

**APPROPRIATENESS OF PAEDIATRIC COMPUTED TOMOGRAPH
SCAN UTILIZATION IN MUHIMBILI NATIONAL HOSPITAL,
DAR ES SALAAM, TANZANIA**

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**Degree of Masters of Medicine (Radiology) of Muhimbili University of Health and Allied
Sciences.**

October 2021

Muhimbili University of Health and Allied Sciences

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**APPROPRIATENESS OF PAEDIATRIC COMPUTED TOMOGRAPH SCAN
UTILIZATION IN MUHIMBILI NATIONAL HOSPITAL**

By

Catherine P. Mlowe

**A dissertation Submitted in (partial) Fulfillment of the Requirement of the Degree of
Master of Medicine (Radiology) of Muhimbili University of Health and Allied Sciences**

October, 2021

CERTIFICATION

The undersigned certify that he/she has read and hereby recommend for examination of dissertation entitled ‘APPROPRIATENESS OF PAEDIATRIC COMPUTED TOMOGRAPH SCAN UTILIZATION IN MUHIMBILI NATIONAL HOSPITAL’ in partial fulfillment of the requirements for the degree of Masters of medicine in Radiology of the Muhimbili University of Health and Allied Sciences.

.....

Dr. FREDERICK LYIMO

(Main Supervisor)

.....

Date:

DECLARATION AND COPYRIGHT

I, Catherine P. Mlowe, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for similar or any other degree award

Signature

Date

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ACKNOWLEDGEMENTS

All praises to God Almighty for the strength and blessings in completing this dissertation.

Obviously, this dissertation report would not have been possible without the effort of supervisors, friends and colleagues at MUHAS.

I am deeply grateful for the support of my supervisor Dr. Frederick Lyimo from MUHAS, department of Radiology, in addition several MNH staff including radiographers, Emergency department, pediatrics department and medical records for making easy for me to get access to the data I needed. Last but not least my husband Michael Arsein Mugabe, for his assistance in data entry and encouragement.

DEDICATION

I dedicate this dissertation to my beautiful family, mostly my lovely parents Mr & Mrs Mlowe, darling husband, Michael Mugabe and beautiful daughters Trinity, Tracey and Melissa for their love, understanding and moral support.

TABLE OF CONTENTS

CERTIFICATION	i
DECLARATION AND COPYRIGHT	ii
ACKNOWLEDGEMENTS.....	iii
DEDICATION.....	iv
LIST OF TABLES.....	viii
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS	ix
DEFINITION OF KEY TERMS	x
ABSTRACT	xi
CHAPTER ONE.....	1
1.0 Introduction	1
1.1 Background information	1
1.2 Literature review.....	3
1.3 Conceptual framework.....	9
1.4 Explanation of the framework	9
1.5 Statement of the problem	10
1.6 RATIONALE.....	11
1.7 OBJECTIVES	11
1.7.0 Broad objective: -.....	11
1.7.1 Specific Objectives: -.....	11
1.8 RESEARCH QUESTIONS	12
CHAPTER TWO	13
2.0 METHODOLOGY	13

2.1 Study design: -	13
2.2 Period of study: -.....	13
2.3 Study area and setting -.....	13
2.4 Study Population: -	13
2.4.0 Inclusion and Exclusion Criteria.....	13
Inclusion Criteria; -	13
Exclusion Criteria:	13
2.5 Variables: -.....	14
2.5.0 Exposure variable:	14
2.5.1 Outcome Variable:.....	14
2.5.2 Covariates:	14
2.6 Sampling and sampling procedure: -	14
2.7 Pre testing Piloting tool.....	14
2.7.0 Data collection and Instruments.....	15
2.8 Data Analysis	15
2.9 Ethical considerations and clearance	16
2.9.0 Study limitation and mitigation	16
CHAPTER THREE	17
3.0 RESULTS.....	17
CHAPTER FOUR.....	26
4.0 Discussion.....	26
CHAPTER FIVE	30
5.1 Conclusion and recommendation.....	30
Conclusion	30

Recommendations.....	30
REFERENCES	31
APPENDICES	35
Appendix I: Data Collection and monitoring tool	35
Appendix II: References for pediatric appropriateness criterias.....	37
Appendix III: Consent Form (English Version)	37
Appendix III: Fomu Ya Ridhaa (Informed Consent Swahili version).....	39

LIST OF TABLES

Table 1: Socio-demographic and clinical characteristics of children imaged by CT at MNH January to March 2021.	17
Table 2: Clinician and Facility related characteristics at MNH	19
Table 3 : Factors associated with appropriateness of the CT scan studies N=145	21
Table 4: Univariate and Multivariate analysis of factors associated with appropriateness	24

LIST OF FIGURES

Figure 1: Proportion of body parts imaged by CT among children attended MNH January to March 2021	18
Figure 2: (Bar graph with error bar). Appropriateness level of the CT scans with reference to the ACR-CR among children attended MNH January to March 2021 N=214	20
Figure 3: Appropriateness level of CT scans among children attended MNH January to March 2021 N=145	23

LIST OF ABBREVIATIONS

ACR	American college of radiology
ACR-AC	American college of radiology Appropriateness criteria
CT	Computed Tomography
CTDwi	Weighted CT dose index
DLP	Dose length product
MGy	Milligray
MGy*cm	Milligray centimeter
MRI	Magnetic resonance imaging
mSV	millisievert

DEFINITION OF KEY TERMS

ACR appropriateness criteria: Are evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical **condition**.(1)

Appropriate: Means suitable or right for a particular occasion

CT scan: Computed tomography (CT) is a diagnostic imaging test used to create detailed images of internal organs, bones, soft tissue and blood vessels.

Deterministic effects: Are the most readily visible effects that can be identified such as hair loss. They occur above a certain dose threshold. (2)

Dose length product: Is a radiation parameter which estimates the total dose delivered over a specific scan length. It is measured in mGy*cm.(3)

Ionizing radiation: Is a type of energy released by atoms in the form of electromagnetic waves of particles (3)

Paediatrics: Pediatrics is a discipline that deals with biological, social, and environmental influences on the developing child and with the impact of disease and dysfunction on development. In radiology, it has been found that, age range of 0-15years old is sufficient to cover the whole pediatric range(4)(5)

Radiation dose: Is the amount of energy absorbed per unit of mass and has units of gray (J/kg).(2)

Radiosensitivity: Radiosensitivity is the response of the tumor to irradiation that can be measured by the extent of regression, rapidity of response, and response durability.(6)

Stochastic effects: Are effects which happen a while after radiation exposure such as cancer, and with a possibility that genetics may be passed on to their offspring. They have no threshold level.(2)

Weighted CT dose index: Is a standardized measure of radiation dose output of a CT scanner, it allows the user to compare radiation output of different CT scanners measured in mGy. (3)

ABSTRACT

Short Background

Computed Tomography scan is an imaging modality that uses high ionizing radiations. It is very useful and widely used to diagnose different diseases. Unlike adults, Children's cells are immature making them more sensitive and susceptible to radiation effects than adults. However, little is known about the frequency and appropriateness of CT scan usage in pediatric patients in Tanzania.

Objective

This study aimed at determining the appropriateness of pediatric CT scan usage at Muhimbili National Hospital-Dar es salaam, Tanzania.

Methodology

The study was a hospital-based cross-sectional study carried out by retrospective review of medical records of all pediatric patients aged 0-15years referred for CT scan imaging from January to march 2021. Data collection was done at MNH. A structured questionnaire was used to collect sociodemographic information, body parts imaged, clinical indications, radiation dosage used, professional position of the clinician who referred the patient for CT scan, admission status, protocol used to refer the patient and appropriateness of each pediatric CT imaging was evaluated according to ACR-AC . Data analysis used the statistical package SPSS version 23. Descriptive analysis was done where frequency tables were sketched and cross-tabulations were run for all variables that are included in the final analysis, median and range were used to describe the continuous variable such as the pediatric patient's age. The appropriateness of pediatric CT scans done at MNH compared to the standard ACR appropriateness criteria was done using Chi-square test. Logistic regression analysis was used to determine the influence of health facility factors, Clinician's professional position and patient related factors to pediatric CT scan imaging utilization at MNH.

Results

Appropriately imaged CT scans were only 42.07%. Appropriateness level was found to be mainly associated with study indication where by patients referred due to trauma were more likely to be appropriately imaged compared to those referred due to non-traumatic indications.

