



Saint Paul's Hospital Millennium Medical College

Department of Radiology and Medical

Radiology Technology

Appropriateness of CT and MRI requests and associated factors at
Saint Paul's Hospital Millennium Medical College, Addis Ababa,
Ethiopia: A Cross-Sectional Study

Investigator: Misganaw (MD, Radiology Resident)

A thesis will be submitted to the department of Radiology and Medical
Radiology Technology at Saint Paul's Hospital Millennium Medical College in
partial fulfillment of the requirements for the specialty certificate in Clinical
Radiology.

June, 2024

Addis Ababa, Ethiopia.

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Advisors: 1. Solomon Tessema, MD, Radiologist, Chest Imaging Fellow

2. Ermiyas Mulu, Assistant Professor, MPH, MHPE, BSc.PH

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ST. PAUL'S HOSPITAL MILLENNIUM MEDICAL COLLEGE

Postgraduate Study Program

Name of investigator	Misganaw Yigletie, MD, Radiology Resident
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Address of investigator	Tel:+251940215662
	Email: misganaw1087@gmail.com
Name of Advisor(s)	1. Solomon Tessema, MD, Radiologist, Chest Imaging Fellow 2. Ermiyas Mulu, Assistant Professor, MPH, MHPE, BSc.PH

ABSTRACT

Background: In recent years, the utilization of computed tomography and magnetic resonance imaging (MRI) has witnessed a significant surge, raising concerns about the appropriateness of these diagnostic imaging tests. The appropriateness of CT and MRI requests plays a crucial role in delivering high-quality healthcare while minimizing unnecessary radiation exposure and healthcare costs. In Ethiopia, there is limited study on the prevalence of appropriateness of CT and MRI requests and its associated factors.

Objective: To assess appropriateness of CT and MRI requests and associated factors at Saint Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia, from January to December 2023.

Method: A retrospective review of CT and MRI requests was conducted in June 2024 among selected sample of 425 requests using a stratified sampling technique. The presence of a statistically significant difference in the characteristics of the dependent and independent variables was assessed using the chi-square test, with a p-value of less than 0.05 indicating statistical significance. To evaluate the statistically significant association between the independent and dependent variables, multivariable binary logistic regression was employed. p-values <0.05 were used to test for significance and interpret the results.

Results: The prevalence of inappropriate requests were 28.7%. The findings indicate that both requests for chronic lower back pain (AOR = 82.11, 95% CI = 8.24, 818.10, p-value <0.001) and requests originating from the Gynecology department (AOR = 3.11, 95% CI = 1.06, 9.08, p-value = 0.04) were identified as significant factors associated with inappropriate CT and MRI requests.

Conclusion: The study findings revealed a significant and concerning prevalence of inappropriate CT and MRI scan requests. In particular, requests related to clinical data of chronic lower back pain and those from the Gynecology department were strongly associated with inappropriateness.

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ACRONYMS AND ABBREVIATIONS

ACR- American College of Radiology

ACR-AC- American College of Radiology Appropriateness Criteria

AR- Appropriateness Rate

CT- Computed Tomography

ETB- Ethiopian Birr

GC- Gregorian Calendar

MDCT- Multi Detector Computed Tomography

MRI- Magnetic Resonance Imaging

PI- Principal Investigator

RIS- Radiology Information System

SPHMMC- Saint Paul's Hospital Millennium Medical Collage

SPSS- Statistical package of social science

ST.- Saint

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1. Introduction

1.1 Background

The growth in medical imaging, such as multi-section computed tomography (CT) and magnetic resonance imaging (MRI), has brought significant benefits to patients. These advancements have contributed to longer and healthier lives by improving diagnostic capabilities, aiding in early detection, and guiding appropriate treatment interventions. Cross-sectional imaging, such as CT and MRI, are powerful imaging modalities that provide detailed anatomical information, but they have different strengths and limitations (1).

CT scans use X-rays to create cross-sectional images of the body, making them particularly useful for evaluating conditions such as trauma, acute abdominal pain, and detecting abnormalities in the chest and abdomen. However, they involve ionizing radiation, which can pose risks, especially with repeated exposure. MRI, on the other hand, uses a strong magnetic field and radio waves to generate detailed images without ionizing radiation. MRI is excellent for soft tissue visualization and is often preferred for evaluating neurological, musculoskeletal, and soft tissue pathologies, such as brain tumors, spinal cord injuries, and joint disorders (2).

The growing utilization of these diagnostic tests highlights the need for meticulous analysis and justification of appropriateness. To determine the appropriateness of CT and MRI requests, various factors, including the patient's clinical presentation, medical history, and the specific diagnostic question at hand, must be considered (3).

There are evidence-based guidelines and clinical protocols for determining the appropriateness of CT and MRI requests, established by the American College of Radiology (ACR) and the European Society of Radiology (ESR). These guidelines help ensure that imaging studies are ordered judiciously, minimizing unnecessary radiation exposure and healthcare costs while maximizing diagnostic yield. Additionally, healthcare providers should consider alternative imaging modalities when appropriate, such as ultrasound or nuclear medicine studies, which may offer advantages in certain clinical scenarios (3).

The Diagnostic Imaging and Interventional Radiology portions of the American College of Radiology Appropriateness Criteria (ACR-AC) contained 233 subjects in 2023, with over 1,100 variants covered. There were almost 3,000 clinical scenarios for the theme of

diagnostic imaging alone. Each clinical scenario represents a unique combination of patient characteristics, signs, and symptoms, necessitating specific imaging considerations (3).

According to ACR-AC, appropriateness is rated on an ordinal scale that uses integers from 1 to 9, grouped into three categories: The category "usually not appropriate" includes 1, 2, or 3 when the risks of the procedure or treatment outweigh the potential benefits; the category "usually appropriate" includes 7, 8, or 9 when the benefits outweigh the potential risks. The numbers 4, 5, or 6 on the scale indicate "may be appropriate" when the risks and benefits are equivocal or unclear, the dispersion of the individual ratings from the panel rating is too large, the evidence is contradictory or unclear, or there are special circumstances or subpopulations that could influence the risks or benefits that are embedded in the variant (3).

