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Inappropriate computed tomography examinations among children and young adults in a limited resource setting: A cross-sectional retrospective study

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Abstract
Objective: To determine the frequency and appropriateness of common CT examinations among children and young adults.
Materials and Methods
Design: Cross-sectional retrospective review.
Study setting: Six hospital-based CT units including public, private not-for-profit (PNFP), private for -profit, tertiary hospitals and university teaching hospitals.
Data source: Paper-based requests for patients aged 35 years and below who had CT examinations performed between 1st July and 31st December 2018 were reviewed independently for appropriateness using an online European Society of Radiology guideline (ESR iGuide). https://prod.esriguide.org. Scores 7-9 were classified as appropriate, while 1-6 as inappropriate.
Outcome measure: The primary outcome measure was the appropriateness rate (AR) for a group.
Results: Of 909 CT examinations 57% were from PNFP hospitals, 29.5% (268/909) for children, 82% 82% (746/909) for head and 73% (666/909) for non-contrasted examinations.
Overall inappropriate CT examinations were 38% (347/909), significantly from PNFP (230/347, 66.2%, p<0.001). Additionally, children were 28% (36% 125/347, vs 64%, 222/347, p<0.001) less likely to have an inappropriate CT scan than adults. Head CT examinations were more likely to be inappropriate (239/316, 75.6%), (p< 0.001), compared to the rest of the anatomical regions. A CT examination performed for non-trauma related indications was 1.3 times more likely to be inappropriate (55.7%, 136/244 vs 44.3%, 108/244, p<0.001) than those related to trauma, while non-contrasted CT examinations were more likely to be inappropriate (190/347, 54.7%, p< 0.001) compared to contrasted examinations (88/347, 25.3%).
Conclusions: The study registered high rates of inappropriate CT examination that significantly varied with age, anatomical region, indication, and use of contrast media.
Future research to identify factors influencing imaging referrers' decision-making when ordering CT examination is recommended. The findings may guide developing strategies and tailored evidence-based interventions to effectively utilize imaging resources and improve healthcare outcomes.

Keywords: Computed tomography, appropriateness, children, young adults, limited resource setting

Introduction

The advances in diagnostic technology such as the Helical Multi-Detector Computed Tomography (MDCT) have improved the outcome of several diseases, especially for emergencies and uncooperative children where sedation would have been required [1]. However, MDCT imparts relatively high organ doses of radiation compared to most conventional radiological procedures, which increase the lifetime risk for radiation-induced cancers [2]. Evidence shows that 20%-40% of all computed tomography (CT) examinations are unnecessary globally [3–6]. Of these, 10-30% are performed among children [7, 8].
It is estimated that 2% of all future cancer cases and 15,000 deaths annually will arise from previous (CT) exposures [2, 9, 10]. The risk of dying from radiation-induced cancer is ten times higher for children than the general population [11–15]. For example, the lifetime risk of a one-year-old child dying from a radiation-induced cancer from a single abdominal and

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head CT scan examination is 1 in 550 and 1 in 1,500 respectively [12]. This is attributed to increased radio-sensitivity of the rapidly dividing cells in developing organs and the child's longer life years providing an adequate window to develop radiation-induced cancers. The smaller size and possibility of repeat examinations are other risks [2, 12, 16].

The International Commission on Radiological Protection (ICRP), whose mission is to protect people from the harmful effects of ionizing radiation, recommended all medical exposures to patients to be justified and appropriate. A medical procedure is considered appropriate when the expected health benefit exceeds the expected negative consequences by a sufficiently wide margin and when the effectiveness, advantages and risks for alternative methods with less radiation dose or no radiation at all such as ultrasound (US) or magnetic resonance imaging (MRI) to the patient is duly taken into consideration [17].

Africa is rapidly acquiring MDCT scanners but there aren't enough resources to acquire adequate numbers of MRI and ultrasound machines, yet these are a good non-ionizing alternative to using CT scan. This was highlighted in a previous audit of radiology equipment in a low resource setting (LRS) which found equipment versus population ratio lagging behind that one recommended by the World Health Organization [18]. Currently there is no evidence for well-laid-down plans for regulation and control of imaging utilization in such setting [19].