Conclusion

Majority of CT scan studies were ordered inappropriately. Physicians training, use of guidelines and preauthorization for pediatric CT scan should be implemented

CHAPTER ONE

1.0 Introduction

1.1 Background information

Appropriateness of any imaging modality focuses on determining whether an imaging examination is likely to generate valuable medical information for the patient or not. Crucial facts have to be addressed before referring patients for any imaging. If not valuable, additional considerations about imaging are considered, however, if valuable, it is important to determine the best protocol and modality for the examination which will be performed with minimum or no ionizing radiations. In order to achieve that, preauthorization of images by a trained personnel or Radiologist is ideal. Pre authorization of images means approving the ordered images before imaging (7).

In German, 639 medical records of CT examination were reviewed and 77.6% of them had appropriate CT scans. Study done in Italy found 78% of CT scan requests were appropriate while in South Africa 63.5% of the CT scans done were found to be appropriate (8)(9)(10). To the best of my knowledge, no study has been done in Tanzania to assess for appropriateness of CT scan utilization in either pediatrics or adult patients.

Despite the fact that, CT scan has a number of advantages into the modern clinical practice especially to severely ill patients/children who cannot withstand long procedures such as MRI, it should be appropriately handled since it delivers higher radiation doses than conventional radiography, eg Average effective dose for Posterior anterior chest X ray is 0.02mSv while that of chest CT scan is 7mSv (5)(11)(12)(13).

Ionizing radiation has a high risk of complications such as carcinogenesis, nephrotoxicity , particularly in patients with severe renal dysfunction due to iodinated contrast agents and allergic reactions from minor reactions to anaphylactic shocks (14). Children are more radiosensitive and have a longer life expectancy than adults (2).When adult sized imaging techniques are used, children will receive a higher radiation dose, hence slightly increasing risk for developing cancer from stochastic effects. Deterministic effects can also occur above certain dose thresholds (1).

Currently at Muhimbili National hospital, there are no specialized pediatric radiologists to handle all matter pertaining to pediatric imaging, neither is there a proper tool that guides Doctors to make proper decisions on referring patients for CT scan, nor regular ongoing trainings provided on awareness of medical imaging radiations. Referrals for CT scan are mainly done without preauthorization by a well trained personnel/radiographer/Radiologist.

A study done in Israel to compare CT scan usage before and after pre authorization showed that, before pre authorization CT utilization were constantly increasing by 20% per year. After pre authorization, CT annual performance rates decreased from 25.9 per 1,000 respectively, in 2,000 to 17.3 per 1,000, respectively, and it resulted to significant cost savings (15). In addition, there are alternative imaging modalities for inappropriate CT scan requests as discussed by scientists in Luxembourg. These were MRI, radiography, ultrasound, and nuclear medicine (16).

This study compared the appropriateness of pediatric CT scans done at MNH from January to March 2021 against the standard ACR appropriateness criteria, it also determined factors that influence appropriate pediatric CT scan utilization at Muhimbili National Hospital from January to March 2021.

1.2 Literature review

There are a number of imaging modalities known in addition to CT scan. As discussed by Luxembourg, these include MRI, radiography, ultrasound, and nuclear medicine (16). These can be used in both children and adults. A United States study in 2009 found that CT is now responsible for 75.4% of the effective radiation dose delivered from all imaging procedures (11).

CT Scan delivers higher radiation doses than conventional radiography, Eg the effective dose of one chest X ray is 0.02mSv while that of one chest CT scan is 7mSv, abdominal X ray dose is 0.7mSv while for abdominal CT scan is 8mSv (13), thus, CT scan imaging should be opted with cautious since, the risk of inducing biological effects increases as the dose increases, increasing the lifetime risk of cancer (17).

Demographic characteristics of pediatric patients who underwent CT scan imaging.

There was an increase of CT scan usage by 600% observed in the United States from the mid-1980s to the mid-1990s, Ct scans in pediatric patients increased from 4% to more than 11% of all CT examinations, whereby, one-third of them were done in the first decade and one-sixth performed within the first five years of life (5)

A total of 8.2 million CT examinations were conducted in Germany with the proportion of pediatric CT scans being about 1% in the year 2005 (14), a study in Saudi Arabia showed that approximately 6% of CT examinations were performed on children below the age of 15 years(18).

According to the IAEA survey of pediatric CT practice, the lowest frequency of pediatric CT examinations in 2009 was in European facilities (4.3%). Frequencies in Asia (12.2%) and Africa (7.8%) were twice as high. Tanzania was found to have a Pediatric CT examination proportion of 11.1% and 9.8% in 2007 and 2009 respectively (19).

Furthermore, data from 101 facilities in 19 developing countries of Africa, Asia and Eastern Europe in 2010, showed that, on average, of all CT examinations, the frequency of Paediatrics CT examinations was 20% in Africa, 16% in Asia and 5% in Eastern Europe. The same study showed that Tanzania had a frequency of Paediatrics CT examination of 13%.

This study indicated a stronger need in many developing countries to justify CT examinations in children and their optimization (20).

The percentage of visits in which CT was performed for infants or toddlers, preschool-aged children, school-aged children, and adolescents by a study in the United States were 16.2%, 11.7%, 12.0%, and 12.2%, respectively. In 1995 to 2008 the study showed no significant difference in CT use between male and female except in 2000. Another Study on increase in CT utilization in children had a median age of 12 and a male/female ratio of 1.3:1 (57% boys, 43% girls) (21)(22).

Although no enough studies were found to show how the ability to pay /not to pay for CT scan imaging influence the number of pediatric CT scan performed, however, there is a study that observed differences in social-economic status had no impact on the number of CT scans per patient (cumulative radiation). The use of different indicators and data on SES collected in different time points led to different relations between social-economic status and frequency of CT scans, outlining the difficulty of adequately capturing the social and economic dimensions which may affect health and health service use (22).

Indications for pediatric CT scan imaging done at the Muhimbili National Hospital from May to October 2020

Neurological and abdominal disorders in children are normally the source of great anxiety for both clinicians and parents/Guardians. Findings from a study on Paediatrics CT in Nigeria showed that a brain scan was most commonly performed (93.6%) and abdominal CT was (6.4%). The predominant indications for brain CT examination in this study were delayed milestones 29 (61.7%), seizures 8 (17.0%), hydrocephalus 2 (4.3%) and trauma 2 (4.3%) (23).

In the Eden and Central Karoo districts of the Western Cape Province, South Africa, the majority of CT scans requested were of: - brain (48.4%), Chest (12.3%), abdomen(10.5%), cervical (3.2%), abdomen and pelvic (2.7%), Pelvic (0.5%), Angiogram of the legs 2.3%, whole body 1.8% and sinuses 0.5% (24).

Clinical indications for brain CT scan examinations in Saudi Arabia were found to be from 32.69% cases of hydrocephalus, 32.69% epilepsy, 13.46% mass and 7.69% trauma. A total of 69.56% of clinical indications for abdominal CT constituted renal disorders, 17.39% liver and bowel disorders, and 13.04% mass. Clinical indications for chest CT included: pneumonia 40%, chest deformity 20%, lymphadenopathy 20%, and diaphragmatic hernia 20% (18).

The IAEA survey of pediatric CT practice found that the most frequently scanned body part was the head, with a mean frequency of almost three quarters, 72%. Chest CT and abdominal CT were imaged less frequently, with an almost equal mean frequency of 15–17% (19).

Evidence from an emergency department in the United States reported head injury and headache as the commonest chief complaints leading to CT scan examination and the least was abdominal pain. The last 4 years of the study period showed that CT was performed in these visits at a rate of approximately 20%–34%, 20%–28%, and 15%–21% for head injury, headache, and abdominal pain, respectively. Other chief complaints for which CT was performed relatively common during the last 4 years included convulsions (18%–32%), syncope (25%–43%), and flank pain (20%–40%) (25).

Health facility factors that influenced pediatric CT scan imaging utilization

It has been shown in a survey study of Pediatric CT that, although the total number of CT examinations in children has increased globally, the recommendations on imaging by agencies, such as the European Commission's Referral Guidelines for Imaging, the National Institute for Health and Clinical Excellence (NICE), and the American College of Radiology appropriateness criteria are not always followed (19). If CT examination for a child is not justified that it will produce a health benefit or inform patient management, then the child only receives the potential detrimental radiation effects (26), in addition to that, a study done in Italy found an association between inappropriateness of CT examinations and contrast agent use (8).

