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Retrospective Study

Navigating Pediatric CT Utilization: Diagnostic Efficacy and Radiation Safety in A Retrospective Audit

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Abstract

Objective: To evaluate the diagnostic yield and clinical utility of pediatric computed tomography.

Study Design: A retrospective audit.

Study Setting and Duration: Department of Radiology, PIMS, Islamabad, including all pediatric CT scans performed during September 2024.

Methodology: Data on demographics, referral source, clinical indication, region scanned, and imaging findings were extracted from RIS/PACS. Scans were categorized as positive or normal, and diagnostic yield was calculated by indication and region. Analysis was performed using SPSS v26, and audit standards were based on RCR and ACR guidelines.

Results: A total of 72 pediatric CT scans were reviewed. Most referrals were from the outpatient department (61%), followed by emergency (26%) and inpatients (13%). Brain imaging was most frequent (49%), with trauma (31%) and hydrocephalus (20%) as leading indications. Overall, 78% of scans showed abnormal findings, with highest yields in abdominal (100%) and brain CTs (86%). Trauma, hydrocephalus, liver abscess, and rare conditions such as cystic hygroma and Wilms' tumor demonstrated strong diagnostic correlation.

Conclusion: Pediatric CT at PIMS in September 2024 showed high diagnostic yield, particularly for trauma, hydrocephalus, and abdominal infections. The findings support CT as a valuable tool in acute pediatric care, while underscoring the need for judicious use to minimize radiation exposure.

Keywords: Pediatrics; Computed Tomography; Clinical Audit; Diagnostic Imaging; Radiation Safety

Introduction

Computed tomography (CT) has become an indispensable imaging modality in pediatric medicine due to its rapid acquisition time, high spatial resolution, and broad diagnostic utility. It plays a pivotal role in evaluating acute neurological, thoracic, and abdominal pathologies, especially in emergency settings where timely decision-making is critical [1]. However, the use of CT in children raises concerns regarding radiation safety, as children are more radiosensitive than adults and face a higher lifetime risk of radiation-induced malignancy [2,3]. Balancing diagnostic benefits with radiation hazards remains a pressing challenge in pediatric radiology.

The escalating utilization of computed tomography in pediatric populations has prompted significant discourse regarding the optimization of diagnostic yield against the imperative for radiation safety [4,5]. While pediatric CT offers undeniable diagnostic value, the inherent risks associated with ionizing radiation exposure necessitate rigorous scrutiny of current imaging practices to mitigate long-term health consequences, particularly concerning the elevated lifetime cancer mortality rates in children compared to adults [6,7].

Several international guidelines, including those from the American College of Radiology (ACR) and Royal College of Radiologists (RCR), recommend the judicious use of CT and emphasize adherence to appropriateness criteria [4,8]. Despite these guidelines, overutilization of CT has been reported globally, often due to diagnostic uncertainty, medico-legal concerns, or lack of access to alternative modalities such as MRI or ultrasound [9,10]. In developing regions, this challenge is compounded by resource limitations, inadequate awareness of radiation risks, and insufficient training in appropriate protocols [11].

Pakistan, like many low- and middle-income countries (LMICs), faces unique challenges in pediatric imaging utilization. While CT availability has increased in tertiary centers, there remains a paucity of local audits examining diagnostic yield, referral patterns, and clinical indications. Evidence from regional studies highlights the predominance of neuroimaging referrals in pediatric populations, with trauma, hydrocephalus, and infectious causes being the most frequent indications [12,13]. However, systematic data to benchmark practice against international standards and to assess the balance between diagnostic efficacy and radiation exposure are limited.

This retrospective audit was conducted to evaluate the diagnostic yield, referral patterns, and clinical utility of pediatric CT at a tertiary care hospital in Pakistan. By benchmarking against international guidelines, this study provides region-specific insights into CT utilization, aiming to inform local practice, highlight areas for radiation stewardship, and contribute to the global discourse on optimizing pediatric imaging.