Since 2014, the European Society of Radiology has collaborated with the ACR to formulate referral guidelines for Europe, which are derived from the ACR-AC and appropriate use criteria established by the ACR Rapid Response Committee. The goal of guidelines is to weigh potential benefits against potential hazards. There is no doubt that radiation can have at least some deleterious effects; younger patients should be especially concerned because of the potential latency of these effects. A significant additional factor is the imaging exam's cost (4).

The appropriateness of CT and MRI requests varies depending on individual patient factors, clinical context, and evolving evidence. Therefore, healthcare providers should consider these evidence-based recommendations as a framework while tailoring their decision-making to each patient's unique circumstances (3). Furthermore, the use of Clinical Decision Support (CDS) systems strategies for inpatient radiological examinations demonstrated positive effects in enhancing appropriateness and guiding healthcare providers toward more evidence-based imaging decisions (5).

1.2 Statement of the problem

In contemporary medical practice, the utilization of advanced imaging technologies such as CT and MRI has become increasingly prevalent for diagnostic purposes. However, concerns arise regarding the appropriateness of ordering these imaging studies, as their indiscriminate use may lead to unnecessary radiation exposure and increased healthcare costs (1, 2, 6).

Despite the existence of several studies in Western countries regarding the prevalence of appropriateness, there remains a gap in understanding the factors influencing the appropriateness of CT and MRI requests in various clinical settings. The data also shows

discrepancies across countries regarding the prevalence of appropriateness of CT and MRI requests. This indicates the need for surveys in various settings (7, 8). On the other hand, in Ethiopia, data are scarce regarding this subject, and the existing studies have methodological limitations. Additionally, this study aims to include factors that have been disregarded in previous studies (9).

By identifying patterns of inappropriate imaging utilization and exploring strategies for improvement, this study seeks to contribute to evidence-based approaches that optimize the judicious use of CT and MRI in healthcare delivery, ultimately enhancing patient care quality and resource utilization efficiency.

1.3 Significance of the study

The findings of this study provides important information for various stakeholders. Primarily, the study's findings are expected to benefit the local health institutions. By understanding the burden of inappropriate diagnostic imaging requests and the associated factors, health institutions will be able to implement evidence-based interventions. Additionally, the study's findings will be valuable for planners and policymakers in developing evidence-based national guidelines for diagnostic imaging requests.

2. Literature review

The appropriateness of CT and MRI requests is a critical concern in healthcare systems worldwide. In both developed and developing countries, ensuring the appropriate utilization of these imaging modalities is essential to optimizing patient care, allocating resources effectively, and minimizing potential risks and costs.

In developed countries, several studies have been conducted to assess the factors influencing appropriateness, prevalence rates of inappropriate requests, and strategies to improve utilization (6, 7, 10). These countries have well-established evidence-based guidelines, clinical decision support systems, and educational programs aimed at promoting appropriate imaging utilization.

In contrast, developing countries face unique challenges in ensuring appropriate CT and MRI requests. Limited healthcare resources, including imaging equipment and trained personnel, contribute to inappropriate utilization. Additionally, economic constraints, a lack of awareness about evidence-based guidelines, and variations in healthcare provider practices further complicate the issue (9, 11).

2.1 Appropriateness rate of CT and MRI requests worldwide

A national audit conducted in Luxembourg on the appropriateness of CT and MRI exams revealed that only 79% of CT and 61% of MRI requests were deemed appropriate. AR was greater when referred by medical specialists rather than general practitioners (70% vs. 37%) and (83% vs. 64%). When it came to CT, AR was higher when requests involved pediatric patients as opposed to adult patients (82% vs. 58%), when radiology departments had both CT and MRI units instead of just CT units (65% vs. 47%), and when requests were made for areas such as the head-neck, chest, and chest-abdominal-pelvic as opposed to spinal, extremity, and abdominal-pelvic areas (8). Similarly, examinations conducted in four Swedish healthcare districts revealed that 76% and 63% of CT and MRI were appropriate, respectively. The percentage of CT examinations deemed inappropriate is 9% for the youngest age group, whereas the overall average across all age groups is 14% (6).

A retrospective review of outpatient CT and MR imaging requested at the Philippine General Hospital outpatient department showed that the rate of appropriateness across all patients is high at 96.6%. There was no statistically significant distinction observed between MRI and CT when comparing their rates. Similarly, there were no substantial variations in the rates of

appropriateness for specific body parts such as the abdomen, cranial region, chest, and spine (12). Similarly, studies conducted in Australia and Finland indicated that diagnostic imaging was appropriately requested in 96.37% and 93 %, respectively (13, 14).

The study conducted among elective outpatient CT and MR requests from adult primary care physicians in the United States showed that 26% were not considered appropriate. These inappropriate examinations included brain CT for chronic headache, lumbar spine MR for acute back pain, knee or shoulder MRI in patients with osteoarthritis, and CT for hematuria during a urinary tract infection. Fifty-eight percent of the appropriate studies had positive results and affected subsequent management, whereas only 24% of inappropriate studies had positive results and affected management (7).

A retrospective medical record study of adult hospital admitted patients in Southern Italy revealed that 78.9% and 77.6%, respectively; got MRI and CT exams had the appropriate scans according to ACR-AC. The least appropriate anatomical scan region for CT exams is the musculoskeletal system (10).

A prospective diagnostic imaging request analysis among outpatients included and not included in a follow-up protocol at the National Institute for Infectious Diseases in Rome, Italy, showed that 56% were found to be appropriate. Among the requests not included in a follow-up protocol, 55.5% were appropriate. The proportion of appropriate requests was not significantly different when comparing prescriptions issued by general practitioners to those issued by medical specialists: 55% and 58%, respectively (15).