Most children referred for CT scan were found to be from the teaching hospital, where by, of the Forty - seven children referred for CT scan during the study period, 45 of them (95.47%) were referred from the Teaching Hospital, this was the finding from a study on (23), however, most studies have not assessed whether the admission status of the patient influences reference of pediatric patients for CT scan imaging.

Influence of Clinician's professional position to pediatric CT scan imaging utilization

There are no enough studies done to show the contribution of clinicians to pediatric patients' referrals for CT scan, However, a Study in German revealed that pediatricians contribute about 44% of all CT referrals of children, surgeons 34%, general practitioners 12% and 10% other specialties (27).

Study in Italian Society of Medical Radiology 2013 about Ionizing radiation awareness showed that the resident doctors', interns', and radiographers' knowledge of radiation exposure from radiological investigations and the associated risks was poor. The frequency of answers underestimating doses was found to be significantly higher ($p < 0.001$) (28).

Assessing for appropriateness in relation to requesting practitioners, study done in south Africa found only 5.4% of inappropriate scans ordered by interns and speculated that may be It is because interns order more straight forward cases and the complicated ones refer to specialists (24) while a study in Cameroon found that more requests were inappropriate when ordered by general practitioners than specialists (29).

Association between the demographic characteristics, clinical indication, health personnel, facility factors and the appropriateness of CT scan imaging in pediatric patients

The American College of Radiology (ACR) Committee on Appropriateness Criteria has developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s)(1). The ACR Appropriateness Criteria uses the following rating scale: 1, 2, 3 'usually not appropriate', 4, 5, 6 'may be appropriate', and 7, 8, 9 'usually appropriate'.(24). In addition to that, a study in southern Italy found that, the tool used is reliable to measure the extent of appropriateness of diagnostic imaging for inpatient examinations (8).

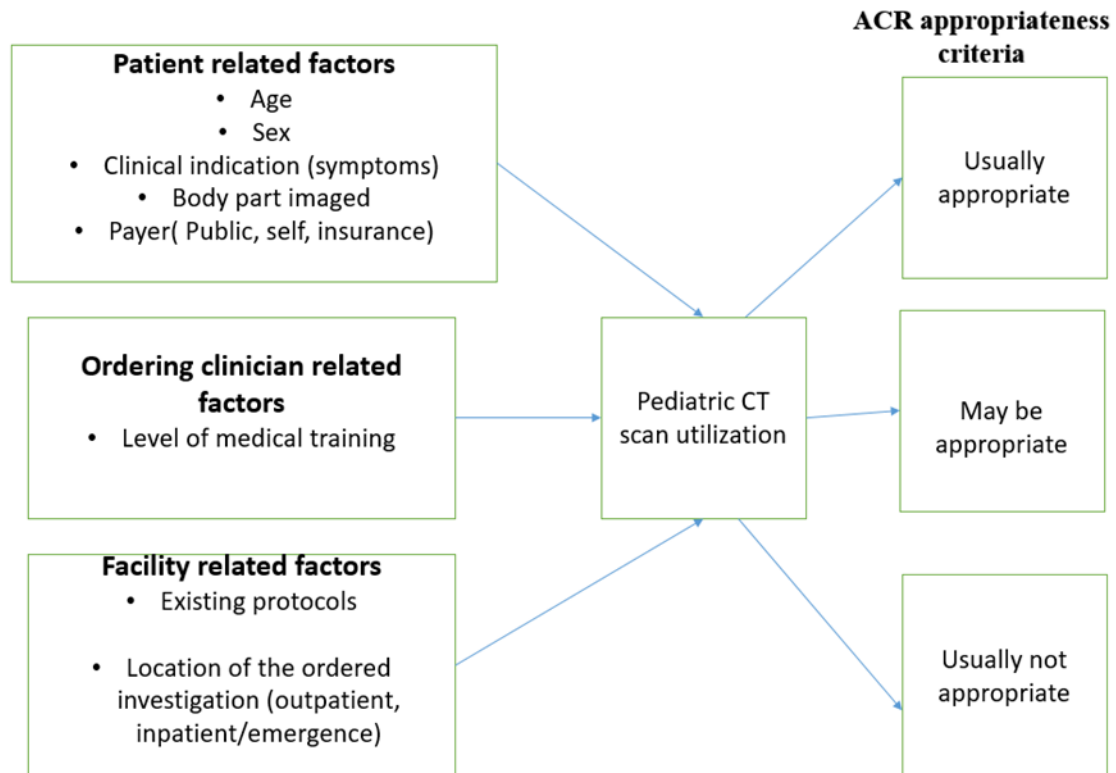
Study in Luxembourg showed that, the appropriateness rate AR was higher for requests referred by medical specialists rather than by general practitioners, both for CT requests (70% vs. 37%; $p < 0.001$) and MRI requests (83% vs. 64%; $p = 0.002$). For CT, AR was higher when the requests concerned pediatric rather than adult patients (82% vs. 58%; $p < 0.001$), when the radiology departments were equipped with both CT and MRI units rather than with only CT units (65% vs. 47%, $p = 0.004$) and when the requests concerned head-neck (79%), chest (77%) and chest-abdominal-pelvic (81%) areas rather than spinal (28%), extremity (51%) and abdominal-pelvic (63%) areas ($p < 0.001$) (27).

Study in Italy showed the following scan rates, head(38.1%), abdomen/pelvis(22.9%) and chest(21.8%). 55.3% of head CT were requested for cerebrovascular disease. Abdominal pain accounted for 34.9% of abdomen/pelvic CT. Most frequent reasons for performing a whole body CT were cancer, it also reported that, use of an appropriate diagnostic technology contribute to confirm diagnostic hypothesis (8). Another study in Italy found a 56% rate of appropriate CT scan requests. It also demonstrated that appropriate prescriptions provided with a specific clinical question led to significantly higher confirmation rates of the diagnostic hypothesis. In addition, inappropriate requests had a major negative economic impact (30).

At Kashan University of Medical Sciences, Tertiary Care University Hospital in Kashan, Iran. Of the total CT scan requests, 9.1% were “inappropriate,” 11.9% were “may be inappropriate,” and 78.9% were “appropriate.” The majority of the appropriate requests in the study were related to the trauma (101 cases, 87.8%)(31) which is also a finding seen in a study done in Cameroon CT imaging of the head and facial bones accounted for slightly more than half of all the scans and head trauma was the most frequent (29). A study in South Africa found that only 6.4% of scans were considered inappropriate, the rest were appropriate, the orthopedics’ department scored the highest rate of appropriate scans (80.0%) and the oncology department the highest rate of inappropriate scans (20.8%) (24).

In another study, CT scan was not indicated in a median of 21% of cases (range 12–53%), more information was required in a median of 16% (0–41%) and in a median of 58% (37–88%), CT scan was considered indicated. A significant proportion of CT scans in patients with acute abdominal pain were not clinically indicated or performed prior to adequate clinical workup, and routine imaging was associated with approximately 40% of the scans being negative for acute pathology. The study concluded that, there was no indication for an abdominal CT scan in one-fifth of all requests (32).

1.3 Conceptual framework



1.4 Explanation of the framework

Several factors influence CT scan utilization in pediatric patients, these can be patient-related such as age, sex, presenting symptoms, body parts to be imaged and the payer which could be health insurance, private or public. Other factors are related to the level of medical training of clinicians who refer the patients for CT scan and existing facility protocols. Regarding criteria set by the ACR, Pediatric CT scan utilization can be categorized as either appropriate, may be appropriate or not usually appropriate.

1.5 Statement of the problem

Computed Tomography is characterized by a significantly higher radiation exposure than radiography. Children at ages up to 10 years, are in general more sensitive to the effects of ionizing radiation by a factor of three (5)(33). Studies on the differences in radio sensitivity between children and adults have found that children are more sensitive for the development of thyroid, brain, skin, breast cancer and leukemia(12).

Radiation doses from CT procedures can often approach or exceed levels known with certainty to increase the probability of cancer. Some studies have suggested that pediatric CT scan doses are higher than necessary. Catherine C etal, in the study done in US stated that there is a chance of developing cancer in 1 child out of 1200 children less than 15 years who undergo abdominal CT scan. Another study, also estimated that 2% of current cancers in the United States are due to CTs performed in the past (18)(32).

