing of masks was observed throughout, social distancing was observed and handwashing and sanitizing was done frequently.

3.12 Study Results Dissemination Plan

The information and data from the study was disseminated through a thesis report, manuscripts and conference presentations to relevant stakeholders.

4.0 CHAPTER IV: RESULTS

4.1 Data Collection

The data was collected from 1st September to 30th November 2021. It was collected in the imaging rooms, reporting areas and the records department. A total of 256 CT scans, 196 MRI scans and 333 plain radiographs were reviewed.

4.2 RTAT in CT, MRI and plain radiographs.

The median time taken from image acquistion to generation of reports was lowest with the PACS CT at 8.8 hours, and highest with the non PACS CT which was at 115.6 hours(4.8 days). (Table 2)

Table 2: Time taken from image acquisition to generation of reports

Examination	No. of exams	Mean ± SD (hours)	Median (IQR) hours
PACS CT	130	18.8 ± 23.4	8.8 (4.8 – 23.3)
Non PACS CT	126	111.0 ± 93.0	115.6 (24.0 – 149.0)
MRI	196	82.5 ± 62.2	71.5 (43.0 – 117.9)
Plain radiographs	333	38.0 ± 41.0	24.9 (21.0 – 45.5)

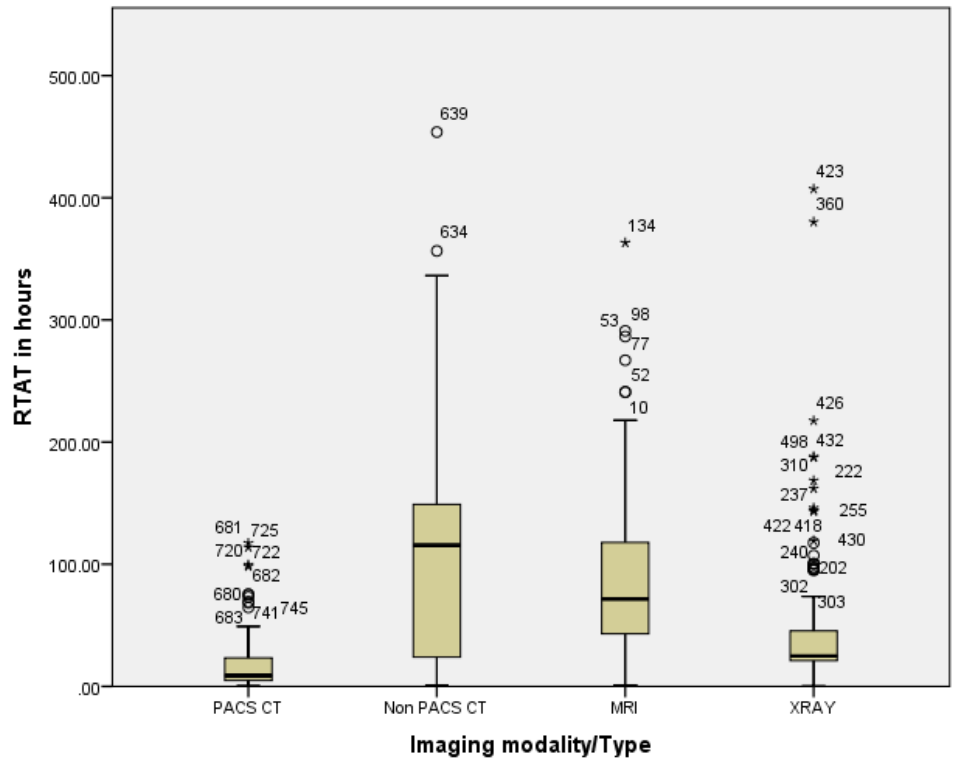

Figure 1: Box plot for time taken from image acquisition to generation of reports

4.3 Time taken from completion of report to collection by the patient /clinician

The results indicate that PACS CT results were collected on the same day, while in the rest of the other modalities it ranged from 1 to 3 days on average. However, the median number of days was 1 day for all modalities with the exception of PACS CT.