A meta-analysis of fourteen papers published between 2003 and 2013 was included in a retrospective review on magnetic resonance appropriateness in Canada. The analysis showed that between 2% and 28.5% of magnetic resonance exams were inappropriately performed. Also, it revealed that roughly 30% of spine imaging was not appropriate (16).

A prospective study after intervention for headache and lumbar in Canadian primary healthcare showed that appropriateness increased to a peak of 57.26% of all referrals in February 2018, whereas inappropriate referrals decreased to a low of 29.82% of all referrals by March 2018 (17).

2.2 Appropriateness rate of CT and MRI requests in Africa

In South Africa, a study found that 6.4% of scans were considered inappropriate, and interns and registrars did not request any inappropriate scans. The orthopedics department had the

highest rate of appropriate scans at 80.0%, while the oncology department had the highest rate of inappropriate scans at 20.8% (18).

Similarly, a hospital-based cross-sectional study conducted at Kenyatta National Hospital's Radiology Department aimed to assess the appropriateness of imaging modalities in the Accident and Emergency Department. The study revealed that 51.9% of imaging requests were appropriate, while 34.6% were deemed inappropriate. Interestingly, 13.6% of the imaging requests involved clinical scenarios that were not found in the ACR database. Among these requests, CT scans had the highest individual percentage of inappropriate requests at 49.3% (19).

Among all patients referred for head CT at five major health facilities across Ghana, revealed that 69.0% of headache patients were likely scanned inappropriately (11). Another study done in Cameroon showed that 16% were deemed inappropriate (20).

A retrospective review of CT requests pre-intervention and post-intervention conducted at Mengo Hospital in Uganda showed that 53% were deemed inappropriate for pre-intervention, while 47% of requests were deemed inappropriate for post-intervention (21).

2.3 Appropriateness rate of CT and MRI requests in Ethiopia

According to a study that was done among patients getting head CT examinations at Tikur Anbessa Specialized Hospital, 11.7% of the scans were deemed inappropriate. The most frequent reasons for an inappropriate scan were headaches (38.5%), seizures (23.1%), and head trauma (23.1%). A significant proportion of inappropriate scans were ordered from adult emergency (26.2%) and central triage (33.3%). In 11.9% of cases, the pediatric department made requests for inappropriate scans. Residents were responsible for the majority of inappropriate scan orders (9).

In addition to the above study, a prospective CT request review of pediatric patients at Tikur Anbessa Specialized Hospital revealed that 6.5% were rejected based on the As low as reasonably achievable (ALARA) justification principle. MRI was suggested in 39.2% of requests, whereas US was suggested in 21.42% of requests in place of CT (22).

2.4 Factors associated with appropriateness CT and MRI requests

A study conducted in Southern Italy showed that the appropriateness was linked to the avoidance of contrast agent use (10). According to a study at Tikur Anbessa Specialized Hospital, Cerebrovascular disease scans had a 240-fold increased likelihood of being

appropriate. There was a significant association between inappropriate scans and young age and use of IV contrast agent. There is about 50 times increased of getting an incidental finding for inappropriate head CT scans than appropriate scans (9).

2.5 Conceptual framework

The following diagram depicts the relationship between the dependent variable and different identified independent variables required in this research. It was developed by the principal investigator after reviewing relevant pieces of literature (9).

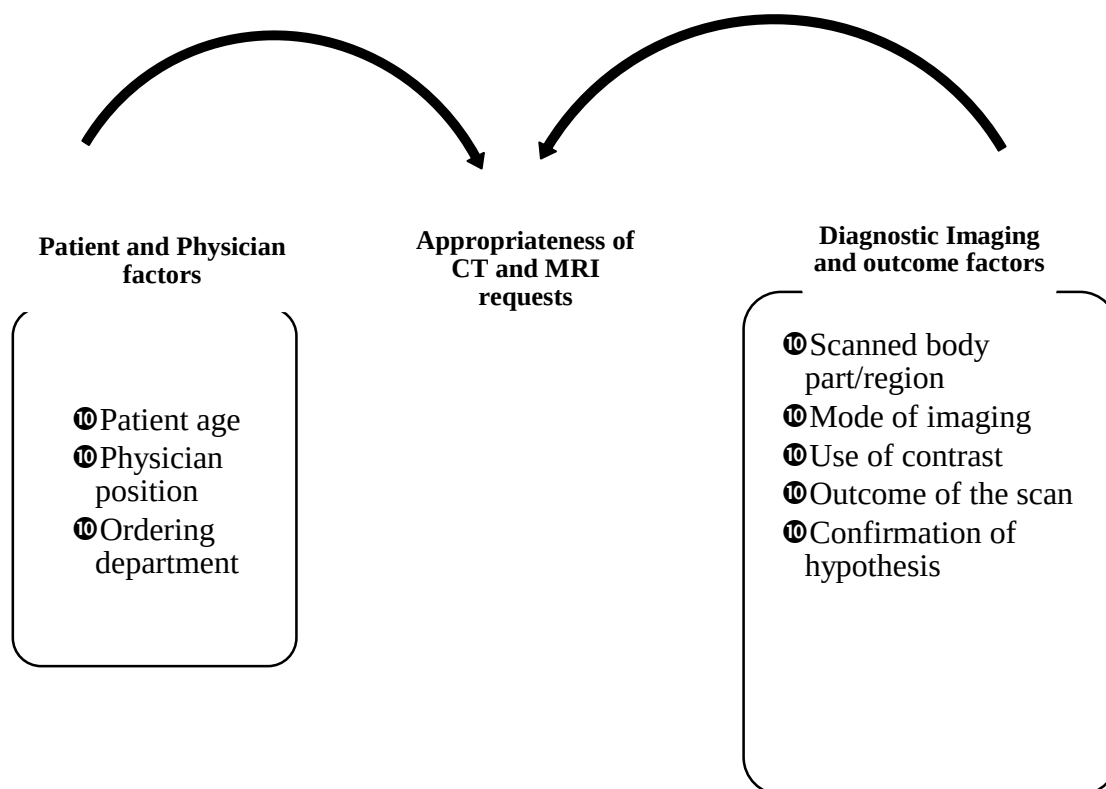


Figure 1: Conceptual framework for factors associated with appropriateness of CT and MRI requests

3. Objectives

3.1 General objective:

- To assess appropriateness of CT and MRI requests and associated factors at St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia, from January to December 2023.