Appropriate use of CT scan imaging to pediatric population is important because it will reduce unnecessary radiation exposure to children when other imaging modalities with no/less ionizing radiations are opted for, or when radiation doses are well optimized for pediatric scanning. This can also save the projected imaging costs.

Currently at Muhimbili National hospital, there are no specialized pediatric radiologists to handle all matters pertaining to pediatric imaging, neither is there a proper tool that guides doctors to make proper decisions on referring patients for CT scan, nor regular ongoing trainings provided to referring Doctors about awareness of medical imaging radiations. Referrals for CT scan are mainly done by both general practitioners and pediatricians without preauthorization by a well-trained personnel/radiographer/Radiologist.

This study is going to address how much our hospital conducts appropriate CT scan imaging in children and enable us to know where we can emphasize, change or improve our pediatric imaging protocol for the benefit of our children and society at large.

1.6 RATIONALE

The number of facilities possessing CT scans in the country is on the rise. Advances in CT scan technology resulting into wider range of clinical applications, shorter scan times and better image quality have made referring doctors request more CT investigations.

Children make up a significant proportion of the country's population. Currently, Tanzania's population is very youthful. Children below 15 years comprise about 44% of the total population (9). Hence will provide knowledge on Pediatric CT scan usage, appropriateness of the requested examinations and radiation exposure.

This study will be an eye-opener to other big studies to understand the handling of Paediatrics CT scan imaging. Furthermore, Tanzania is a developing country hence doing a study that will guide into reduction of unnecessary CT scan costs and decrease the future burden that might be brought by increased cancer patients will be a giant step forward.

1.7 OBJECTIVES

1.7.0 Broad objective: -

1. To determine the proportion of appropriate CT scan imaging among pediatric patients at Muhimbili National Hospital, Dar es Salaam – Tanzania

1.7.1 Specific Objectives: -

- 1 To determine socio-demographic characteristics of pediatric patients undergoing CT scan imaging at Muhimbili National Hospital from January to March 2021
- 2 To compare the appropriateness of pediatric CT scans done at MNH from January to March 2021 against the standard ACR appropriateness criteria.
- 3 To determine factors that influence appropriateness of paediatric CT scan imaging utilization at Muhimbili National Hospital from January to March 2021

1.8 RESEARCH QUESTIONS

Main Research question

What is the proportion of appropriately imaged Computed Tomograph scans among pediatric patients at Muhimbili National Hospital, Dar es Salaam – Tanzania?

Specific research questions

1. What are the socio-demographic characteristics of pediatric patients undergoing CT scan imaging at Muhimbili National Hospital from January to March 2021?
2. How appropriate are the pediatric CT scans done at MNH compared to the standard ACR appropriateness criteria?
3. What are the factors that influence appropriate pediatric CT scan utilization at Muhimbili National Hospital?

CHAPTER TWO

2.0 METHODOLOGY

2.1 Study design: -

This was a hospital based cross sectional study using a research questionnaire-driven secondary analysis of clinical data collected between January to March 2021 at Muhimbili National Hospital.

2.2 Period of study: -

The study was conducted over a period of 3 months from January to March 2021

2.3 Study area and setting -

The study was conducted at Muhimbili National Hospital, in the radiology department. MNH is the largest referral and teaching hospital in Tanzania located in Ilala Dar -es- Salaam city.

2.4 Study Population: -

All pediatric patients aged 15 years or less referred for CT scan in the radiology department at Muhimbili National hospital between January to March, 2021 were eligible for the study. A total of 214 pediatric patients were subjected to CT scan during the study period.

2.4.0 Inclusion and Exclusion Criteria

Inclusion Criteria; -

Children aged 15 years or less referred to MNH Radiology department for CT scan from January to March 2021.

The choice of the upper limit of pediatric age is based on a study done which found that in radiology, age range of 0-15years old is sufficient to cover the whole pediatric range (5)\

Exclusion Criteria:

All pediatric patients referred for CT scan with missing important clinical information even from their wards/Files and those whose clinical indications were not covered by ACR-AC list.

2.5 Variables: -

2.5.0 Exposure variable:

Pediatric patients CT scan utilization at MNH from January to March 2021

-All pediatric CT scan imaging done at MNH from January to March 2021, for patients aged 0-15years old

2.5.1 Outcome Variable:

- Appropriate pediatric CT scans done at MNH from January to March 2021
- (The evaluation of appropriateness will performed according to the American College of Radiology Appropriateness Criteria, which assigns three levels of appropriateness as “Usually appropriate”, “May be appropriate” and “Not usually appropriate”. The tool is found on the ACR website on the link below
(https://acsearch.acr.org/list?_ga=2.27598458.71352955.1612522317-1435312372.1580110353)
- This tool was reliable to measure the extent of appropriateness of diagnostic imaging (8)

2.5.2 Covariates:

Age (0-15 years), sex, clinical indications, body part imaged, coverage of CT scan bills (Public, self, insurance), referring department (Emergency,outpatient, inpatient) and referral guideline.

2.6 Sampling and sampling procedure: -

All 214 patients who attended during the study duration were enrolled in the study.

2.7 Pre testing Piloting tool

The structured checklist was used. Specific questions related with study were included in order to consider the availability of data and if available information was going to answer the research questions.

2.7.0 Data collection and Instruments.

Data collection was done using a structured questionnaire (Appendix 1), Data for pediatric patients scanned during the study period was collected retrospectively from all available sources of medical records, including CT imaging registrar book, request forms, Jeeva data system and some from patient's files by the principal investigator. Questionnaire was used to collect sociodemographic information, body parts imaged, their clinical indications, radiation dosage used, level of medical training of the Doctor who referred the patient for CT scan, admission status, protocol used to refer the patient for CT scan and appropriateness of each pediatric CT imaging done with reference to the recommended ACR appropriateness criteria.

2.8 Data Analysis

The collected data was coded, entered and analyzed using the statistical package SPSS. As a first step, descriptive analysis and frequency tables were run for all pediatric patients referred for CT scan during the study period. Cross-tabulations was done for only those patients who had a clear complete clinical indication for CT scan and whose indications were covered by the ACR-AC list, these are the ones who were included in the final analysis. If a patient had received more than one diagnostic imaging examination, the judgement of appropriateness was carried out for each examination. If all examinations were judged appropriate, the patient was classified as being among those who received appropriate examinations. If at least one examination was inappropriate, the patient was classified the as being among those who received an inappropriate examination. Median and range was used to describe numerical characteristics of the patients such as age.

Comparison of the appropriateness of pediatric CT scan imaging at MNH to the standard ACR appropriateness criteria was done using Pearson Chisquare test. Logistic regression analysis was used to determine the influence of health facility factors, Clinician's professional position and patient related factors to appropriateness of pediatric CT scan utilization at MNH. Variables which showed association with appropriateness of CT utilization with p – value less than 0.2 at univariate analysis were included in multivariate analysis for controlling confounders.

2.9 Ethical considerations and clearance

Parents/guardians for all participants were consented for their voluntary participation in the study and individual rights were observed. Issues of confidentiality, anonymity, and privacy were protected during the research period, Data obtained was handled confidentially by the investigator and stored in a secured place. The proposal was be presented to the Radiology department and ethical clearance was sought from Senate of Research and Ethics Committee of Muhimbili University of Health and Allied sciences (MUHAS) and Muhimbili National Hospital.

2.9.0 Study limitation and mitigation

Muhimbili is a tertiary hospital, data obtained may not be representative of general population. The data is going to be used to add value to literature review.

CHAPTER THREE

3.0 RESULTS

A total of 214 children underwent CT scan imaging from January to March 2021 and they were all considered eligible for the study, descriptive analysis was done for all of them but only those without any of the exclusion criteria were enrolled for cross tabulations and further analysis.

Table 1: Socio-demographic and clinical characteristics of children imaged by CT at MNH January to March 2021.