Methodology

This retrospective audit was conducted in the Department of Radiology, Pakistan Institute of Medical Sciences (PIMS), Islamabad, and included all pediatric CT examinations performed during September 2024. Data were retrieved from the Radiology Information System (RIS) and Picture Archiving and Communication System (PACS), cross-checked with referral registers, and analyzed using Microsoft Excel and SPSS (version 26.0). Patients aged 0–12 years were included, while incomplete records, repeat scans for the same indication, and studies performed outside PIMS were excluded. Information on demographics, mode of admission, clinical indication, region scanned, and imaging findings was collected. Findings were categorized as positive or normal, and diagnostic yield was calculated for each indication and anatomical region. The audit was benchmarked against Royal College of Radiologists (RCR) and American College of Radiology (ACR) standards. Ethical approval was obtained from the PIMS Ethical Review Committee, and as anonymized data were used, individual consent was not required.

Results

During the month of September, a total of seventy-two computed tomography (CT) examinations were performed in the pediatric department. The analysis of referral patterns revealed that the outpatient department (OPD) was the leading source of CT requests, accounting for 44 cases (61.1%). Emergency referrals contributed 19 cases (26.4%), while inpatient department (IPD) referrals accounted for the remaining 9 cases (12.5%). This distribution highlights that the majority of CT utilization in pediatric patients arises from elective or semi-elective outpatient evaluations, although urgent and inpatient needs continue to represent a substantial portion of demand (Figure 1).

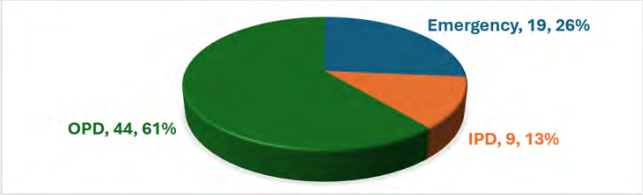

Figure 1: Pie chart showing OPD, Emergency, and IPD distribution out of 72 cases.

With respect to regional distribution, brain imaging dominated, representing 35 of the 72 examinations (48.6%). Abdominal CTs were the second most frequent, performed in 10 patients (13.9%).

High-resolution chest CTs (HRCT) constituted 8 scans (11.1%), while conventional chest CTs accounted for 7 cases (9.7%). Temporal bone imaging was performed in 4 cases (5.6%). Other regions including the neck and paranasal sinuses (PNS) were scanned in 2 cases each (2.8%), while orbit, angiography, spine, and kidney-ureter-bladder (KUB) CTs were performed rarely, with only one case each (1.4%). These findings indicate that nearly half of all pediatric CTs were neuroimaging studies, underscoring the predominance of neurological and trauma-related conditions in pediatric imaging demands (Figure 2).

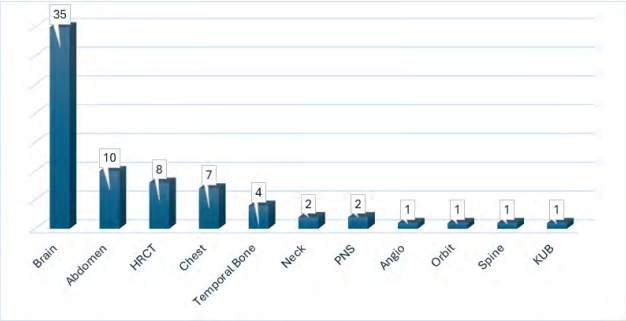

Figure 2: Bar chart depicting frequency of CT scans by anatomical region (N = 72).