Table 3: Time taken from completion of report to collection by the patient in days

Examination	No. of exams	Mean ± SD (days)	Median (IQR) days
PACS CT	119	0.7 (1.5)	0.0 (0.0 – 1.0)
Non PACS CT	126	1.1 (1.9)	1.0 (0.0 – 1.0)
MRI	196	3.4 (4.8)	1.0 (1.0 – 5.0)
Plain radiographs	333	1.2 (1.5)	1.0 (0.0 – 1.0)

4.4 RTAT Emergency vs Non-emergency

Table 4: Time taken from image acquisition to generation of reports by emergency

Examination	No. of exams	Mean ± SD (hours)	Median (IQR) hours
PACS CT			
Emergency	86	8.7±9.1	6.1 (4.0 – 9.7)
Non-emergency	44	38.4±29.8	27.5 (16.6 – 47.7)
Non PACS CT			
Emergency	19	41.6±47.0	21.0 (14.3 – 53.2)
Non-emergency	107	123.3±93.8	118.1 (28.8 – 165.0)
MRI			
Emergency	-		
Non-emergency	196		
Plain radiographs			
Emergency	11	7.9±8.9	3.8 (3.1 – 7.3)
Non-emergency	322	39.1±41.3	25.0 (21.3 – 45.8)

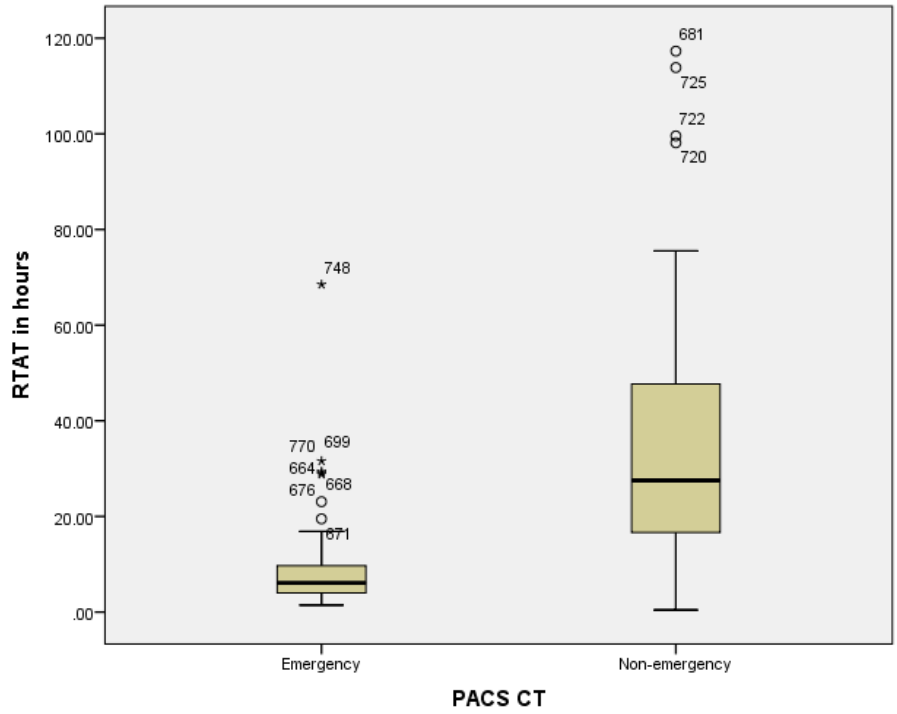

Figure 2: Box plot for turnaround time for the PACS CT

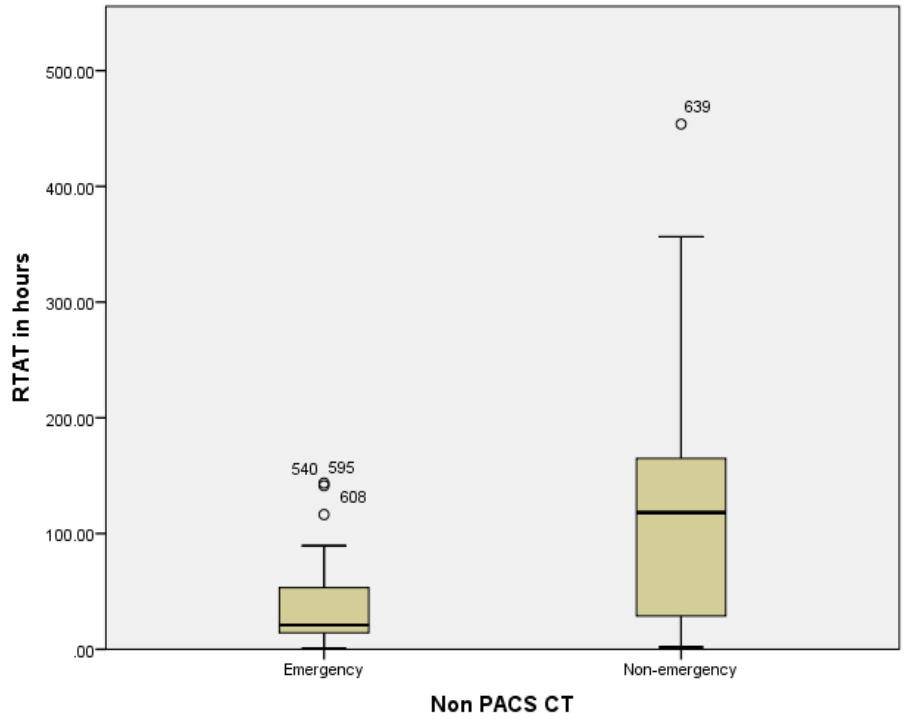

Figure 3: Box plot for turnaround time for the Non PACS CT

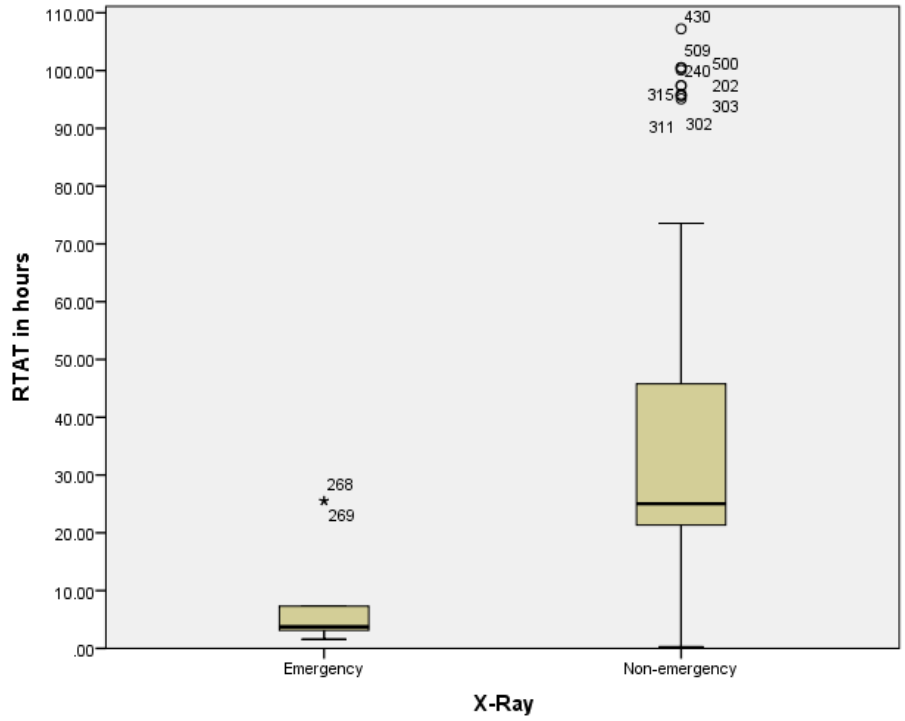

Figure 4: Box plot for turnaround time for the plain radiographs.

4.5 RTAT by patient type.

The median time taken from image acquisition to generation of reports for the inpatients was 28.6 hours, and that for the outpatients was 24.9 hours. (Table 4)

Table 5: Time taken from image acquisition to generation of reports by patient type

Examination	No. of exams	Mean ± SD (hours)	Median (IQR) hours
Inpatient	349	56.5±54.1	28.6 (23.2 – 73.6)
Outpatient	436	58.6±71.9	24.9 (17.3 – 72.7)