3.2 Specific objective:

- To determine the prevalence of appropriateness of CT and MRI requests.
- To identify factors associated with the appropriateness of CT and MRI requests.

4. Methods

4.1 Study Setting and Period

The study was conducted at St. Paul's Hospital Millennium Medical College in June 2024 among CT and MRI requests from January to December 2023. St. Paul's Hospital Millennium Medical College is one of Ethiopia's largest Hospitals and medical schools, found in the capital city, Addis Ababa, in the Gulelle sub-city near Swaziland Street. It was established in 1969 G.C. by Emperor Haile Selassie.

The college is governed by a board under the Federal Ministry of Health. It has more than 2800 clinical, academic, administrative, and support staff that provide medical specialty services to patients who are referred from all over the country, teaching medicine, public health science, and nursing students, and doing basic and applied research. While the inpatient capacity is more than 700 beds, the college sees an average of 1200 emergency and outpatient clients daily.

The Radiology Department is one of the biggest departments in the nation, providing diagnostic and interventional radiology services. The department is equipped with working MRI, MDCT, mammography, x-ray, fluoroscopic, and several ultrasound machines. The residency program began nine years ago, and a fellowship program in neuroradiology, cardiothoracic, musculoskeletal, body, and interventional radiology, as well as a master's degree for medical radiology technologists, has recently begun. On average, more than 1500 cross-sectional images (CT and MRI) are done monthly.

4.2 Study Design

An institution-based cross-sectional study design through retrospective CT and MRI request review was employed.

4.3 Source Population

All CT and MRI requests on RIS from January to December 2023.

4.4 Study Population

All selected CT and MRI requests on RIS from January to December 2023 fulfilling the inclusion criteria.

4.5 Study Units

Computed Tomography and MRI requests and/or charts.

4.6 Inclusion and Exclusion criteria:

Inclusion criteria:

Those CT and MRI requests within the study period were included.

Exclusion criteria:

Oncology patients were excluded since the oncology patients have different guidelines.

4.7 Sample Size

The sample size was determined using single proportion formula for the first objective. This calculation took into account of P value of 0.11 based on previous similar study done in Ethiopia, confidence interval of 95%, a tolerable margin of error of 5% and design effect of 1 (9).

$$n = \frac{(Z_{\frac{\alpha}{2}})^2 P(1-P)}{d^2}$$

Where:

n= minimum sample size required for the study

Z= standard normal distribution (Z=1.96) with CI of 95% and $\alpha = 0.05$

P=prevalence/ population proportion (p=11%)

d=is a tolerable margin of error (d=0.05)

Substituting the values into the formula, we got: $n = \frac{(1.96)^2 (0.11) (1-0.11)}{(0.05)^2} = 151$.

The sample size for second objective was determined using double proportion formula. This calculation considered various exposure variables known to have a significant association with the prevalence of appropriateness of CT and MRI requests as identified in a previous study (9).

Table 1: Sample size calculation for the second objective using the double population proportion formula.

Variables		% of inappropriate requests	Adjusted Odds ratio	Sample size	Reference
Indications	Cerebrovascular disease	3.3	0.004	406	(8)
	Seizure	52.2	0.02	48	
	Others	11	1		

As a result, the sample size calculated for the second objective was notably larger compared to that obtained for the first objective. Consequently, the sample size was determined to be 406. Considering a 10% non-response rate, the final sample size was set at 447.

4.8 Sampling Procedure

Stratified sampling technique was used and proportional sample size was allocated based on scanned region into 1) Head/Head and neck 2) Chest 3) Abdomen/ Pelvic/Abdominopelvic 4) Spine. 5) Others.

A systematic random sampling technique was used to select samples from each stratified group. The sampling interval (K) was determined for each scanned region group by dividing the total study population who has CT and MRI requests during one-year study period by the sample sizes.

Table 2: Proportional sample size allocation

Scanned region	Source population	Sample size
Head/Head and neck	5173	123
Chest	3730	89
Abdomen/ Pelvic/Abdominopelvic	5951	141
Spine	3117	74
Musculoskeletal	798	20
Total	18784	447

4.9 Study variables

Dependent variables:

- Appropriateness of CT and MRI requests

Independent variables:

Patient and Physician Related factors • Age of the patient • Sex of the patient • Physician position • Ordering department • Clinical indication	Diagnostic imaging Related factors • Scanned body part/region • Mode of imaging • Type of cross-sectional imaging modality • Use of contrast • Outcome of the scan • Confirmation of hypothesis
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4.10 Data Collection and Procedures

Using structured self-prepared questionnaire, which were developed after reviewing relevant literatures, a retrospective review of CT and MRI requests from RIS and patient chart were taken. Appropriateness of requests was decided based on ACR-AC. Principal researcher and trained junior radiology residents collected the data.

4.11 Operational Definition

Appropriate: The imaging procedure at a favorable risk-benefit or the risk-benefit ratio for patients is equivocal based on ACR-AC (3).

Not Appropriate: The imaging procedure is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable based on ACR-AC (3).

4.12 Data Quality Control and Management

The structured questionnaire was properly designed and coded. It was evaluated by the research advisor. The training was given to a data collector about the checklist and how to collect the data. To maintain the reliability of the data, the collected data was reviewed by the principal investigator to check for mistakes, legibility, completeness, and consistency of the data.