The clinical indications for CT varied considerably across regions. Among the 35 brain CTs, trauma was the leading indication, documented in 11 patients (31.4%). Hydrocephalus was identified as the indication in 7 patients (20%), followed by meningitis and seizures (fits) in 5 patients each (14.3%). Two patients (5.7%) were referred for evaluation of headache, while rare indications such as Torch infection, jaundice, delayed milestone, anencephaly, and unspecified causes were observed in single cases. Neck CTs were performed exclusively for cystic hygroma, accounting for both cases (100%). Abdominal CTs most frequently investigated liver abscess, documented in 7 of 10 patients (70%), while the remaining cases evaluated abdominal masses, Wilson's disease, and collections (10% each). Chest CTs were primarily performed for suspected infection in 4 patients (57.1%), whereas anatomical defects and mass lesions accounted for 1 case each. High-resolution chest CTs were largely undertaken for respiratory pathologies, including cystic fibrosis (25%), pneumonia (37.5%), and respiratory distress (37.5%). Temporal bone imaging revealed polypoid changes in 2 patients (50%), tuberculosis in 1 patient (25%), and hearing loss in 1 patient (25%). Other indications included urinary tract infection (KUB CT, 100%), spina bifida (spine CT, 100%), supraorbital lesion (orbit CT, 100%), and angiographic evaluation (100%). This wide diagnostic spectrum illustrates the role of CT as a versatile modality in both acute and chronic pediatric conditions (Figure 3).

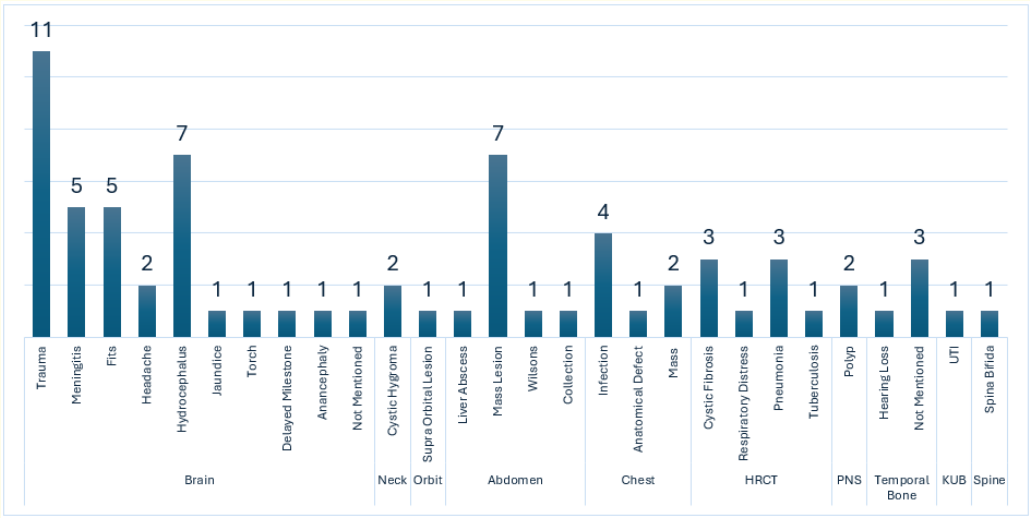

Figure 3: Bar chart outlining region wise diagnostic indications such as trauma, hydrocephalus, meningitis, liver abscess, pneumonia, etc. (N = 72).

The analysis of findings confirmed that CT had a high diagnostic yield. Overall, 56 of the 72 scans (77.8%) demonstrated positive findings, while 16 scans (22.2%) were unremarkable. In brain CTs, hydrocephalus, brain atrophy, and fractures were equally frequent, each diagnosed in 6 patients (17.1%). Post-traumatic sequelae and hemorrhage were noted in 4 patients each (11.4%), while hypoxic ischemic encephalopathy and infection were documented in 2 cases each (5.7%). Five patients (14.3%) demonstrated normal scans. Abdominal CTs were uniformly positive, with abdominal mass lesions observed in 4 patients (40%), hepatic abscess in 2 patients (20%), liver mass in 2 patients (20%), Wilson's disease in 1 patient (10%), and intra-abdominal collection in 1 patient (10%). Chest CTs revealed infectious changes in 2 cases (28.6%) and miscellaneous lesions in 5 cases (71.4%). HRCT demonstrated hydropneumothorax in 2 patients (25%), infectious changes in 2 patients (25%), cystic fibrosis in 1 patient (12.5%), while 3 patients (37.5%) had normal findings. Temporal bone CTs confirmed mastoiditis in 3 patients (75%) and were normal in 1 case. Less frequent findings included Wilms' tumor, cystic hygroma, supraorbital lesions, and spina bifida, each confirmed in the respective indicated cases, as illustrated in figure 4.