A study that assessed diagnostic imaging needs in Uganda found low utilization levels of the more sophisticated imaging modalities such as CT and MRI possibly due to costs and unavailability. However, the same study found that not all CT examinations were appropriate, despite their high costs [10]. This is a radiation and public health concern for LRS given the low radiation knowledge levels among health care professionals, the youthful population (75% of the population is 35 years and below, with a median age of 15.8 years), the shortage of modalities that use less or no-ionizing radiation and lack of clinical decision support tools. Individual radiation dose per procedure would rarely be concerning but the population collective dose tends to be high.

Furthermore, unnecessary CT examinations can strain healthcare resources and costs, longer waiting times for treatment, increased workload for radiology departments, and potential delays in diagnosis for patients with more urgent needs. Over diagnosis, overtreatment, invasive diagnostic procedures and risks of contrast media-induced kidney injuries are other consequences [20]. It is, therefore, crucial to prioritize appropriate and evidence-based use of CT scans in resource- constrained settings to mitigate these consequences and ensure optimal healthcare delivery.

Previous studies have cited the utilization of CT scans to be influenced by multiple, complex clinical and non-clinical interrelated factors involving various aspects of healthcare infrastructure, socio-economic conditions, and healthcare provider capabilities [21-23].

The International Basic Safety Standards for Protection Against Risks associated with exposure to ionizing radiation recommends measuring the appropriateness of imaging requisitions against evidence-based guidelines or use /medical records for clinical audits [24].

This study sought to determine the frequency and proportion of inappropriate commonly performed CT examinations among children and young adults 35 years and below. To the best of our knowledge, this is the first multi-center study to assess objectively the CT ordering practice behaviors of imaging referrers in Uganda, using evidence based clinical imaging guideline as a reference.

Materials and Methods

Ethics approval and consent to participate

Ethical approval was obtained from the institutional Research and Ethics Committee (REC), REF: #REC REF 2017-118, and the National Council for Science and Technology, REF: HS1313ES. Administrative clearance was also obtained from all the participating health facilities before the start of the study. All study procedures were in accordance with the ethical standards of the 1964 Helsinki Declaration. A waiver of consent was obtained from REC to access all patient records.

Design

This was a cross-sectional study that retrospectively reviewed CT requisition forms (CTRFs) for common examinations (Head, paranasal sinuses (PNS), chest, abdomen, spine and others.)

Setting

Six hospital-based CT units, representing almost 1/3 of the 22 functional CT scanners in the country at the time of the study participated. The hospitals included 2 publics (National and regional referral hospitals, university teaching hospitals), 2 private-for-profits (PFP), and 2 private not-for-profits (PNFP). The selection of the participating hospitals was based on geographical and CT scan services representation in the country.

Data sources

Paper-based request forms for patients aged 35 years and below who had CT scans for the head, paranasal sinuses, chest, abdomen, pelvis and spine performed from 1st July to 31st December 2018 were retrieved from each hospital's records. The upper limit of 35 years was chosen because the attributable risk of cancer from low-dose radiation among adults plateaus beyond this age [4]. These were categorized as children and young adults. According to the United Nations Convention on the Rights of the Child, Article 2 of the African Charter on the Rights and Welfare of the Child, and Article 257 (1) (c) of the 1995 Constitution of Uganda, children are any persons under the age of 18 years.

The main author (HNK) reviewed all the retrieved CTRFs. Unreadable records, verbal requests, duplicates, canceled examinations, electronic medical requests and requests from prescribers outside the participating hospitals were excluded.

Rating of CTRs for appropriateness

Appropriateness of the CT requisitions was assessed using an online computer program; "Consult Appropriate Use Criteria (AUC)". This is based on the Appropriateness Criteria developed by the American College of Radiology and embedded into European Society of Radiology (ESR)-ACR guide, computerized decision support (CDS) platform. https://prod.esriguide.org/Account/registration

Permission and virtual trainings to a group of researchers on how to use the web-based guideline were given by the secretariat for the panel of ESR-ACR iGuide Project of the

European Board of Radiology. Prior to this study, a pilot study of a sample of 100 CT scan requests were independently evaluated by 3 researchers to test the study protocol, and adjustments were made accordingly.