4.13 Data Analysis Plan and Procedures

The data were collected using Kobotoolbox, cleaned, stored, and exported into SPSS version 26 software for analysis. Categorical variables were summarized using frequencies and percentages, and numerical variables were summarized with a mean and standard deviation. A chi-square test was run to determine the presence of a significant difference between the independent variables and the appropriateness of the requests. A statistically significant difference was detected for variables with a P-value of < 0.05 .

To identify significant associations between the dependent variable and the independent variables, a binary logistic regression analysis was performed. A bivariable analysis was conducted to select candidate variables for multivariable logistic regression analysis. Variables with p-values < 0.25 at bivariable analysis were entered into the multivariable logistic regression analysis model to control for the effect of confounding factors while assessing the effect of each independent variable on the dependent variable. Variables with a p-value < 0.05 in the multivariable logistic regression analysis were considered statistically significant. The adequacy of the final model was assessed using the Hosmer – Lemeshow test, and the final model fitted the data well (p-value < 0.001).

4.14 Ethical Consideration

Ethical clearance was obtained from the ethical review committees of research and publication of the Department of Public Health, SPHMMC, after being approved by the research advisor. Confidentiality was maintained by avoiding recording the names of clients in the data collection format; client records were available to the investigators and data collectors only. Permission to collect data was obtained from the Department of Radiology, SPHMMC.

5. RESULT

5.1 Prevalence, Sociodemographic, diagnostic imaging-related variables and comparison between appropriate and inappropriate requests

Data was collected from a total of 425(95%) eligible requests out of the initially considered 447. The average age of the patients was 43.4 years (SD=19.3). Among the sample, 6.1% were under the age of 14. Among the patients included in the study, 55.3% (235 individuals) were female (Figure 2).

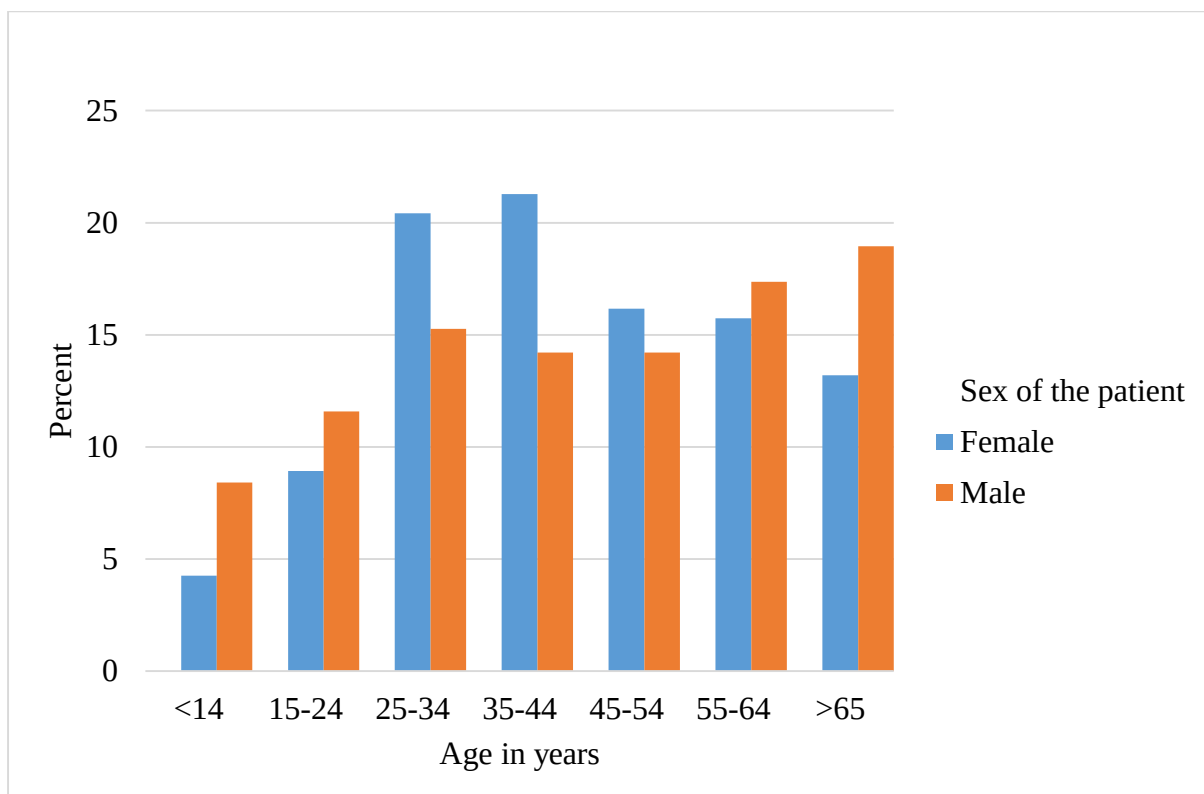


Figure 2: Sex and Age of patients in categories

Out of the 425 requests analyzed in the study, it was found that 28.7% (with a confidence interval of 24.4% to 33.2%) were classified as inappropriate (Figure 3). The breakdown showed that 25.6% of the inappropriate requests were for CT scans, while 35.5% were for MRI scans, as determined by the ACR-AC criteria (Table 3).