Variable	Category	Frequency (n)	Percent (%)
Age group (years)	< 5	101	48.1
	≥ 5	109	51.9
Median age in years (IQR)		5 (3,10)	
Sex of the child	Male	137	64.0
	Female	77	36.0
Number of scans in 3 months' period	One	200	93.5
	Two	12	5.6
	Three	2	0.9
Clinical indication*	Trauma	39	19.3
	Non-traumatic	163	80.7
Who paid for CT Scan*	Health insurance	69	39.9
	Private	14	8.1
	Public	57	32.9
	Cost sharing	33	19.1

* Variable with missing value due to missing clinical data

Median age was 5 (range 3 - 10) years. Boys constituted 64% (137/214) of all participants. Majority 80.7%(163/214) were referred due to non-traumatic causes. Most of the referrals had their CT scan bills covered by health insurance in 39.9%(69/214) while only few covered their own bills privately 8.1%(14/214)

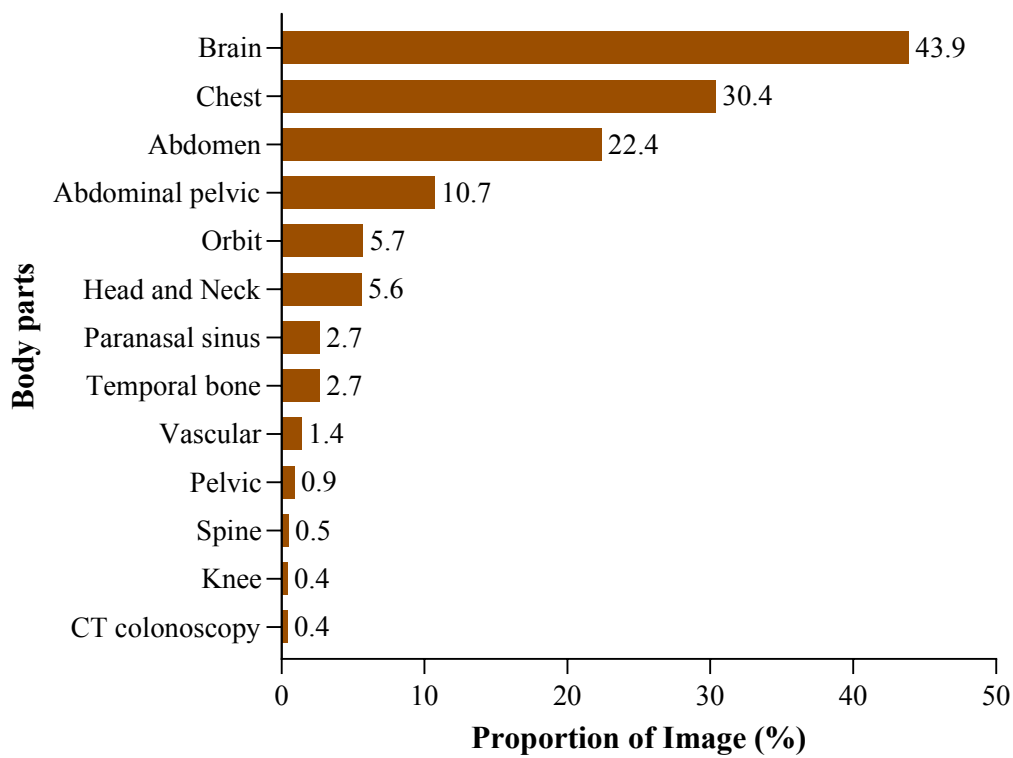


Figure 1: Proportion of body parts imaged by CT among children attended MNH January to March 2021

Brain was the most common imaged body part 43.9%, followed by Chest 30.4% and abdomen 22.4% while knee and colon were the least. 0.4% each.

Table 2: Clinician and Facility related characteristics at MNH

Variable	Category	Frequency (n)	Percent (%)
Use of IV contrast	Pre &post Contrast	169	79.0
	Pre contrast	45	21.0
Documented imaging guideline	Yes	1	0.5
	No	213	99.5
Referring department*	EMD	56	28.0
	Inpatients	91	45.5
	Outpatient	53	26.5

*** Variables with missing values due to poor documentation.**

Significant number 79%(169/214) of CT scans taken were done both pre and post contrast. Of all CT scans done, only 0.5% (1/214) had a documented imaging guideline that was used to refer the patient. Most patients referred for CT scan were inpatients 45.5%(91/214), followed by 26.5%(53/214) outpatients and 28.0%(56/214) from emergency department.

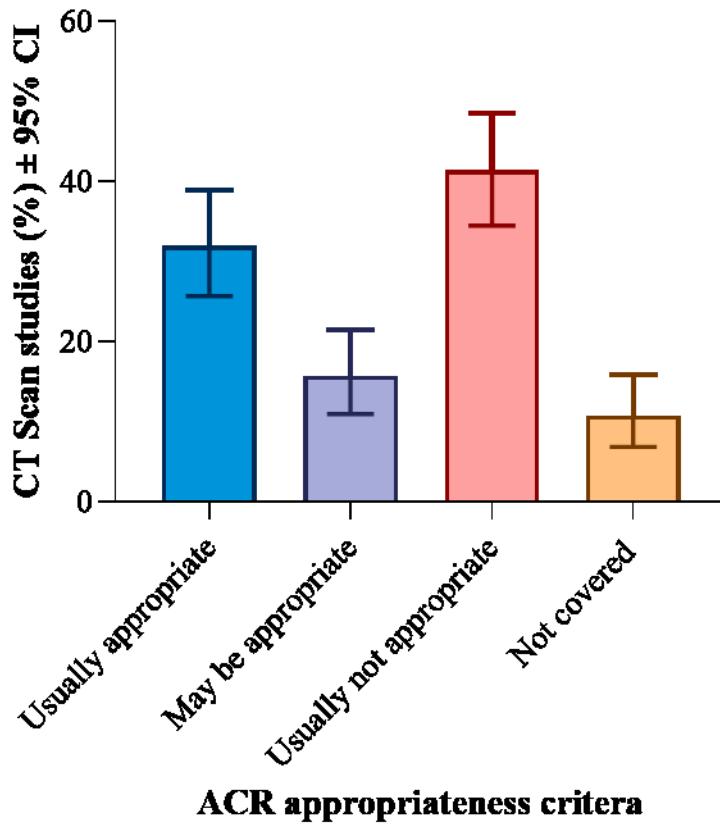


Figure 2: (Bar graph with error bar). Appropriateness level of the CT scans with reference to the ACR-CR among children attended MNH January to March 2021 N=214

Table 3 : Factors associated with appropriateness of the CT scan studies N=145

Cross tabulation was done for 145 children who had well documented indications that were covered by the ACR-AC list

Variable	Category	CT Scan studies		P - values
		Appropriate (%)	Inappropriate (%)	
Documented guideline	Yes	1 (100)	0 (0.0)	0.421
	No	60 (41.7)	84 (58.3)	
Patients from	EMD	31 (66.0)	16 (34.0)	< 0.001
	Inpatients	14 (25.0)	42 (75.0)	
	Outpatients	12 (34.3)	23 (65.7)	
Specialty	Resident /pediatrician	5 (45.5)	6 (54.5)	< 0.001
	Resident /oncologist	5 (14.3)	30 (85.7)	
	Resident/ EM physician	33 (63.5)	19 (36.5)	
	Other specialty	3 (50.0)	3 (50.0)	
CT scan diagnosis	Normal	22 (56.4)	17 (43.6)	0.314
	Abnormal	31 (46.3)	36 (53.7)	
Use of IV contrast	Pre & post contrast	28 (24.5)	80(75.5)	0.000
	Pre contrast	35(89.7)	4(10.3)	
Other specialty	Resident /Cardiologist	1 (100)	0 (0.0)	0.450
	Dental surgeon	1 (50.0)	1 (50.0)	
	ENT surgeon/ENT resident	3 (33.3)	6 (66.7)	
	Nephrologist /resident	0 (0.0)	2 (100)	
	Neurologist	2 (100)	0 (0.0)	
	Neurosurgeon /Resident	1 (50.0)	1 (50.0)	
	Ophthalmologist/Resident	2 (25.0)	6 (75.0)	
	Surgeon/Resident	1 (50.0)	1 (50.0)	
Thoracic surgeon	1 (100)	0 (0.0)		

For table 3:

Appropriateness of pediatric CT scan imaging was significantly associated with clinical indications, referring department, use of intravenous contrast and the body part imaged.

Patients from the emergency department 31/145 (66.0%), CT scan due to trauma 32/145(88.9%), and CT scan of the brain 43/145(53.1%) were factors associated with more appropriate CT scan referrals.