Each requisition was reviewed independently by at least two researchers (HNK and RM) to identify a match between the clinical information and an option of a clinical condition reported in the ESR-ACR iGuide. Disagreements were resolved by discussion and consensus. If still no agreement, a third reviewer (MGK) was the tie-breaker. The free text narrative portion of the clinical information on the majority of request forms was converted using a coding system to derive ratings of appropriateness. Each eligible requisition was manually coded into the software by entering the patient demographics (Age and sex) and relevant clinical indication, clinical symptom, clinical diagnosis, or a differential diagnosis that could contribute to the justification of the CT examinations. The computer system scored each requisition according to the 1 to 9 ordinal-point rating scale, 1 being the least appropriate and 9 being the most appropriate. In this study, the 9-point rating scale for appropriateness was reduced to a two-grade scale as used by Vilar-Palop *et al*. [25]. A clinical situation defined with a score of 7–9 was classified as appropriate, and a score of 1-6 was classified as inappropriate. When CTRFs did not have enough clinical information to enable the understanding of the patient's clinical condition and evaluate the appropriateness of the exam according to the guideline, it was categorized as not justified and therefore included in the inappropriate group. Requests that could not be categorized based on the guideline were excluded from the study.

Those CTRFs requesting scanning for more than one body part (for example, CT of both chest and abdomen regions), were treated as two separate CT requests (i.e., one for CT chest and one for CT abdomen), and criteria/guidelines were applied individually to each of them.

Outcome measures

The primary outcome variable was the appropriateness rate (AR) for a group which was defined as the ratio between the number of appropriate requests in the group and the total number of analyzed requests in the group.

Data analysis

Data was analyzed using STATA-14. The level of appropriateness was presented for age group, gender, anatomical region, use of contrast media, and depending on the indication (trauma /not trauma). The difference between groups was determined using Fisher's exact test and a *P*-value <0.05 was considered for statistical significance. The results were presented as proportions / frequencies / tables / figures.

Results

A total of 931 CTRFs were reviewed, of which 22 could not be categorized by the guideline and therefore excluded from the analysis. Of the 909 CTRFs analyzed, 63.4% (576/909) were males, and 29.5% (268/909) children. Head CT accounted for 82% (746/909) and non-contrasted studies for 73.6% (666/909) as shown in table 1 below: [Insert table 1]

Overall level of appropriateness of 909 CTRFs assessed

Out of the 909 CTRFs analyzed, over a third 347 (38%) of them were not medically justified. Additionally, there was a significant variation in rates of inappropriate CT examination across the PFPs, PNFPs and Public facilities. We found more non-medically justified CT CTRFs in PFPs and PNFPs than in the Public facilities as shown in the figure 1 below:

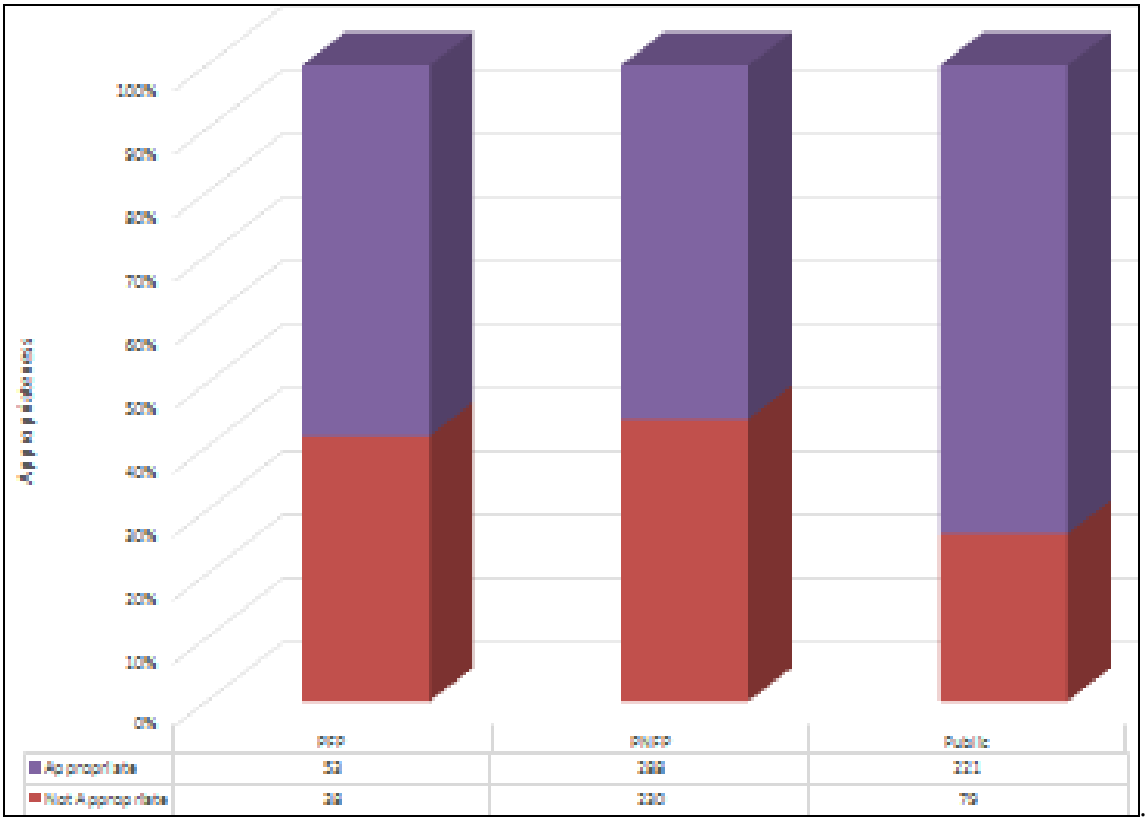

Fig 1: Appropriateness of CT examinations across different categories of hospitals (Public, PFP and PNFP)

Relationship between patient characteristics and level of appropriateness

The null hypothesis in this study was that; 'there is no relationship between selected patient characteristics and level of appropriateness'.

Patients from hospitals that were PNFP were more likely to have a CT scan categorized as inappropriate (230/347, 66.2%) (p<0.001) than those from public (79/347, 22.8%) and PFP hospitals (38/347, 11%). Additionally, we found children were 28% (125/347, 36%) less likely to have an inappropriate CT scan than adults, 64% (222/347 (p<0.001). Head CT scans were more likely to be inappropriate (239/316, 75.6%, p< 0.001), compared to the rest of the anatomical regions. A non-contrasted CT examination was more likely to be inappropriate (190/347, 54.7%, p< 0.001) compared to a contrasted examination (88/347, 25.3%). The details are shown in table 2 below: [Insert Table 2]

Relationship between level of appropriateness and trauma across different anatomical regions

Patients with head trauma were more likely to have an appropriate CT examination (361/517, 71%, p< 0.001) compared to non-traumatic indications (150/517, 29%). This is shown in the table 3 below: [Insert Table 3]

Discussion

Although a CT scan is a valuable diagnostic tool, a significant number of examinations, 38% (347/909) were performed without a valid medical reason given. This may lead to unnecessary healthcare costs and potential harm to patients. Justification of medical exposures is a key principle of radiation protection, which was emphasized in two high-level meetings by the International Atomic Energy Agency, one of which resulted in the Bonn Call for Action agreement [26, 27]. The ''good'' (i.e., the benefits) should substantially outweigh the risks that may be incurred, after considering alternative modalities that use non-ionizing radiation. Unfortunately, many countries in sub-Saharan Africa face the challenge of a shortage of advanced medical equipment that use less or no radiation such US and MRI [28].

The current study showed a higher rate of inappropriate CT examinations compared to previous studies from Cameroon, Ethiopia and South Africa [29-31]. On the other hand, a lower rate of inappropriate CT examinations was registered in this study compared to a study conducted in an urban private health care setting [32] and in an emergency department of a national hospital [33].

Comparisons with previous studies must be made with caution taking into consideration differences in study methodology such as study setting (Emergency/ non-emergency), anatomical region (s), clinical practice behaviors such as, vetting of CT requisitions by a radiologist, inclusion and exclusion criteria used, as well as source of data. For example, our data is from emergency and non-emergency conditions, as well as in-patient and outpatient settings, which could have influenced the overall level of appropriateness since decision-making to order a CT scan may be influenced by the nature of the condition and study setting.