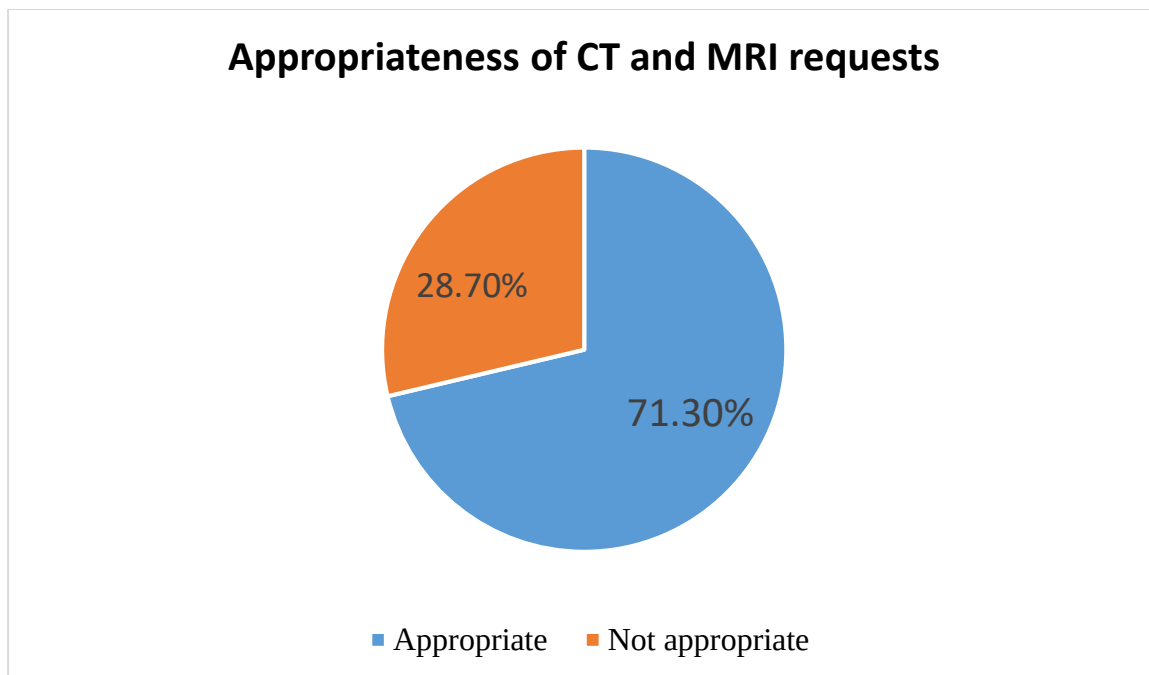


Figure 3: Prevalence of appropriateness of CT and MRI requests at St. Paul’s Hospital Millennium Medical College, Addis Ababa, Ethiopia

Out of all the examinations conducted, 258 requests (60.7%) were CT scans. In total, 253 (59.5%) of the examination were requested without the use of intravenous (IV) contrast. The most frequently scanned regions were the abdomen and pelvic area, accounting for 29.9% of the total requests, followed by the head region at 27.8%. The primary clinical indications for scanning the head, chest, abdomen and pelvic regions, and spine were cerebrovascular disease, pulmonary thromboembolism, urolithiasis, and chronic back pain, respectively. Nearly half of the requests were requested from the Internal Medicine department. Out of all the requests, 16.2% were classified as emergency scans, while the remaining were elective. In approximately one-third of the cases, the outcome of the scan was either normal or revealed incidental findings (Table 3).

The chi-square test yielded statistically significant variations in the appropriateness of requests across various factors, including age groups, scanned regions, ordering departments, clinical data of patients, outcomes of the scans, and confirmation of diagnostic hypotheses.

There was a noteworthy difference observed in the prevalence of inappropriate requests within the age group of 35-44 years, with a significantly higher percentage found to be inappropriate (45.5%, $p\text{-value} < 0.0001$). The majority of requests for spine imaging were deemed inappropriate, accounting for 69% of the total requests (inappropriate) versus 31% (appropriate) (Table 3).

Furthermore, a significant majority of requests related to chronic lower back pain were deemed inappropriate, with 94.6% falling into this category compared to only 5.4% being considered appropriate. Conversely, requests for cerebrovascular disease exhibited a significantly higher percentage of appropriateness, with 91.9% being categorized as appropriate compared to 8.1% being deemed inappropriate (p-value < 0.001) (Table 3).

A substantial number of inappropriate requests originated from the departments of Internal Medicine (39.7%), Gynecology (36.7%), and Pediatrics (30.4%), in descending order of frequency. Among incidental scan outcome of the requests, higher percentage (53.2%) were falling into inappropriate category. From a total of requests confirming the diagnostic hypothesis, inappropriate requests were accounted for 22.2% only (Table 3).

Table 3: Sociodemographic and diagnostic imaging related variables and comparison between appropriate and inappropriate requests

Variables	Appropriate n(%)	Not Appropriate n(%)	Total n(%)	P- value
Age group in years				
0-14	18(69.3)	8(30.7)	26(6.1)	0.002*
15-24	35(81.4)	8(18.6)	43(10.1)	
25-34	50(65)	27(35)	77(18.1)	
35-44	42(54.5)	35(45.5)	77(18.1)	
45-54	52(80)	13(20)	65(15.3)	
>55	106(77.4)	31(22.6)	137(32.2)	
Sex of patients				
Female	166(70.6)	69(29.4)	235(55.3)	0.74
Male	137(72.1)	53(27.9)	190(44.7)	
Scanned region				
Abdomen &/ pelvic	97(76.4)	30(23.6)	127(29.9)	<0.001*
Chest	64(80)	16(20)	80(18.8)	
Head	94(79.7)	24(20.3)	118(27.8)	
Others	26(89.7)	3(10.3)	29(6.8)	
Spine	22(31)	49(69)	71(16.7)	
Types of cross-sectional imaging modality				
CT	192(74.4)	66(25.6)	258(60.7)	0.077
MRI	111(66.5)	56(33.5)	167(39.3)	
Clinical data of the patients				
Cerebrovascular disease	34(91.9)	3(8.1)	37(8.7)	<0.001*
Chronic Lower back pain	2(5.4)	35(94.6)	37(8.7)	
Others	207(72.6)	78(27.4)	285(67)	
Pulmonary thromboembolism	17(89.5)	2(10.5)	19(4.5)	
Seizure/epilepsy	20(95.2)	1(4.8)	21(4.94)	
Urolithiasis	23(88.5)	3(11.5)	26(6.1)	
Ordering department				
Emergency medicine and critical care	27(84.4)	5(15.6)	32 (7.5)	<0.001*
Gynecology	19(63.3)	11(36.7)	30(7.1)	
Internal medicine	126(60.3)	83(39.7)	209(49.2)	
Others	42(97.7)	1(2.3)	43(10.1)	
Pediatrics	16(69.6)	7(30.4)	23(5.4)	
Surgery	73(83)	15(17)	88(20.7)	
Mode of scan				
Elective	247(69.4)	109(30.6)	356 (83.8)	0.048
Emergency	56(81.2)	13(18.8)	69(16.2)	
Use of contrast				
No	183(72.3)	70(27.7)	253(59.5)	0.566
Yes	120(69.8)	52(30.2)	172(40.5)	
Outcome of the scan				
Abnormal	216(78.3)	60(21.7)	276(64.9)	<0.001*
Incidental	37(46.8)	42(53.2)	79((18.6)	
Normal	50(71.4)	20(28.6)	70(16.5)	
Confirmation of diagnostic hypothesis				
No	128(63.1)	75(36.9)	203(47.8)	<0.001*
Yes	175(78.8)	47(21.2)	222(52.2)	