Those referred for chest 30/145(85.7%), head & neck scans 7/145(100%) and those whose imaging protocol included scanning both pre and post contrast were associated with more inappropriate CT scan referrals

Note: - Those who had multiple CT examinations, where by at least one of the cases was inappropriate, the child was rated as inappropriately imaged. Cases analyzed are only those whose indications were covered by the ACR

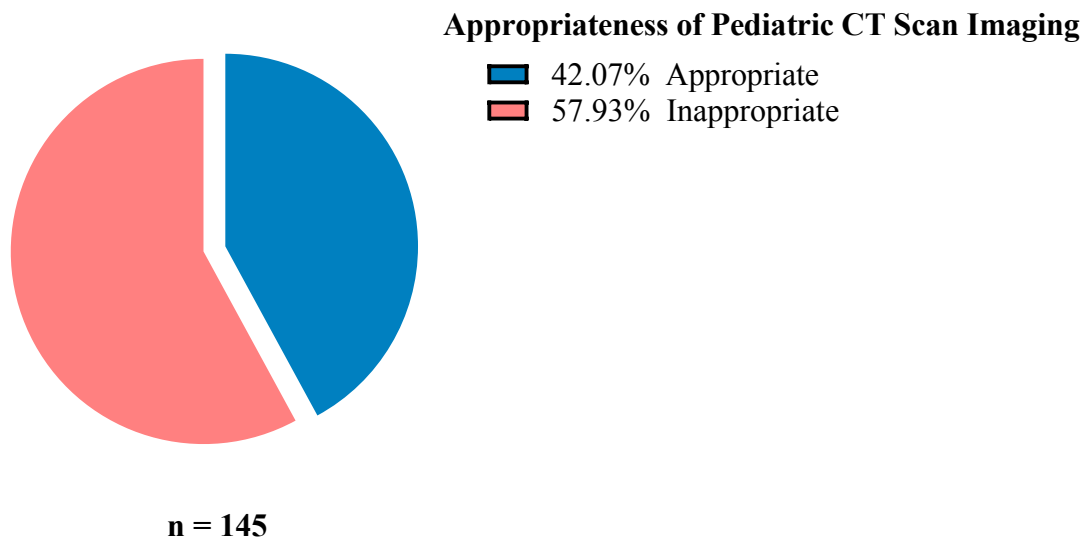


Figure 3: Appropriateness level of CT scans among children attended MNH January to March 2021 N=145

The proportion of children who were appropriately imaged by CT scan during the study period was lower 42.07% compared to those who were inappropriately imaged 57.93%

Table 4: Univariate and Multivariate analysis of factors associated with appropriateness

Variable	Univariate analysis			Multivariate analysis		
	cOR	95% CI	P – value	aOR	95% CI	P – value
Use of IV contrast						
Pre contrast	26.92	8.74 – 82.93	< 0.001	4.18	0.65 – 26.66	0.131
Pre & post contrast	Ref					
Department referred from						
Inpatients	0.17	0.07 – 0.40	< 0.001	4.12	0.24 – 70.32	0.329
Outpatients	0.27	0.11 – 0.68	0.005	1.48	0.07 – 31.19	0.801
EMD	Ref					
Clinical indication						
Trauma	10.17	3.36 – 30.73	< 0.001	14.21	2.01 – 100.20	0.008
Non traumatic	Ref					
CT Scan of the Brain						
Yes	0.83	0.43 – 1.60	0.570	0.17	0.02 – 1.24	0.080
No	Ref					
CT Scan of the Chest						
Yes	2.10	0.94 – 4.71	0.070	0.05	0.003 – 0.64	0.022
No	Ref					
Payment of CT Scan						
Private	1.67	0.35 – 7.88	0.519	3.23	0.32 – 32.66	0.320
Public	1.80	0.75 – 4.31	0.188	2.30	0.48 – 11.12	0.298
Cost sharing	1.08	0.40 – 2.92	0.874	1.62	0.20 – 13.21	0.653
Health insurance	Ref					

Key: cOR: Crude odds ratio, aOR: Adjusted odds ratio, Ref: Reference category

For table 4:

At univariate analysis level, hospital department from which patients were referred from was significantly associated with appropriateness level, where by those from inpatient and outpatient department were inappropriately referred (OR crude = 0.17, 95% CI = 0.07 – 0.40) and (OR crude = 0.27, 95% CI = 0.11 – 0.68) respectively, compared to those referred from the emergency department.

At univariate analysis level, use of contrast was significantly associated with appropriateness level where by those imaged without contrast were more appropriately imaged (OR crude = 26.92, 95% CI = 8.74 – 82.93) compared to those imaged with and without contrast at the same setting.

At univariate analysis level, clinical indication was significantly associated with appropriateness level, where by those referred for CT scan due to trauma were more appropriately imaged (OR crude = 10.17, 95% CI = 3.36 – 30.73) compared to those referred due to non-traumatic causes

At multivariate level, clinical indication (OR crude = 14.21, 95% CI = 2.01 – 100.20) was the only factor that had independent significant association with appropriateness level of pediatric CT imaging.

CHAPTER FOUR

4.0 Discussion

Appropriate use of medical imaging such as Computed Tomography is very important economically and for radiation safety. However, this study represents the first attempt to assess appropriateness of pediatric CT scan in Tanzania using the ACR-AC as reference. The study pointed out that, appropriateness of requests was unsatisfactory, with only 42.07% of patients appropriately imaged while the rest, 57.93% were inappropriately imaged. These findings raise high concerns regarding potential non-justified exposure of pediatric patients to ionizing radiations.

These results are different from previous studies done in Italy, New York, and south Africa which had higher proportion of appropriate CT imaging, 77.6%, 96%, and 93.6% respectively.(8)(16)(34)(24). However, comparisons with previous studies must be made with caution, since differences exist with respect to forms of care and methodology.

I speculate that, above findings in this study may be due to unavailable CT imaging referral guidelines just like it was stated in a study on survey of pediatric CT practice in 40 countries including Africa(19). Also referrals for CT scan are not justified by radiologist or trained physicians as it has been stated in one study in Australia that, a justified, optimized computed tomography scan will result in more benefit than harm hence a doctor must justify the necessity for a CT scan before referring an individual for imaging (26).

Most inappropriateness might have been contributed by our common practice of taking CT images both pre and contrast in most studies while they could only be acquired by either pre or post contrast and not both, as observed most recommended studies by ACR-AC made careful decisions on the use of contrast agent.

This study outlined an association between appropriateness of CT examinations and contrast agent use, where by those imaged pre contrast were more appropriately imaged, while most of those who were imaged pre and post contrast had inappropriate scans, findings are similar to a study done in Southern Italy. (8) This result highlights the importance of a careful use of contrast agent, because it can result in unnecessary exposure of patients to the risk of adverse reactions or nephropathy (35).

Boys and older children aged ≥ 5 years were found more likely to be referred for CT scan which is the same finding like in other studies done in Germany(27)(36) However these factors did not show any statistical significance with appropriate of CT imaging perhaps because all of them were taken care of in the same clinical setting.

Taking into consideration payment modality as a measure of social economic status, it showed no significant association with appropriateness of CT scan, similar to a finding observed in Spain although these two studies used different indicators for socio economic status. No study in Africa that assessed the influence of socioeconomic status to appropriateness of CT scan imaging. However, payment modality may not be a good indicator for socioeconomic status since those who could not afford to pay for CT scan were assisted by the public through social workers

Appropriate use of CT scan was observed more in CT scan of the head area than other body parts which is a similar finding to a previous study in Italy and South Africa (8)(24). Appropriate use of CT scan was also observed more in patients imaged due to trauma same as a study done in Iran. (31)(29). I speculate that, since most patients involved in trauma are referred for CT scan from the emergency department, it is the reason why both variables have a crude significant association with appropriate use of CT scan compared to other departments/ medical specialties, however, it may also be because they deal with a broader spectrum of clinical situations.

Finally, it is worth noticing that clinical indication was the only factor independently associated with appropriateness level, where by trauma was associated with more appropriate CT scan utilization compared to non-traumatic indications for CT scan. Comparing to a previous study done in German,(27) cancer was the Common indication for non-traumatic referrals, mainly renal and eye tumor for this study. Inappropriate imaging in non-traumatic patients may be attributed by poor clinician's knowledge of radiation exposure as seen in a previous study(28).

There is a possibility that those referred due to non-traumatic causes may not have clear clinical history or were not properly examined before referring them for CT scan. Imaging referral guidelines for other clinical presentations other than trauma may not be familiar to clinicians as PECARN rule for trauma which was however mentioned only once in this study.