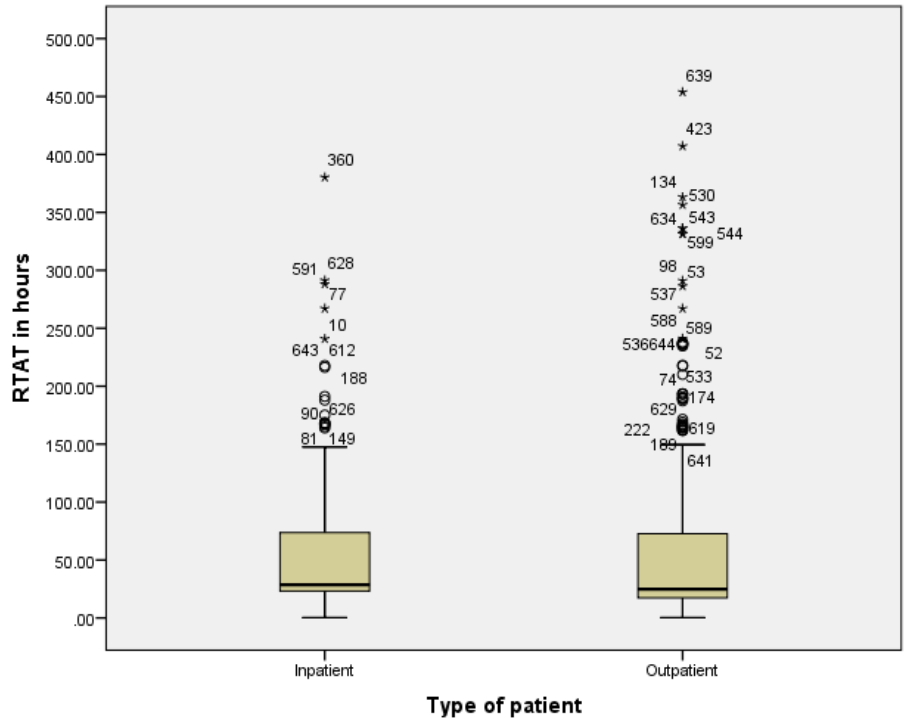

Figure 5: Box plot for turnaround time for type of patient

Table 6: Time taken from image acquisition to generation of reports by patient type

Examination	No. of exams	Mean ± SD (hours)	Median (IQR) hours
Inpatient			
PACS CT	28	27.1±25.3	20.5 (7.4 – 43.9)
Non PACS CT	57	87.1±72.1	100.0 (23.0 – 139.9)
MRI	94	76.0±56.7	60.7 (41.2 – 114.8)
Plain radiographs	170	40.3±38.8	25.9 (23.5 – 47.2)
Outpatient			
PACS CT	102	26.5±22.5	7.3 (4.6 – 15.7)
Non PACS CT	69	105.8±103.6	119.0 (28.0 – 189.5)
MRI	102	88.4±66.6	72.2 (45.1 – 118.4)
Plain radiographs	163	35.7±43.1	22.7 (19.7 – 44.3)