*Statistically significant

5.2 Factors associated with appropriateness of CT and MRI requests

A univariate analysis at a 25% level of significance was conducted, and the age of the patient group, clinical data of the patient, ordering department, scanned region, outcome of the scan, and confirmation of diagnostic hypothesis variables were found to be significantly associated with the appropriateness of requests.

These variables were included in the final multivariable regression model. According to multivariable binary logistic regression, age of the patient group, clinical data of the patient, and ordering department were found to be significantly associated with the appropriateness of requests at the 5% level of significance.

After adjusting for other covariates included in the final regression model, the odds of inappropriate requests were more likely among patients in the age range of 35–44 years compared with those >55 years (AOR = 2.20, 95% CI = 1.24, 5.85, p-value = 0.01).

The odds of inappropriate requests for chronic lower back pain were 81.1 times higher compared to requests for urolithiasis (AOR = 82.11, 95% CI = 8.24, 818.10, p-value <0.001). Regarding the ordering department, the odds of inappropriate requests among the Gynecology department were 3.11 times higher compared to the Surgery department (AOR = 3.11, 95% CI = 1.06, 9.08, p-value = 0.04) (Table 4).

Table 4: Results for the final multivariable binary logistic regression model among CT and MRI requests (n = 425)

Variables	COR (95% CI)	AOR (95% CI)	P-value
Age of patient group (in years)			
0-14	1.52 (0.60, 3.83)	10.45 (0.61, 177.69)	0.12
15-24	0.78 (0.33, 1.86)	0.85 (0.29, 2.49)	0.76
25-34	1.85 (0.99,3.42)	2.2 (0.98, 4.92)	0.56
35-44	2.85 (1.56, 5.20)	2.2 (1.24, 5.85)	0.01*
45-54	0.86(0.41,1.77)	0.51 (0.18, 1.46)	0.21
>55	1	1	0.006*
Scanned region			
Abdomen &/Pelvic	0.14 (0.07, 0.27)	0.87 (0.28, 2.73)	0.81
Chest	0.11 (0.05, 0.24)	0.60 (0.2, 1.64)	0.30
Head	0.12 (0.06,0.23)	1.20 (0.42, 3.49)	0.73
Others	0.05 (0.01, 0.19)	1.22 (0.21, 7.06)	0.82
Spine	1	1	0.653
Clinical data of patients			
Cerebrovascular disease	0.68 (0.13, 3.65)	0.21 (0.02, 1.80)	0.15
Chronic lower back pain	134.17 (20.78, 886,12)	82.11 (8.24, 818.10)	<0.001*
Others	2.89 (0.84, 9.90)	2.20 (0.54, 9.90)	0.26
Pulmonary thromboembolism	0.90 (0.14, 6.01)	0.60 (0.06, 5.92)	0.66
Seizure/Epilepsy	0.38 (0.04,3.40)	0.11 (0.01, 1.40)	0.089
Urolithiasis	1	1	<0.001*
Ordering department			
Emergency	0.90 (0.30, 2.72)	3.81 (0.72, 20.25)	0.12
Gynecology	2.82 (1.12, 7.12)	3.11 (1.06, 9.08)	0.04*
Internal medicine	3.21 (1.72, 5.96)	2.31 (0.81,6.57)	0.12
Others	0.12 (0.02,0.91)	0.03 (0.002, 0.44)	0.01*
Pediatrics	2.13 (0.75, 6.07)	0.44 (0.02, 9.71)	0.60
Surgery	1	1	0.006*
Outcome of scan			
Abnormal	4.09 (2.41, 6.92)	0.84 (0.31, 2.25)	0.72
Incidental	1.44 (0.80, 2.60)	1.45 (0.56, 3.80)	0.45
Normal	1	1	0.572
Confirmation of diagnostic hypothesis			
No	2.18 (1.42, 3.35)	1.41 (0.60, 3.30)	0.43
Yes	1	1	

COR Crude Odds ratio, AOR Adjusted Odds ratio, CI Confidence interval *Statistically significant

6. Discussion

To the best of my knowledge, this study represents the first attempt in Ethiopia to assess the appropriateness of both CT and MRI examinations. Our sample encompassed individuals from all age groups and body systems, including both outpatient and inpatient cases.

The findings of this study revealed a significantly higher prevalence of inappropriate scans when compared to previous studies conducted in Finland and the Philippines (12, 14). However, the prevalence observed in our study is similar to that reported in studies conducted in the United States, Sweden, and Luxembourg (6-8).