4.1.0 Study Limitation

- i. Retrospective data collection may have distorted the actual rate of appropriateness, since it is influenced by the quality of medical records.
- ii. Some clinical indications were not covered by the ACR appropriateness criteria

4.1.1 Study strength

Appropriateness was exclusively evaluated through the American College of Radiology appropriateness criteria guidelines which allow objective appropriateness assessment

CHAPTER FIVE

5.1 Conclusion and recommendation

Conclusion

With regard to appropriateness of pediatric CT scan in Muhimbili National hospital. Less proportion of Children referred for CT scan are appropriately imaged compared to inappropriately imaged children. Appropriateness level has a significant independent association clinical indication for imaging where by those referred due to trauma are more appropriately imaged than those referred due to non-traumatic indications and it is where focus should be made to improve the situation.

Recommendations

1. Further research in order to expand appropriateness evaluation.
2. Introduce the use of medical imaging referral guideline such as ACR-CR and train clinicians to use them
3. Justification/Indication of imaging requests provided by the requesting Clinicians/Physician then validated by the Radiologist.
4. Awareness campaigns on radiation exposure in children to public and health professionals
5. Use a team approach to review and optimize scan protocols and determine best practice by implementing child-size imaging guidelines.

REFERENCES

1. European Society of Radiology (ESR), American College of Radiology (ACR). European Society of Radiology (ESR) and American College of Radiology (ACR) report of the 2015 global summit on radiological quality and safety. *Insights Imaging*. 2016;7(4):481–4.
2. Nelson TR. Practical strategies to reduce pediatric CT radiation dose. *J Am Coll Radiol*. 2014;11(3):292–9.
3. McCollough CH. CT dose: How to measure, how to reduce. In: *Health Physics*. 2008. p. 508–17.
4. The American Academy of Pediatrics POLICY STATEMENT. *J Sch Nurs*. 2003;19(3):127–9.
5. Vock P. CT dose reduction in children. *Eur Radiol*. 2005;15(11):2330–40.
6. Catheryn M. Yashar. Basic principles in Gynaecological Radiotherapy. 2018. 586-605.e3 p.
7. Thrall JH. Appropriateness and Imaging Utilization. *Acad Radiol*. 2014;21(9):1083–7.
8. Bianco A, Zucco R, Lotito F, Pavia M. To what extent do hospitalised patients receive appropriate CT and MRI scans? Results of a cross-sectional study in Southern Italy. *BMJ Open*. 2018;8(2).
9. Unicef, Scjcr, Kingston S, Webster C, Ngutu JA, Shrivastava G, et al. Briefing Note-Tanzania. *Natl Inst Stand Technol*. 2017;23(March):1–8.
10. Becker J, Jenkins LS, Swardt M De, Sayed R, Viljoen M. Appropriateness of computed tomography and magnetic resonance imaging scans in the Eden and Central Karoo districts of the Western Cape Province, South Africa. *South African Med J*. 2014;104(11):762–5.

11. Fazel R, Krumholz HM, Wang Y, Ross JS, Chen J, Ting HH, et al. Exposure to low-dose ionizing radiation from medical imaging procedures. *N Engl J Med.* 2009;361(9):849–57.
12. Kutanzi KR, Lumen A, Koturbash I, Miousse IR. Pediatric Exposures to Ionizing Radiation: Carcinogenic Considerations. Vol. 13, *International journal of environmental research and public health.* 2016.
13. Mettler FA, Huda W, Yoshizumi TT, Mahesh M. Effective doses in radiology and diagnostic nuclear medicine: A catalog. *Radiology.* 2008;248(1):254–63.
14. Goerne H, Rajiah P. Computed tomography. In: *Right Heart Pathology: From Mechanism to Management.* 2018. p. 601–12.
15. Blachar A, Tal S, Mandel A, Novikov I, Polliack G, Sosna J, et al. Preauthorization of CT and MRI Examinations: Assessment of a Managed Care Preauthorization Program Based on the ACR Appropriateness Criteria® and the Royal College of Radiology Guidelines. *J Am Coll Radiol.* 2006;3(11):851–9.
16. Bouëtté A, Karoussou-Schreiner A, Ducou Le Pointe H, Grieten M, de Kerviler E, Rausin L, et al. National audit on the appropriateness of CT and MRI examinations in Luxembourg. *Insights Imaging.* 2019;10(1).
17. Amis ES, Butler PF, Applegate KE, Birnbaum SB, Brateman LF, Hevezi JM, et al. American College of Radiology White Paper on Radiation Dose in Medicine. *J Am Coll Radiol.* 2007;4(5):272–84.
18. Alzimami K. Assessment of Radiation doses to Paediatric Patients in Computed Tomography Procedures. *Polish J Radiol.* 2014;79:344–8.
19. Vassileva J, Rehani MM, Al-Dhuhli H, Al-Naemi HM, Al-Suwaidi JS, Appelgate K, et al. IAEA survey of pediatric CT practice in 40 countries in Asia, Europe, Latin America, and Africa: Part 1, frequency and appropriateness. *Am J Roentgenol.* 2012;198(5):1021–31.

20. Muhogora WE, Ahmed N a., AlSuwaidi JS, Beganovic a., Ciraj-Bjelac O, Gershan V, et al. Paediatric CT examinations in 19 developing countries: Frequency and radiation dose. *Radiat Prot Dosimetry*. 2010;140(1):49–58.
21. Broder J, Fordham LA, Warshauer DM. Increasing utilization of computed tomography in the pediatric emergency department, 2000-2006. *Emerg Radiol*. 2007;14(4):227–32.
22. De Basea MB, Espinosa A, Gil M, Figuerola J, Pardina M, Vilar J, et al. CT scan exposure in Spanish children and young adults by socioeconomic status: Cross-sectional analysis of cohort data. *PLoS One*. 2018;13(5).
23. Inah GB, Kajogbola G, Ani N. Computed tomography scan findings in children from a Tropical Region. *Open Access Maced J Med Sci*. 2018;6(4):656–8.
24. J. B, L.S. J, M.D. S, R. S, M. V. Appropriateness of computed tomography and magnetic resonance imaging scans in the Eden and Central Karoo districts of the Western Cape Province, South Africa. *South African Med J* [Internet]. 2014;104(11):762–5. Available from: http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L604587557%5Cnhttp://dx.doi.org/10.7196/SAMJ.8158%5Cnhttp://sfx.hul.harvard.edu/sfx_local?sid=EMBASE&issn=02569574&id=doi:10.7196%2FSAMJ.8158&atitle=Appropriateness+of+computed+tomograph
25. Larson DB, Johnson LW, Schnell BM, Goske MJ, Salisbury SR, Forman HP. Rising use of CT in child visits to the emergency department in the United States, 1995-2008. *Radiology*. 2011;259(3):793–801.
26. Brady Z, Cain TM, Johnston PN. Justifying referrals for paediatric CT. *Med J Aust*. 2012;197(2):95–9.
27. Merzenich H, Krille L, Hammer G, Kaiser M, Yamashita S, Zeeb H. Paediatric CT scan usage and referrals of children to computed tomography in Germany-a cross-sectional survey of medical practice and awareness of radiation related health risks among

- physicians. *BMC Health Serv Res.* 2012;12(1).
28. Günalp M, Gülünay B, Polat O, Demirkan A, Gürler S, Akkaş M, et al. Ionising radiation awareness among resident doctors, interns, and radiographers in a university hospital emergency department. *Radiol Medica.* 2014;119(6):440–7.
 29. Tambe J, Mbuagbaw L, Nguéfack-Tsague G, Foyet J, Ongolo-Zogo P. Multidetector computed tomography utilization in an urban sub-saharan africa setting: User characteristics, indications and appropriateness. *Pan Afr Med J.* 2020;37(42):1–12.
 30. Cristofaro M, Busi Rizzi E, Schininà V, Chiappetta D, Angeletti C, Bibbolino C. Appropriateness: Analysis of outpatient radiology requests. *Radiol Medica.* 2012;
 31. Meidani Z, Hamidian Y, Farzandipour M, Aliasgharzade A. CT Utilization: A Case Study in Iran based on ACR Appropriateness Criteria. *Radiol Manage.* 2017;39(1):33–8.
 32. Calvert C, Strauss KJ, Mooney DP. Variation in computed tomography radiation dose in community hospitals. In: *Journal of Pediatric Surgery.* 2012. p. 1167–9.
 33. Pages J, Buls N, Osteaux M. CT doses in children: A multicentre study. *Br J Radiol.* 2003;76(911):803–11.
 34. Rosenkrantz AB, Marie K, Doshi A. Assessing the Appropriateness of Outpatient Abdominopelvic CT and MRI Examinations Using the American College of Radiology Appropriateness Criteria. *Acad Radiol.* 2015;
 35. Andreucci M, Faga T, Pisani A, Sabbatini M, Michael A. Acute kidney injury by radiographic contrast media: Pathogenesis and prevention. *BioMed Research International.* 2014.
 36. Rao S, Rao S, Rincon S, Caruso P, Ptak T, Raja AS, et al. Assessment of Pediatric Neurotrauma Imaging Appropriateness at a Level I Pediatric Trauma Center. *J Am Coll Radiol.* 2016;13(7):788–93.