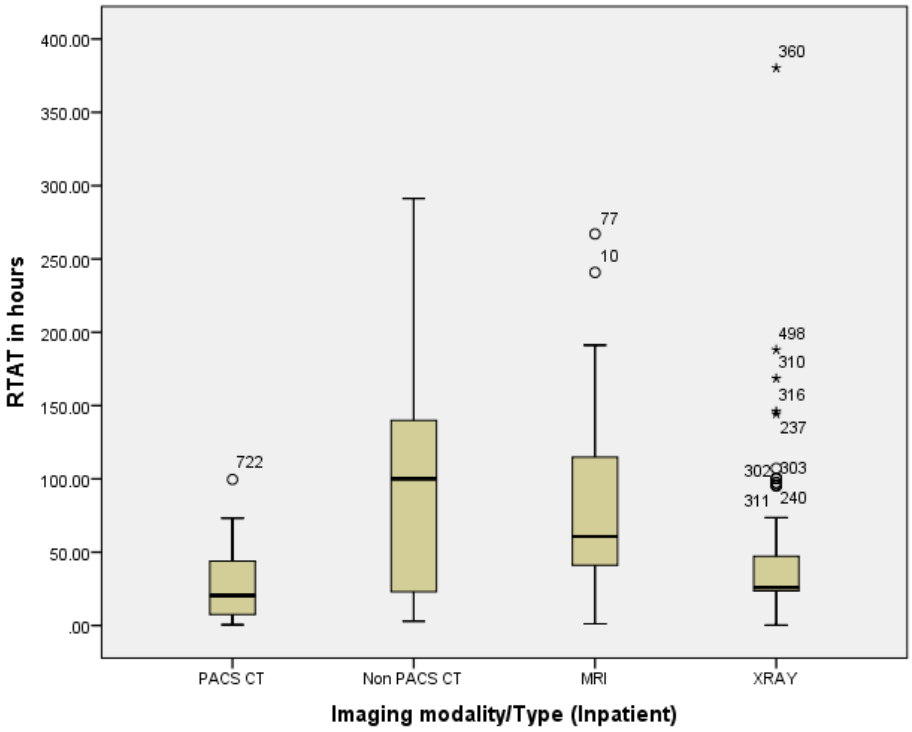

Figure 6: Box plot for turnaround time for inpatient and modality

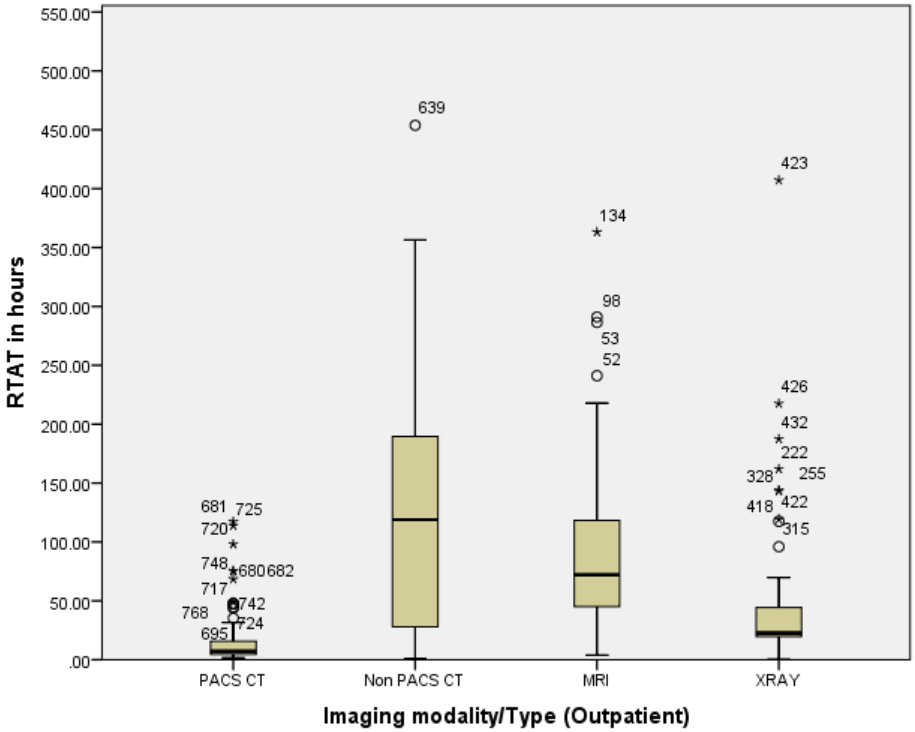

Figure 7: Box plot for turnaround time for outpatient and modality

CHAPTER 5

5.0 DISCUSSION

The report turnaround time was shortest with PACS CT at 8.8 hours (IQR 4.8-23.3 hours).

This was attributed to the fact that using the PACS system, radiologists could report remotely making it possible to report even at night and during the weekend. The KNH radiology department is a 24-hour department working 7 days a week. During the weekdays, there are four reporting radiologists on CT, two in MRI, one in plain radiographs. During the weekends, there is a radiologist on call during the day and night together with the residents on call.

Preliminary reports done by the residents could also be verified quickly by radiologists offsite on the PACS system.

Our results confirm the improvements reported in literature concerning report turnaround time using PACS system(23).

The report turnaround time (RTAT) was longest with non PACS CT at 115.6 hrs (IQR 24.0-149.0 hours).

This was much longer than expected and there is need for improvement in this area. This could be attributed to the fact that the reports had to be done on site. It was observed that more residents and radiologists reported the studies in the PACS system as compared to the non-PACS CT. Additionally, the more complex studies such as cardiac CT, vascular studies and non- emergency studies were done on the non- PACS system which led to longer interpretation times.

Interestingly, MRI studies had a shorter RTAT than non- PACS CT with a median of 71.5 hrs (3 days)(IQR 43.0-117.9). This is despite MR studies being more complex to interpret. Towards the end of the study period, two of the radiologists reporting MRI left the service and this impacted negatively on the MRI RTAT as studies took longer to be reported.

The fact that there were no emergency MRI also contributed to the longer RTAT as emergency studies were given priority during reporting.

Lack of a PACS system for the MRI also increased RTAT as they could not be reported offsite and on weekends.