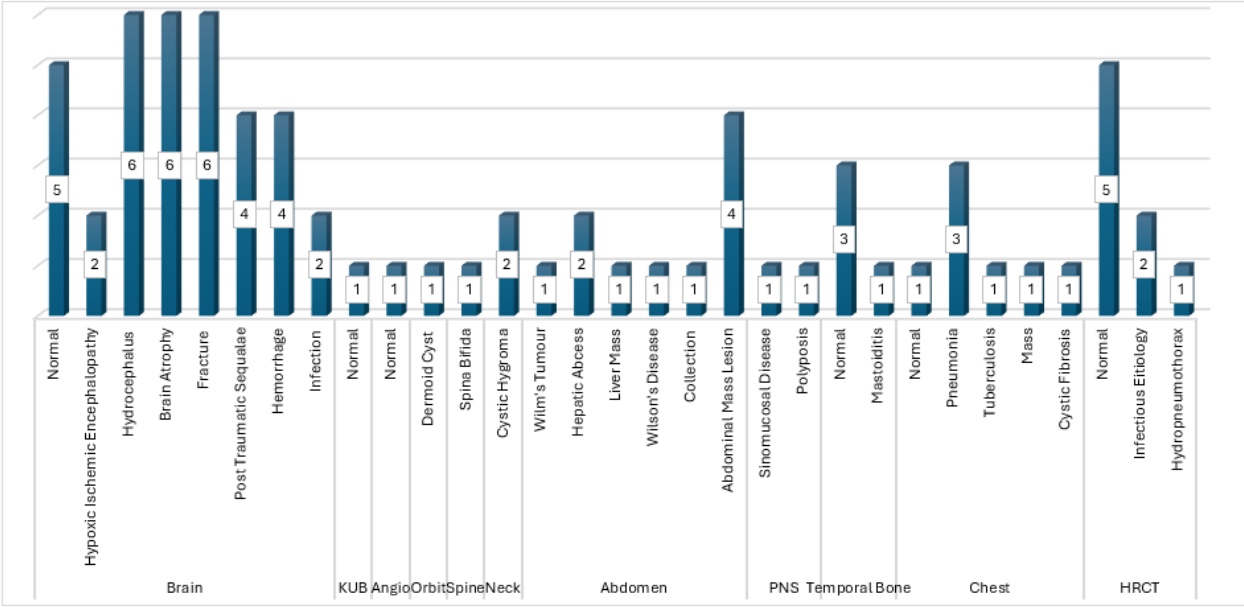

Figure 4: Bar chart summarizing positive diagnostic findings across different anatomical regions (N = 72).

Overall, these findings highlight that pediatric CT in this cohort had a remarkably high diagnostic yield of 78%, particularly for neuroimaging, trauma, and infectious conditions. Brain and abdominal imaging contributed the highest volume and diversity of findings, while less common indications such as cystic hygroma, spina bifida, and orbital lesions maintained strong diagnostic correlation.

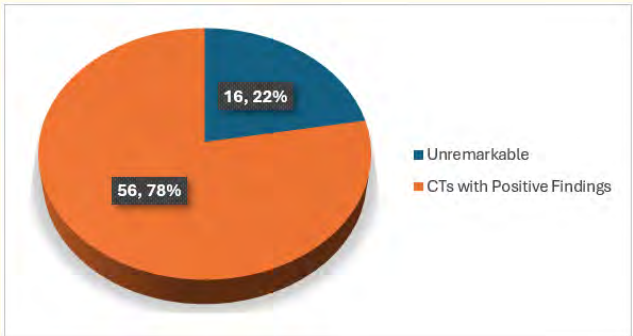

Figure 5: Pie chart showing proportion of CTs with positive findings vs. unremarkable scans (N = 72).