APPENDICES

Appendix I: Data Collection and monitoring tool

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES
SCHOOL OF MEDICINE- DEPARTMENT OF RADIOLOGY
P.O.BOX 65001 MUHIMBILI
DAR ES SALAAM
TANZANIA

Circle the appropriate number/ fill in the blanks

Identification number.....

Sociodemographic information

Date of birth.....

Age

Sex

Address.....

Patient related factors:-

1. Body Part imaged.

I. Head

II. Abdomen

III. Chest

IV. Abdominal pelvic

V. Orbit

VI. Paranasal sinuses

VII. Other, Mention.....

2. The study done was.

I. Contrasted

II. Non Contrasted

Note: If more than one study, specify the type of study

3. Clinical indication(s) that initiated the study.

I. Trauma

II. Non traumatic

4. Who covered for CT scan bills?

I. Health insurance

II. Private

III. Public

5. Documented protocol followed

I. Referral guideline (Mention.....)

III. None

6. Hospital Department from where the patient is referred

I. EMD

II. Inpatient

III. Outpatient

Appropriateness of the CT scan with reference to the ACR appropriateness criteria(AppendixII):

8. Based on the ACR appropriateness criteria, the study is: -

I. Usually appropriate

II. May be appropriate

III. Usually not appropriate

Appendix II: References for pediatric appropriateness criterias

(https://acsearch.acr.org/list?_ga=2.27598458.71352955.1612522317-1435312372.1580110353).

Appendix III: Consent Form (English Version)

MUHIMBILI UNIVERSITY OF HEALTH AND ALLIED SCIENCES

DIRECTORATE OF RESEARCH AND PUBLICATIONS, MUHAS

ID-N0 HD/MUH/T.247/2018

Introduction

My name is Dr. Catherine Peter Mlowe; I am conducting research with the objective of determining the appropriateness of CT scan utilization among pediatric patients at Muhimbili National Hospital.

Purpose of the study

The study is for the partial fulfillment for attaining of the degree of Masters of medicine in Radiology from the Muhimbili University. Moreover, the study aims at establishing a base for paediatric radiology and policy makers towards appropriate means to reduce unnecessary radiation exposures to children.

Participant involvement

Once a patient agrees to be involved in the study and informed consent has been signed, clinical details from the request form as well as the imaging dose used will be obtained in a discreet manner.

Confidentiality

Information obtained from each study participant will be kept confidential. No name will appear on any document of the study, and identification numbers shall be used instead.

Participant rights

The decision to participate in the study is voluntary. Refusal or withdrawal from the study will not have interference with your management at the hospital, and no penalty will be given.

Benefits

Your participation will guide into reduction of unnecessary pediatric CT scan and decrease the future burden that might be brought by increased radiation exposure to children and added costs. Furthermore, in so doing, will assist in better care and imaging plan of pediatric patients in our community.

Risks

Your participation in this study will not compromise your child’s disease outcome or influence your health service provision. Also all your personal medical information will not be disclosed to the public and will be always be kept confidential except to those involved in undertaking the study.

Contacts

In case you have doubts or need more clarification regarding the study, you can contact me, Dr. Catherine Peter Mlowe, the Principal Investigator through my mobile number +255 787 654352, or P. O. Box 65001 Dar es Salaam.

Dr. Frederick Lyimo (Mobile number +255 766 466 184, P. O. Box 65000 Dar es Salaam), the Supervisor of this study, a Lecturer from the Department of Radiology.

Furthermore, in case you need more information on your participation rights, you may contact Dr. Joyce Masalu, Chairperson of the Senate Research and Publications Committee, P. O. Box 65001Dar es Salaam. Telephone: +255 022 2152489

I have read and understood the contents of this form. I have agreed/not agreed to participate in this study.

Signature of ParticipantDate.....

Signature of ResearcherDate.....

Appendix III: Fomu Ya Ridhaa (Informed Consent Swahili version)

MUHIMBILI UNIVERSITY COLLEGE OF HEALTH SCIENCES DIRECTORATE OF RESEARCH AND PUBLICATIONS

Namba ya utambulisho _____

Utangulizi

Jina langu ni Dr. Catherine Peter Mlowe. Mimi ninafanya utafiti kwa lengo la kutambua usahihi wa matumizi ya kipimo chenye mionzi cha CT Scan kwa watoto wadogo wanaohudhuria na kuhudumiwa katika hospitali ya Taifa Muhimbili.

Malengo ya utafiti

Utafiti unaofanywa ni kwa ukamilisho wa shahada ya uzamili (the degree of Master Medicine in Radiology) kutoka Chuo kikuu cha Muhimbili. Utafiti huu unalenga kuweka msingi kwenye sekta ya radiolojia ya watoto na watunga sera kuandaa mapendekezo muafaka yatakayosaidia kupunguza utumiaji wa vipimo vyenye mionzi visivyo vya lazima kwa watoto

Ushiriki

Mara tu mgonjwa akikubali kushiriki katika utafiti na fomu ya ridhaa kuwa imesainiwa, maelezo ya sababu za kufanyiwa kipimo yatachukuliwa katika fomu yake ya kuombea kipimo, taarifa za sehemu ya mwili inayofanyiwa kipimo pamoja na dozi itakayotumika zitachukuliwa kwa njia ya busara.

Usiri

Taarifa zitakazopatikana kutoka kwa kila mshiriki wa utafiti huu zitahifadhiwa kwa siri. Hakuna jina litakaloonekana kwenye hati yoyote ya utafiti na badala yake namba zitatumika.

Haki ya mshiriki

Uamuzi wa kushiriki katika utafiti ni wa hiari. Kukataa/kujiondoa kwenye utafiti hakutoathiri upatikanaji wa huduma na hakuna adhabu yoyote itakayotolewa.

Manufaaa

Ushiriki wako utatusaidia katika kupunguza madhara yatokanayo na ongezeko la kipimo chenye mionzi cha CT scan kwa watoto, na gharama iambatanayo na matumizi ya kipimo hicho.

Madhara -Ushiriki wako kwenye utafiti huu hautoathiri matokeo ya ugonjwa wa mtoto, pia hautoathiri kupata huduma hospitalini. Pia taarifa binafsi zihusuzo ugonjwa/matibabu hazitofichuliwa kwa umma na zitahifadhiwa kwa siri isipokuwa kwa wale wanaohusika katika kufanya utafiti.

Mawasiliano

Endapo una shaka, ama utahitaji maelezo zaidi juu ya utafiti huu, wasiliana na:-

Dr. Catherine Mlowe, Mtafiti Mkuu (namba ya simu +255 787654352, SLP 75998, Dar es Salaam)

Dr. Frederick Lyimo (Namba ya simu+255 766 466 184 , SLP 65000 Dar es Salaam), ambaye ni mshauri na msimamizi wa mtafiti mkuu. Dr Frederick ni mkufunzi/mwalimu wa kitengo cha Radiolojia.

Endapo utahitaji taarifa zaidi kuhusu haki ya ushiriki wako katika utafiti huu wasiliana na Dr. Joyce Masalu, ambaye ni mwenyekiti wa bodi ya utafiti na uchapaji, SLP 65001 Dar es Salaam kwa namba ya simu +255 022 2152489.

Mimi _____ nimesoma / nimeelewa yaliyomo katika fomu hii. Nimekubali/sijakubali kushiriki katika utafiti huu.

Sahihi ya mshirikiTarehe.....

Sahihi ya mtafitiTarehe.....