The plain radiographs RTAT was 24.9 hours with a mean of 38 hours. This was similar to a study by Andrea Nitrosi et al in a study on radiographs prior to implementation of a PACS system.(21)

In terms of emergency, the RTAT for emergency CT on the PACS CT was a median of 6.1 hours while on the non- PACS CT was 21 hours. This was much longer than the recommended 1 hour turnaround time for emergency cases in other studies done.
Despite the emergency CT scans being reported promptly by residents and preliminary report issued, it may take a few hours before the final report is signed off by the consultant radiologist. This impacts negatively on the RTAT.
Having a dedicated in-house emergency radiologist in addition to a radiology resident could significantly reduce RTAT for emergency studies as shown in a study by Leslie Lamb et al. The presence of an in house emergency radiologist in addition to a radiology resident in the emergency department decreased median final report times from 5 hrs to 2.75 hrs.(25)

Emergency plain radiographs were reported within a median of 3.8 hrs while non-emergency radiographs were reported within a median of 25 hours. The sample of emergency radiographs taken for reporting was very small (3.3%). This was due to doctors in the emergency department interpreting the studies for themselves to expedite patient management, which is less than ideal. The implementation of a PACS system for the radiographs would ensure radiologists report more radiographs.

Of the four modalities studied, outpatient RTAT was 24.9 hours while inpatient RTAT was 28.6 hours. Outpatient non-PACS CT had the longest RTAT of 119 hours while in-patient non-PACS CT was 100 hours.
The outpatient PACS CT had a RTAT of 7.3 hours while inpatient PACS CT was 20.5 hours. This is attributed to most of the outpatient PACS CT being emergencies hence reported promptly.

The time taken from completion of report to collection by patient/ clinician was shortest on PACS CT, collected in less than a day. MRI, plain radiographs and non- PACS CT were collected in 1 day. This is attributed to most PACS CT studies being emergencies. The report collection time had many confounders such as reports from the clinic taking up to a month to be collected during the patients next appointment.

Sub-specialized reporting should be embraced to reduce RTAT as there are subspecialists in KNH. This is as shown in a study done by Cristoph Stern et al in 2018 where it was found that change from general reporting to sub specialized reporting reduced RTAT from a median of 17.04 hours during the period of general reporting to 3.38 hours for the period of sub specialized reporting resulting in a 4.7-fold improvement(6). The productivity of radiologists also improved. This improved the efficiency of the radiology department and resulted in faster management of patients

In this study, there are outliers due to complex or time consuming exams such as cardiac CT or MRI. Nevertheless, regarding distortion caused by outliers, the median serves as a robust measurement.

5.1 CONCLUSIONS

Findings from this study show that the turnaround time for emergencies on PACS CT was 6.1 hours, which was longer than the 1 hour expected in an ideal set-up. Reports from the non-PACS CT took 115 hrs (4.8 days). These were mainly non-emergency cases. MRI studies had a RTAT of 71.5 hours (3 days) while the plain radiographs took 24.9 hours (1 day). For the emergency cases, the reports were collected within the day. The rest of the reports were collected within 24 hours. The RTAT for CT reports from the PACS system was 13 times faster than those from the non-PACS system. PACS can lead to increased productivity by improving efficiency at many levels.

5.2 LIMITATIONS

This study faced a number of limitations including the PACS system being affected by network outages leading to delays in reporting which may not reflect the true RTAT. Furthermore, poor record keeping on time reported and time collected by the records department made the data collection difficult. The final report time on the PACS CT changed when report was opened

by different people. This could lead to inaccurate data. Finally, some of the reports remained uncollected as patients went with the films and never came for the reports.

5.3 RECOMMENDATIONS

There is need for Digitization of the radiology department with integration of a RIS, PACS and VR system.

There is need for increase of radiologist numbers to be able to handle increased workload.

Increase number of weekend and night shift staff in order to reduce number of cases not reported.

Provision of a dedicated in-house emergency radiologist in addition to a resident to report emergency studies.

Weekend cases that are yet to be reported should be given first priority at the start of the week.

Change of reporting system from modality based to subspecialized reporting by sub-specialists.

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APPENDICES

Appendix I: Consent Form (English)

Research title: Report turnaround time of different imaging modalities at Kenyatta National Hospital for patient management.

Waiver of consent will be sought. Attached is the form.

KNH-UoN ERC

REQUEST FOR WAIVER OF INFORMED CONSENT

(Not Required for Exempt Studies)

Project Title:

Reporting turnaround times of different imaging modalities at Kenyatta National Hospital._____

Principal Investigator and Institutional affiliation: __

Dr. Deborah Mocheche Osiemo , University of Nairobi_____

Date: ___4/2/2021_____

Under special circumstances, investigators may request one of three types of waivers to obtaining written informed consent from research participants.

1. **Alteration of informed consent.**

With this waiver, the investigator may provide to the participants a consent which does not include or which alters one or all of the required elements. Examples of when this waiver might be applicable would be, when a researcher is conducting secondary data analysis and the participants cannot be located or when requiring informed consent might somehow actually have negative consequences for research participants.