When stratified by region, the diagnostic yield was consistently high. Abdominal, neck, orbital, PNS, and spinal CTs demonstrated a 100% positive yield. Brain CTs were abnormal in 30 of 35 patients (85.7%) and normal in 5 patients (14.3%). HRCT demonstrated abnormalities in 5 of 8 cases (62.5%), while chest CTs were abnormal in 6 of 7 cases (85.7%). Temporal bone scans showed abnormalities in 3 of 4 patients (75%), while angiographic imaging revealed pathology in the single case evaluated. Conversely, the KUB CT performed for urinary tract infection was normal (100% unremarkable), as shown in figure 6.

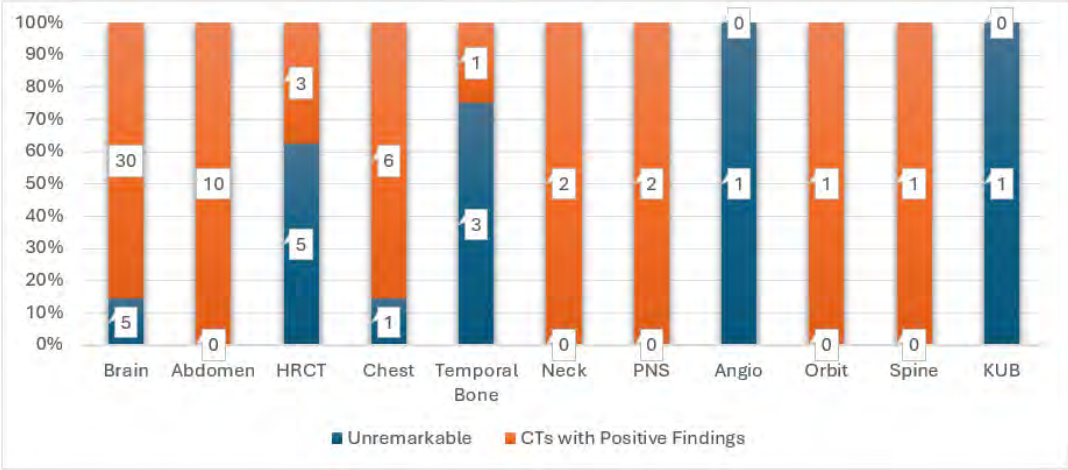

Figure 6: Stacked bar chart illustrating abnormal vs. normal outcomes stratified by region (N = 72).

Cross-tabulation of indications with outcomes further reinforced the diagnostic efficacy of CT. Trauma-related CTs, accounting for 11 patients, demonstrated positive findings in 100%, primarily fractures and post-traumatic sequelae. All 7 hydrocephalus referrals confirmed the diagnosis, yielding a 100% positive rate. Seizure and meningitis referrals showed abnormalities in 80% of cases, with one normal scan each. Liver abscess indications were highly predictive, with 7 of 7 scans (100%) confirming abscess. Respiratory-related indications including pneumonia and distress yielded abnormalities in 83.3% of cases. Temporal bone scans for mastoiditis and polypoid disease had a 75% positive yield. Isolated indications such as cystic hygroma, spina bifida, Wilms tumor, and orbital lesions were uniformly diagnostic, with a 100% yield in each case.

The diagnostic correlation between indications and findings was strong across most categories. All trauma-related CTs (n = 11) demonstrated abnormal findings, primarily fractures (n = 6, 54.5%) and post-traumatic sequelae (n = 4, 36.4%), with one case of intracranial hemorrhage (9.1%). Hydrocephalus indications (n = 7) were fully concordant with imaging, yielding hydrocephalus in 6 patients (85.7%) and hypoxic ischemic encephalopathy in 1 patient (14.3%). Among meningitis referrals (n = 5), three demonstrated hydrocephalus (60%) while two were normal (40%). Seizure-related CTs (n = 5) showed abnormal findings in four patients (80%), including brain atrophy and post-traumatic sequelae, while one scan was normal.