Out of every five CT examinations performed, four of them were for the head (Table 1). This same anatomical region also had the highest number of inappropriate examinations performed (239/347, 76%). Similar findings were noted by Becker *et al.* [34] and Fouche *et al.* [31]. Usually, clinicians and patients have high levels of intolerance of uncertainty, especially in case of head injury. This is escalated by the fear of missing severe complications and medico-legal issues [14]. In addition, the lack of evidence-based decision-support tools to guide clinicians in appropriate decision-making when ordering for CT scan is a big challenge [13, 26, 27, 35-37]. Without such decision-aid tools, CT scans are used as a screening tool to triage patients in busy emergency departments, even when other clinical tools, like history taking and assessment would have served the purpose.

There was an association between the inappropriateness of head CT examinations and non-traumatic causes (136/244, 55.7% vs 108/244, 44.3%, p<0.001), Table 2. Such indications included chronic headache with no neurological symptoms, pediatric seizures suspected hydrocephalus, etc. According to the reference guideline, the imaging modality of choice for seizures with neurological deficits in children would be MRI. The shortage of such technology in many countries in sub-Africa is a diagnostic dilemma [18, 28, 34, 38-40].

Non-contrasted CT examinations were 2.2 times more likely to be inappropriate compared to contrasted ones (190/ 347, 54.7% vs 88 /347, 25.3%, p< 0.001). Our results agree with the findings by Lehnert *et al.* [41].

The possible explanation is that most contrasted scans tend to be elective procedures, with the possibility of being vetted by a radiologist. Vetting (triaging) and cancellation of inappropriate radiology requests tends makes the overall delivery of radiological services both safer and more efficient by preventing unnecessary radiation and inappropriate examinations [42].

Study strengths and limitations

- The multi-center representation of CT services in this study increases the possibility of generalizability of the results to all hospitals with CT services in Uganda.
- The retrospective clinical information may have distorted the actual rate of appropriateness.
- Using only clinical information provided on the request form without consulting other sources of information such as referring clinicians and patient's files is a limitation.
- Using a guideline developed for high resource settings as a gold standard for assessing appropriateness of CT procedures in a LRS could have influenced the study outcome.
- The relatively high number of head CT scans, 82% (746/909) included in the study, almost two-thirds of which were due to trauma could have influenced the AR, since a head CT scan in the context of a head injury tends to be justified.
- Some valid clinical reasons for ordering a CT scan did not match the coding terminology possibly due to the limited software vocabulary.
- Combining both emergency and non-emergency conditions in determining overall AR is a limitation given that decision-making to order a CT scan differs in each of the circumstance.

Table 1: Demographic and clinical characteristics of 909 patients who underwent CT procedures

Variable		Percentage
Facility		
A	58	6.4
B	193	21.2
C	33	3.6
D	107	11.8
E	103	11.3
F	415	45.7
Total	909	100
Sex		
Female	331	36.4
Male	576	63.4
Missing	2	0.2
Total	909	100
Age category		
0-1	36	4
1.01-5	63	6.9
6-10	48	5.9
11-18	121	8.7
19-25	229	29.2
26-35	412	45.3
Total	909	100
Age category		
<18 years	268	29.5
>18 years	641	70.5
Total	909	100
Anatomical region		
Head	746	82.1
paranasal sinus	16	1.8
chest	48	5.3
abdomen	34	3.7
spine	20	2.2
Others	11	1.2
Missing	34	3.7
Total	909	100
Contrasted study		
No	666	73.3
Yes	113	12.4
Missing	130	14.3
Total	909	100

Table 2: Statistical difference of appropriateness across the different demographic and clinical characteristics for commonly performed CT examinations

	Overall	**Not appropriate**	**Appropriate**	
Variable	**n (%)**	**n (%)**	**n (%)**	**p-value**
Overall	909	347 (38.2)	562 (61.8)	
Facility				
PFP	91	38 (11)	53 (9.4)	
PNFP	518	230 (66.2)	288 (51.3)	
PH	300	79 (22.8)	221 (39.3)	<0.001
Sex				
Female	331 (36.5)	139 (40)	192 (34.3)	
Male	576 (63.5)	208 (60)	368 (65.7)	0.08
Total	907	347	560	
Age categorized				
<18 years	268 (29.5)	125 (36)	143 (25.4)	
≥ 18 years	641 (70.5)	222 (64)	419 (74.6)	0.001
Total	909	347	562	
Anatomical region				
Head	746 (85.)	239 (75.6)	507 (90.2)	
Paranasal sinus	20 (2.3)	8 (2.5)	12 (2.1)	
Chest	34 (3.9)	25 (7.9)	9 (1.6)	
Abdomen	48 (5.5)	27 (8.5)	21 (3.9)	
Spine	16 (1.8)	7 (2.2)	9 (1.6)	
Others	11 (1.3)	7(2.2)	4 (0.7)	<0.001*
Total	878	316	562	