2. **Waiver of parental permission**.

This waiver would be used in cases where something may be legal for a child to do (i.e. contraception) without parental permission and obtaining parental permission would violate that privacy. An example of this type of waiver would be a survey on children (which would require parental permission) but the survey is about their experience on contraception usage.

3. **Waiver of written documentation** that informed consent was obtained. With this waiver, the investigator would be required to read or provide the informed consent form to a participant, but would not need to obtain the participant's signature on the consent form. Examples of when this waiver might be applicable would be some internet or phone surveys or when signing the form might have some negative consequence for the participant. It must be emphasized that these waivers will be given only when there are compelling reasons for doing so.

The Ethics and Research Committee determines which type of consent applies to your research, but please indicate the type that you are requesting.

☐ **Waiver or alteration of the informed consent process.** *(Complete Section I)*

☐ **Request for waiver of parental permission.** *(Complete Section II)*

☐ **Waiver of written documentation of consent.** *(Complete Section III)*

I. Request for waiver or alteration of the consent process (Not required for Exempt studies)

I believe that this protocol is eligible for waiver or alteration of required elements of the informed consent process because the protocol meets all of the following criteria: (Provide protocol-specific supporting information for each criterion that justifies the findings for the following :)

1. The research presents no more than "minimal risk" of harm to participants. ____
The research involves analysis of data and there will be no contact with patients during the study
period._____

_____

2. The waiver or alteration will not adversely affect the rights and welfare of the participants.

_____There will be no contact with the patients during the period of the study._____

_____

_____

3. The research could not practicably be carried out without the waiver or alteration.There will be no contact with the patients and it will be impossible to locate the patients during data collection._____

_____

4. Whenever appropriate, the participants will be provided with additional pertinent information after participation.

Not/applicable_____

_____

5. Elements of informed consent for which a waiver or alteration is requested and the rationale for each:

Voluntariness_-the study involves data analysis and it will be impossible to locate the patients for consent.

Compensation- it will be impossible to locate the patients during data collection and analysis.

6. The research does not involve non-viable neonates:

Yes_____

_____

7. The research is not subject to FDA and/or national research regulation:

_____

_____Yes_____

II. Request for waiver of parental permission (Not required for Exempt studies)

I believe that this protocol is eligible for waiver of parental permission because the protocol meets all of the following criteria: (Provide protocol-specific supporting information for each criterion that justifies the findings for one of the following two options :)

Option 1

1. The research presents no more than "minimal risk" of harm to participants.

_____

_____

2. The waiver or alteration will not adversely affect the rights and welfare of the participants.

_____

_____

3. The research could not practicably be carried out without the waiver or alteration.

_____

_____

4. Whenever appropriate, the participants will be provided with additional pertinent information after participation.

_____

_____

5. Elements of informed consent for which a waiver or alteration is requested and the rationale for each:

_____

_____

6. The research does not involve non-viable neonates:

_____

_____

7. The research is not subject to FDA and/or national research regulation:

_____

_____

Option 2:

1. The research protocol is designed for conditions or for a participant population for which parental or guardian permission is not a reasonable requirement to protect the participants (for example, neglected or abused children)

_____

_____

2. An appropriate mechanism for protecting the children who will participate as participant in the research will be substituted

_____

_____

3. The research is not subject to FDA and/or national research regulation:

_____

_____

4. The waiver is consistent with international and national law:

_____

_____

III. Request for waiver of written documentation of consent (Not required for Exempt studies and not required when the consent process is waived.)

I believe that this protocol is eligible for a waiver of written documentation of informed consent because the protocol meets one of the following criteria: (Provide protocol-specific supporting information for each criterion that justifies the findings for one of the following two options :) **(NOTE: Even when documentation of informed consent is waived, the investigator is required to give participants full consent information, and to obtain their voluntary consent orally.)**

Option 1

(Example: Conducting interviews with street children engaged in drug abuse. The only record of the name or other identifying information of the participants would be the signed consent form and knowledge of an individual's participation or information provided could lead to potential legal, social, or physical harm.)

Explain*:*

1. The only record linking the participant and the research would be the consent document.

_____

_____

2. The principle risk would be potential harm resulting from breach of confidentiality.

_____

_____

3. Each participant will be asked whether the subject wants documentation linking the participant with the research and the participant's wishes will govern.