Abdominal CTs for suspected liver abscess (n = 7) showed complete concordance, with 2 scans revealing hepatic abscesses (28.6%) and 5 scans revealing alternative pathologies such as abdominal mass lesions and collections. Similarly, CTs for pneumonia and respiratory distress (n = 6) confirmed disease in 83.3% of cases, with findings of consolidation, cystic fibrosis, or hydropneumothorax. Temporal bone indications (n = 4) correlated with mastoiditis in 3 patients (75%) and were unremarkable in 1 patient (25%). Rare indications such as cystic hygroma, spina bifida, orbital lesion, and Wilms' tumor showed perfect diagnostic correlation (100%).

Indication	No. of CTs (n)	Abnormal Findings	Normal Findings	Diagnostic Yield (%)
Trauma (Brain)	11	Fracture (6), Post-traumatic sequelae (4), Hemorrhage (1)	0	100
Hydrocephalus (Brain)	7	Hydrocephalus (6), HIE (1)	0	100
Meningitis (Brain)	5	Hydrocephalus (3)	2	60
Fits/Seizures (Brain)	5	Brain atrophy (2), Post-traumatic sequelae (2)	1	80
Headache (Brain)	2	Non-specific	1	50
Misc. Neurological (Torch, Jaundice, Anencephaly, Delayed milestone)	4	Atrophy/Developmental anomalies (3)	1	75
Liver Abscess (Abdomen)	7	Hepatic abscess (2), Abdominal mass (3), Collection (2)	0	100
Abdominal Mass (Abdomen)	1	Abdominal mass lesion (1)	0	100
Wilson's Disease (Abdomen)	1	Wilson's changes (1)	0	100
Collection (Abdomen)	1	Intra-abdominal collection (1)	0	100
Infection (Chest)	4	Consolidation/infection (4)	0	100
Anatomical Defect (Chest)	1	Structural defect (1)	0	100
Mass (Chest)	1	Chest mass (1)	0	100
Misc. (Chest)	1	Nonspecific	0	100
Pneumonia/Respiratory Distress (HRCT)	6	Pneumonia (3), Hydropneumothorax (2)	1	83.3
Cystic Fibrosis (HRCT)	2	CF findings (2)	0	100
Temporal Bone (Polyp, TB, Hearing loss)	4	Mastoiditis (3)	1	75
Cystic Hygroma (Neck)	2	Cystic hygroma (2)	0	100
Supraorbital Lesion (Orbit)	1	Lesion confirmed (1)	0	100
UTI (KUB)	1	0	1	0
Spina Bifida (Spine)	1	Spinal defect (1)	0	100
Wilms' Tumor (Abdomen)	1	Tumor (1)	0	100

Table 1: Cross-tabulation of Indications vs. CT Findings in Pediatric Patients (N = 72).

The cross-tabulated analysis demonstrated a strong diagnostic correlation between clinical indications and radiological findings. Indications such as trauma, hydrocephalus, liver abscess, cystic hygroma, Wilms' tumor, and orbital lesions achieved 100% diagnostic yield, confirming the robustness of CT for these conditions. Meningitis, seizures, and headache showed lower yields, reflecting the possibility of normal scans despite clinical suspicion. Respiratory indications demonstrated high but not absolute correlation, with pneumonia and distress cases yielding pathology in 83.3% of patients. Overall, this cross-tabulation confirms that pediatric CT has both high diagnostic utility and strong predictive correlation with clinical indications.