Contrasted study				
No	666 (73.3)	190 (54.7)	476 (84.7)	
Yes	113 (12.4)	88 (25.3)	25 (4.4)	
Not categorized	130 (14.3)	69 (20)	61 (10.9)	<0.001
Total	909	347	562	

Table 3: Relationship between appropriateness and trauma across different anatomical regions for commonly performed examinations

	Not appropriate	Appropriate	
Anatomical region	**n (%)**	**n (%)**	**p-value**
Head			
Trauma	108 (44.3)	367 (71)	
Non trauma	136 (55.7)	150 (29)	<0.001*
Total	244	517	
Chest			
Trauma	5 (19.2)	0 (0.0)	
Non trauma	21 (80.8)	9 (100.0)	0.3
Total	26	9	
Abdomen			
Trauma	1 (3.9)	1(5.3)	
Non trauma	25 (96.2)	18(94.7)	1.0
Total	26	19	
Spine			
Trauma	2 (33.3)	9 (81.8)	
Non trauma	4 (66.7)	2 (18.2)	0.10
Total	6	11	
Other anatomical regions			
Trauma	2 (28.6)	1 (25)	
Non trauma	5 (71.4)	3 (75)	1.0
total	7	4	

Conclusion

A significant number of CT examinations performed in the study settings were deemed medically not justified. These varied with age, anatomical region, indication, and use of contrast media.

Studies to identify factors influencing CT ordering practice behaviors among imaging referrers are recommended. The findings may guide the development of strategies and evidence-based interventions to improve effective utilization of imaging resources and health care outcomes.

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Conflict of Interest

Not available

Financial Support

Not available

References

1. ESR ES of R 2009 communications@ myESR. The future role of radiology in healthcare. Insights Imaging. 2010;1:02-11. DOI: 10.1007/s13244-009-0007-x. PMCID: PMC3259353PMID: 22347897
2. Pearce MS, Salotti JA, Little MP, *et al*. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: A retrospective cohort study. The Lancet. 2012;380:499-505. PMID: 22681860. PMCID: PMC3418594
3. Carlos Angrisano, Diana Farrell, Bob Kocher, *et al*. Accounting for the Cost of Health Care in the United States. https://www.mckinsey.com/industries/healthcare/our-insights/accounting-for-the-cost-of-health-care-in-the-united-states. https://www.mckinsey.com/industries/healthcare/our-insights/accounting-for-the-cost-of-health-care-in-the-united-states
4. Brenner DJ, Hall EJ. Computed tomography-an increasing source of radiation exposure. N Engl. J Med. 2007;357:2277-84. DOI: 10.1056/NEJMra072149. PMID: 18046031.
5. Picano E. Sustainability of medical imaging. BMJ. 2004;328:578-80. DOI: 10.1136/bmj.328.7439.578. PMID: 15001510; PMCID: PMC381057
6. Radiation UNSC on the E of A. UNSCEAR 2008 Report: Sources and effects of ionizing radiation. Rep Gen. Assem. 2010, 1.
7. Malone J, Guleria R, Craven C, *et al*. Justification of diagnostic medical exposures: some practical issues. Report of an International Atomic Energy Agency Consultation. Br. J Radiol. 2012;85:523-538. DOI: 10.1259/bjr/42893576. Epub. 2011 Feb 22. PMID: 21343316; PMCID: PMC3479887.
8. Panel discussion. Session 1: helical CT and Cancer Risk. Pediatr. Radiol. 2002;32:242-244.
9. Preston DL, Ron E, Tokuoka S, *et al*. Solid cancer incidence in atomic bomb survivors: 1958–1998. Radiat Res. 2007;168:61-64. DOI: 10.1667/RR0763.1. PMID: 17722996
10. Martin DR, Semelka RC. Health effects of ionising radiation from diagnostic CT. The Lancet. 2006;367:1712-1714. DOI: 10.1016/S0140-6736(06)68748-5. Erratum in: Lancet. 2006 Oct 28;368(9546):1494. PMID: 16731253