_____

_____

4. The research is not subject to FDA and / national research regulation.

_____

_____

Option 2

(Example: Using an anonymous survey consent or conducting telephone interviews with politicians about how constitutional provision for funding of political parties will affecting the campaign process of smaller parties

1. The research presents no more than minimal risk of harm to participants.

_____

_____

_____

2. The research involves no procedures for which written consent is normally required outside of the research context.

_____

_____

_____

Approval (KNH-UoN ERC Chairperson: Check all that apply to indicate that the waiver or alteration is approved and to indicate agreement with the investigators protocol specific findings justifying the waiver.)

☐ Waiver or Alteration of the Consent Process

☐ Waiver of parental permission

☐ Waiver of Written Documentation of Consent

NOTE: To approve a waiver of written documentation of informed consent the investigator must provide a written document describing the information to be disclosed. This document has to include all required and appropriate additional elements of consent disclosure, unless the consent process has been altered.

Chose one of the following when approving a waiver of written documentation:

☐ The investigator must provide a written description of the information provided orally to the participant.

☐ The investigator does not have to provide a written description of the information provided orally to the participant.

APPROVED BY CHAIR KNH-UoN ERC:

Name: _____

Signature _____

Date and Stamp:_____

Appendix II: Data Extraction Tool

Table 2:Data extraction tool

Unique No.	Imaging modality/Type	Date	Requesting department	Emergency/ non-emergency	Time image acquired	Time reported	RTAT	Report Collection time
	CT PACS NON-PACS							
	MRI							
	XRAY							

Appendix III: Data analysis plan

Table 3:RTAT of CT examinations

CT examination	No. of exams	Mean (hours)	Standard deviation (hours)	Median (hours)
Siemens(non PACS)	Emergency			
	Non-emergency			
Neusoft (PACS)	Emergency			
	Non-emergency			

Table 4:RTAT of MRI examinations

MRI exams	No. of exams	Mean(hours)	Standard deviation(hours)	Median(hours)
Inpatient				
Outpatient				

Table 5:RTAT OF X-rays

x-ray	No. of exams	Mean (hours)	Standard deviation (hours)	Median (hours)
Emergency				
Non-emergency				

Table 6:Report collection time

Examination	Mean (hours)	Standard deviation(hours)	Median (hours)
CT			
MRI			
X-RAY			

Appendix IV: Timeline

	Oct-Dec 2020	Jan-2021	Feb-2021	Mar-2021	May 2021	Aug - Dec 2021	Jan-Feb 2022	March 2022
Proposal write up	"	"						
Correction of supervisors' input		"						
1st submission to KNH-ERC			"					
2nd submission & corrections				"				
Final submission & expected approval					"			
Data collection						"		
Data entry						"		
Data analysis						"		
Report writing							"	
Dissertation submission								"

Appendix V: Budget

Item	Unit cost (Ksh)	Number	Total cost
Research assistants	40,000	2	80,000
Biostatistician fee	30,000	1	30,000
Ethical review fee	2,000	1	2,000
Supplies and equipment			
Printing cartridge	5,000	2	10,000
Printing paper	500	3	1,500
Binding proposals	100	6	600
Files	100	6	600
Pens	20	20	400
Flash Disks	1,000	2	2,000
Internet cost	5,000/month	10	50,000
Miscellaneous			30,000
Contingency			20,000
Grand Total			227,100

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Ref: KNH-ERC/A/178

21st May 2021

KENYATTA NATIONAL HOSPITAL APPROVED 21 MAY 2021 KNH/UoN-ERC P. O. BOX 20723 - 00202 NAIROBI

Dr. Deborah M. Osiemo
Reg. No.H58/11599/2018
Dept. of Diagnostic Imaging and Radiation Medicine
School of Medicine
College of Health Sciences
University of Nairobi

Dear Dr. Osiemo

RESEARCH PROPOSAL – REPORT TURNAROUND TIME OF DIFFERENT IMAGING MODALITIES AT KENYATTA NATIONAL HOSPITAL (P57/02/2021)

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 21st May 2021 – 20th May 2022.

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
e. e 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.
f. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
g. 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*).
h. Submission of an *executive summary* report within 90 days upon completion of the study.

This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

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

Yours sincerely,

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

c.c. The Principal, College of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information Dept, KNH
The Dean, School of Medicine, UoN
The Chair, Dept. of Diagnostic Imaging and Radiation Medicine, UoN
Supervisors: Dr. Angeline Aywak, Dept.of Diagnostic Imaging and Rad. Medicine UoN
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