Discussion

This retrospective audit demonstrates a high diagnostic yield of pediatric computed tomography (CT), with 78% of scans showing positive findings. The strongest diagnostic concordance was observed in trauma, hydrocephalus, and abdominal infections, while lower yields were seen in meningitis, seizures, and headache. These findings are in line with recent international studies which highlight that CT remains a frontline modality in acute pediatric care but is frequently overutilized in lower-yield indications [1,12].

High-yield indications such as trauma and hydrocephalus exhibited near-perfect diagnostic accuracy in this audit. All trauma-related CTs showed abnormal findings, underscoring CT's pivotal role in detecting fractures, hemorrhage, and post-traumatic sequelae. Similar results have been reported in multicenter audits where CT was indispensable for acute neurotrauma evaluation, with diagnostic accuracy exceeding 95% [8]. Hydrocephalus referrals also demonstrated a 100% positive yield, consistent with reports that CT rapidly identifies ventricular dilatation and complications, guiding urgent neurosurgical intervention [4]. Abdominal CTs, particularly for liver abscess, were uniformly positive, reflecting South Asian data on the burden of pediatric infectious pathology [2].

Lower-yield indications were observed in seizure, meningitis, and headache evaluations, where 20–40% of CTs were normal. This mirrors global patterns indicating that MRI offers greater sensitivity for parenchymal and infectious central nervous system diseases [13]. A recent systematic review reported that up to 60% of CTs for pediatric headache revealed no significant abnormalities, questioning their appropriateness outside of red-flag clinical scenarios [12]. Similarly, CT for seizures often fails to detect etiologies that MRI subsequently reveals, supporting the preferential use of non-ionizing modalities in such contexts [13].

Radiation safety is a critical issue in pediatric imaging. Children are several times more radiosensitive than adults, and cumulative CT exposure has been linked to increased cancer risks. Large-scale cohort studies confirm that pediatric CT is associated with elevated risks of brain, thyroid, and hematologic malignancies, with hazard ratios ranging between 1.07 and 1.29 depending on dose and organ site [14]. Modeling analyses from the United States estimated that CT utilization in 2023 could lead to ~103,000 future cancers, with children bearing disproportionately higher per-scan risks [15]. These findings reinforce the importance of adhering to the ALARA principle and international safety campaigns such as "Image Gently" [1].

Policy implications arise from the observation that most referrals in this audit originated from outpatient departments, suggesting an expanding role of CT beyond emergencies. While improved access is welcome, it also raises concerns about overutilization. Comparable audits in South Africa and Sweden highlight similar trends, showing that 20–30% of pediatric CTs fail appropriateness criteria [9,10]. For LMICs like Pakistan, where MRI availability is limited, these findings emphasize the need for structured imaging pathways, appropriateness checklists, and clinician education on radiation risks [16,17].

Study limitations include its single-center and short-duration design, as well as the lack of radiation dose metrics. These constraints limit generalizability, although the strong diagnostic correlation observed across several indications strengthens the study's internal validity.

Future directions should include multicenter audits with larger cohorts, prospective dose tracking, and the use of decision-support tools such as ACR Appropriateness Criteria embedded into ordering systems. Artificial intelligence-driven models for appropriateness checking and ultra-low-dose CT protocols may also enhance diagnostic efficiency while reducing radiation exposure [6]. Long-term follow-up studies to assess health outcomes would provide further insights into the balance between diagnostic benefit and radiation risk.

Conclusion

Trauma, hydrocephalus, and infectious conditions such as liver abscess were the leading indications, and the overall diagnostic yield was high at 78%, with abdominal and neurological CTs showing the greatest utility. Strong concordance between indication and findings was observed in trauma, hydrocephalus, and liver abscess, while lower yields in seizures, meningitis, and headache suggest the need for alternative modalities such as MRI or ultrasound. These results highlight both the diagnostic value of CT in acute pediatric care and the importance of appropriateness criteria, radiation safety, and adherence to international guidelines. Future audits incorporating multicenter data and radiation dose metrics are recommended to enhance generalizability and benchmark practice against reference standards.

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