11. Zondervan RL, Hahn PF, Sadow CA, *et al*. Body CT scanning in young adults: Examination indications, patient outcomes, and risk of radiation-induced cancer. Radiology. 2013;267:460-469. DOI: 10.1148/radiol.12121324. Epub 2013 Feb 5. PMID: 23386731.
12. Brenner DJ, Elliston CD, Hall EJ, *et al*. Estimated risks of radiation-induced fatal cancer from pediatric CT. Am J Roentgenol; c2012. DOI: 10.2214/ajr.176.2.1760289. PMID: 11159059.
13. Hadley JL, Agola J, Wong P. Potential impact of the American College of Radiology appropriateness criteria on CT for trauma. AJR Am. J Roentgenol. 2006 Apr;186(4):937-942. DOI: 10.2214/AJR.05.0041. PMID: 16554560
14. Levin DC, Rao VM. Turf wars in radiology: the overutilization of imaging resulting from self-referral. J Am. Coll. Radiol. 2004;1:169-172. DOI: 10.1016/j.jacr.2003.12.009. PMID: 17411553.
15. Hricak H, Brenner DJ, Adelstein SJ, *et al*. Managing radiation use in medical imaging: A multifaceted challenge. Radiology. 2011;258:889-905. DOI: 10.1148/radiol.10101157. Epub 2010 Dec 16. PMID: 21163918.
16. Mathews JD, Forsythe AV, Brady Z, *et al*. Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: Data linkage study of 11 million Australians. BMJ, 2013, 346. DOI: https://doi.org/10.1136/bmj.f2360
17. What do we mean by appropriate health care? Report of a working group prepared for the Director of Research and Development of the NHS Management Executive. Qual. Health Care QHC. 1993;2:117-123. DOI:10.1136/qshc.2.2.117
18. Kiguli-Malwadde E, Byanyima R, Kawooya MG, *et al*. An audit of registered radiology equipment resources in Uganda. Pan Afr. Med. J., 2020, 37. DOI: 10.11604/pamj.2020.37.295.22046. PMID: 33654516; PMCID: PMC7881928.
19. Kalra MK, Maher MM, D'Souza R, *et al*. Multi-detector computed tomography technology: current status and emerging developments. J Comput. Assist Tomogr. 2004;28:S2-6. DOI: 10.1097/01.rct.0000120857.80935.bd. PMID: 15258486.
20. Weidman EK, Loftus ML. The Consequences of Inappropriate Use of Emergency Imaging. Evid-Based Emerg. Imaging Optim. Diagn. Imaging Patients Emerg Care Setting; c2018. p. 37-46.
21. Hatting HL, Michaleff ZA, Fawzy P, *et al*. Ordering of computed tomography scans for head and cervical spine: a qualitative study exploring influences on doctors' decision-making. BMC Health Serv Res. 2022;22:790. DOI: 10.1111/1754-9485.13004. Epub 2020 Feb 12. PMID: 32052577.
22. Melnick ER, Shafer K, Rodulfo N, *et al*. Understanding Overuse of Computed Tomography for Minor Head Injury in the Emergency Department: A Triangulated Qualitative Study. Acad. Emerg. Med. 2015;22:1474-83. DOI: 10.1111/acem.12824. Epub 2015 Nov 14. PMID: 26568523.
23. Mendelson RM. Diagnostic imaging: doing the right thing. J Med. Imaging Radiat. Oncol. 2020;64:353-60. DOI: 10.1111/1754-9485.13004. Epub 2020 Feb 12. PMID: 32052577.
24. Agency IAE. Radiation protection and safety of radiation sources: international basic safety standards. International Atomic Energy Agency; c2014.
25. Vilar-Palop J, Hernandez-Aguado I, Pastor-Valero M, *et al*. Appropriate use of medical imaging in two Spanish public hospitals: A cross-sectional analysis. BMJ Open. 2018;8:e019535. DOI:10.1136/bmjopen-2017-019535
26. IAEA. Justification of Medical Exposure in Diagnostic Imaging; c2009. https://www-pub.iaea.org/mtcd/publications/pdf/pub1532_web.pdf
27. IAEA, WHO. Bonn Call for Action. 2012. https://www.iaea.org/sites/default/files/17/12/bonn-call-for-action.pdf
28. Frija G, Blažić I, Frush DP, *et al*. How to improve access to medical imaging in low- and middle-income countries? eClinical Medicine. 2021;38:101034. DOI: 10.1016/j.eclinm.2021.101034. PMID: 34337368; PMCID: PMC8318869.
29. Tambe J, Mbuagbaw L, Nguefack-Tsague G, *et al*. Multidetector computed tomography utilization in an urban sub-Saharan Africa setting: user characteristics, indications and appropriateness. Pan Afr. Med. J. 2020, 37. DOI: 10.11604/pamj.2020.37.42.21176. PMID: 33209169; PMCID: PMC7648473
30. Demeke E, Mekonnen A. Appropriateness of Head CT Scans at Tikur Anbessa Specialized Hospital, Ethiopia. Ethiop J Health Sci. 2022, 32. DOI: 10.4314/ejhs. v32i2. DOI:10.4314/ejhs. v32i2
31. Fouche PE, Jenkins LS, Vermeulen A. Appropriateness of computed tomography and magnetic resonance imaging scans in a rural regional hospital in South Africa: A 6-year follow-up study. S Afr. Med. J. 2021;111:46-51. DOI: 10.7196/SAMJ. 2020.v111i1.14860. PMID: 33404005.
32. Eng YCM, Awana AP, Engoumou AMS, *et al*. Utility, Appropriateness of Request and Report of Computed Tomography Scan for the Diagnosis of Paranasal Sinuses Pathologies in a Sub-Saharan Africa Urban Setting. Open J Radiol. 2021;11:175-186. https://doi.org/10.4236/ojrad.2021.114016
33. Ahmed SS, Onyambu CK, Omamo E, *et al*. Appropriateness of imaging modality choice by doctors at the Kenyatta National Hospital's Accident and Emergency Department. SA J Radiol. 2022;26:2367. DOI: 10.4102/sajr.v26i1.2367PMCID: PMC9257894PMID: 35812704
34. Becker J, Jenkins LS, Swardt M de, *et al*. Appropriateness of computed tomography and magnetic resonance imaging scans in the Eden and Central Karoo districts of the Western Cape Province, South Africa. S Afr. Med J. 2014;104:762-765. DOI: 10.7196/samj.8158. PMID: 25909118
35. Stiell IG, Clement CM, Rowe BH, *et al*. Comparison of the Canadian CT Head Rule and the New Orleans Criteria in Patients with Minor Head Injury. JAMA. 2005;294:1511-1518. DOI:10.1001/jama.294.12.1511
36. Triantopoulou Ch, Tsalafoutas I, Maniatis P, *et al*. Analysis of radiological examination request forms in conjunction with justification of X-ray exposures. Eur. J Radiol. 2005;53:306-11.