In terms of studies conducted in Africa, the prevalence of inappropriateness observed in this study is higher than those reported in South Africa and Cameroon but lower than the findings in Uganda (18, 20, 21). Additionally, a study conducted in Ethiopia showed a lower proportion of inappropriateness compared to the present study (9). It is important to note that when comparing our results to previous studies, variations in methodology, reference guidelines, and sociodemographic variables among the studies must be taken into consideration (7, 15).

The chi-square test demonstrated a notable association between the outcome of the scan and the region being scanned with regards to inappropriateness. It was observed that a higher proportion of scans resulting in incidental findings were deemed inappropriate. These results match a study conducted at Tikur Anbessa Specialized Hospital (9). Consistent with earlier research findings, the prevalence of inappropriate utilization of spine imaging was found to be higher (7, 10). Similarly, in line with a previous study, requests for imaging related to cerebrovascular disease demonstrated a higher proportion of appropriateness (91.9% vs 93.4%) (9).

In the multivariable binary logistic regression analysis, several factors were found to have a significant association with the appropriateness of imaging requests. These factors included the age of the patient group, the clinical data of the patient, and the department responsible for ordering the imaging. Notably, the odds of inappropriate requests for chronic lower back pain were 81.1 times higher compared to requests for urolithiasis. These findings potentially indicate a trend where physicians are increasingly relying on diagnostic imaging rather than primarily considering clinical findings when making these requests.

Furthermore, it was observed that the likelihood of inappropriate imaging requests in the Gynecology department was 3.11 times higher compared to the Surgery department. This observation indicates a possible lower level of awareness among Gynecology residents in appropriately selecting cross-sectional imaging for different cases.

A previous study mentioned potential reasons for inappropriate imaging, such as lengthy wait times for the most suitable test, which may lead providers to request a less appropriate test, resulting in inconclusive results and the need for further testing, potentially delaying a definitive diagnosis. Another issue identified is the fragmented nature of the healthcare system, particularly the lack of effective communication between referring physicians and radiologists, which contributes to inappropriate exams. Insufficient information exchange, incomplete clinical histories, and inadequate collaboration can result in ordering the wrong test or missing relevant information, leading to suboptimal patient care (16).

The higher prevalence of inappropriate scans compared to previous studies conducted in other countries suggests that there is a significant issue with the appropriateness of diagnostic imaging utilization in the institution. This finding indicates that there is room for improvement in the selection of imaging tests, ensuring that they are appropriate and align with established guidelines.

Similar to other developing nations, Ethiopia faces constraints in terms of healthcare resources such as imaging equipment, trained staff, and financial capabilities. The prevalence of inappropriate imaging requests exacerbates these limitations, resulting in a strain on the already scarce resources. This diversion hinders the availability of imaging services to patients who genuinely require them. Enhancing the appropriateness of imaging utilization becomes crucial in order to optimize resource allocation. By doing so, healthcare facilities can ensure that imaging services are directed towards cases where they offer the highest potential benefit.

7. Strength and Limitation

The study explores an under-researched area in Ethiopia, which can be considered as a strength. However, the limitation of the study is the restriction to a single institution may hinder the generalizability of its findings to broader clinical practices in the country. The other factors associated with appropriateness, such as the education level or position of the physician and the waiting list before getting diagnostic imaging, were not documented on the request or chart.

8. Conclusion

The study findings revealed a significant and concerning prevalence of inappropriate CT and MRI scan requests. In particular, requests related to clinical data of chronic lower back pain and those from the Gynecology department were strongly associated with inappropriateness.

9. Recommendation

For SPHMMC

Firstly, providing medical professionals with education and training on the appropriate use of imaging tests, emphasizing the importance of increasing awareness and understanding of the American College of Radiology appropriateness criteria for informed decision-making regarding CT and MRI orders is recommended. Secondly, it is strongly recommended that preauthorization systems be introduced to ensure the appropriate utilization of imaging tests. Furthermore, regular quality assurance assessments and audits should be conducted to monitor and evaluate the appropriateness of imaging requests.

Last but not least, further study should be done to address other associated factors that were not addressed in this study.

For the Federal Ministry of Health

It is recommended to develop a customized national guideline that addresses the specific healthcare context, resource limitations, and clinical needs of Ethiopia, with a focus on the appropriate usage of CT and MRI scans.

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11. Assurance of Principal Investigator

I the undersigned agree to accept all responsibilities for the scientific and ethical conduct of the research project. I will provide timely progress report to my advisor and seek the necessary advice and approval from my primary advisors in the course of the research. I will communicate timely to my advisors all stakeholders involved in the study including any source of funding for this research.

Name of the student: Dr. Misganaw Yigletie, MD, Radiology Resident

Signature: _____

Date: _____

Approval of the Clinical Advisor

Name of the primary advisor: Dr. Solomon Tessema, MD, Radiologist, Chest Imaging Fellow

Signature: _____

Date: _____

Approval of the Clinical Advisor

Name of the primary advisor:

Signature: _____

Date: _____

Approval of the Clinical Advisor

Name of the primary advisor:

Signature: _____

Date: _____

Approval of the research directorate Advisor

Name of the primary advisor: Mr. Ermiyas Mulu, Assistant Professor, MPH, MHPE, BSc.PH

Signature: _____

Date: _____

12. Annexes

Checklist

	Categories
Age of the patient(year/month)	
Sex	Male Female
Requesting department	Internal medicine Surgery Gynecology and obstetrics Pediatrics ENT Neurosurgery Orthopedics Ophthalmology
Qualification of Physician	Intern General Practitioner Resident Specialist
Scanned Region	Head Chest Abdomen/ and pelvic

	Spine Others
Type of cross sectional imaging	CT MRI
Use of contrast	Yes No
Mode of Scan	Emergency Elective
Clinical indication	-----
Outcome of the Scan	Normal Incidental Abnormal
Confirmation of diagnostic hypothesis	Yes No
Appropriateness of the request based on ACR-AC	Appropriate Not Appropriate