DOI: 10.1016/j.ejrad.2004.02.012
37. Remedios D, France B, Alexander M. Making the best value of clinical radiology: iRefer Guidelines, 8th edition. Clin. Radiol. 2017;72:705-707. DOI: 10.1016/j.crad.2017.05.009
38. Horner K. New Regulations on X-Ray Use: Likely Implications of Irr17 and Irmer18. Prim Dent J. 2017;6:19-21. DOI:10.1308/205016817822230184
39. Bianco A, Zucco R, Lotito F, *et al*. 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:e018125. DOI:10.1136/bmjopen-2017-018125
40. Rehani B. Imaging overutilization: Is enough being done globally? Biomed Imaging Interv. J. 2011;7:e6. Doi:10.2349/biij.7.1. e6
41. Lehnert BE, Bree RL. Analysis of Appropriateness of Outpatient CT and MRI referred from Primary Care Clinics at an Academic Medical Center: How Critical Is the Need for Improved Decision Support? J Am Coll. Radiol. 2010;7:192-7. 1 ESR ES of R 2009 communications@ myESR. The future role of radiology in healthcare. Insights Imaging. 2010;1:2-11. DOI: 10.1007/s13244-009-0007-x. PMCID: PMC3259353PMID: 22347897
42. IR(ME)R 8 Implications for clinical practice in diagnostic imaging, interventional radiology and diagnostic nucer medicine:www.rcr.uk

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