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Overuse of head CT scans in non-traumatic paediatric cases in the West Bank, Palestine: a cross-sectional study

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ABSTRACT

Background Overuse of CT scans is associated with multiple harms, such as an increased risk of cancer development, particularly in children. However, the rate of CT scan use is high and unwarranted worldwide.

Objectives This study aimed to identify the patterns and reported indications for head CT scans ordered for non-traumatic paediatric cases in Palestine.

Design This was a retrospective, cross-sectional study based on a desk review.

Setting The study was carried out from June 2024 to September 2024 in five hospitals located in five major Palestinian governorates in the West Bank.

Participants The study included records of children aged 14 or younger, presenting with non-traumatic complaints and having undergone head CT between January 2020 and September 2024. A total of 3715 patient records were explored, of which 2977 were included in the final analysis; 1764 (59.3%) males and 1213 (40.7%) females.

Primary and secondary outcome measures A pilot review of 100 records was conducted, and the data collection spreadsheet included demographic and clinical characteristics, presentations, reported reasons for CT requests, CT results, and information on lumbar puncture (LP) performance.

Results The mean age of patients was 4.3 years (SD±3.3), with 59.3% aged 3 to 11 years, and 47.7% presenting to hospitals in northern governorates. The most commonly reported presentation was fever and convulsion (8.2%), followed by convulsions (7.7%), and a combination of fever, headache and vomiting (6.5%). Only 12.9% of the CT scans yielded positive findings, including dilated ventricles (19.3%), sinusitis (18.8%), brain oedema (12.9%), and brain mass (11.1%). Most CT scans were requested to check for contraindications to LP, with only 4.1% having a positive CT finding indicating a contraindication. At the multivariate level, a positive CT result was associated with being a neonate, having a past medical condition, ordering CT to check for contraindication to LP and presenting with convulsions.

Conclusions CT scans were found to be overused without justification, particularly for ruling out contraindications to LP. The development of clear and specific national guidelines is recommended. This process can be supported through training, decision support tools, alternative management pathways and specialist consultations to ensure compliance. Additionally, enhancing reporting quality and using health information systems are vital for monitoring and improving radiological safety.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Included a large pediatric sample from five West Bank hospitals.
- ⇒ Multi-year retrospective design enabled trend analysis.
- ⇒ Findings reflect real-world documentation practices.
- ⇒ Free-text data entry by physicians introduced variability and limited the consistency of clinical information.
- ⇒ The retrospective and subjective nature of some medical records limited the ability to verify data accuracy.

BACKGROUND

Although the advances in health technologies using ionising radiation have substantially improved the diagnosis of human diseases, inappropriate use poses potential health risks to patients and healthcare workers alike.[1] CT is among the most widely used medical tests that cause radiation exposure. Direct radiation effects may result from contrast injection, ranging from mild symptoms, such as nausea, abdominal pain and vomiting, to more serious outcomes, including contrast material-induced allergic reactions and acute kidney injury.[2] Additionally, direct radiation damage can lead to tissue injuries, commonly affecting the skin and lens of the eye, resulting in the development of cataracts[3] and skin pigmentation and atrophy.[4] Moreover, exposure to ionising radiation may lead to cell death or DNA mutations. Genetic mutations develop when the cell fails to repair the damage through apoptosis, increasing the risk of cancer.[5] Notably, CT demonstrates a dose-response oncogenic effect.[6] This is especially relevant to children as a vulnerable age group due to the high risk of cancer development resulting from susceptibility to growing body tissues and having a smaller body size and longer life span than adults, allowing for a long induction period for cancer development.[7 8]

The International Commission on Radiological Protection introduced the principles of 'justification, optimisation and dose limitation' in 1977 to mitigate the health risks associated with radiation exposure (1). The principle of justification requires that radiation exposure be justified based on the associated risks and benefits.[9]

Despite its merits, the use of CT scans remains high and frequently unwarranted worldwide.[10–16] Saran *et al* identified a global trend of CT overuse in cases of mild head injuries, with rates ranging from 10% to 72%.[11] Another review reported that pooled rates of CT overuse for paediatric and adult patients were 27% and 32%, respectively.[17] The frequency of CT scan requests is higher in Asia and Africa than in Europe,[18] which is part of a broader trend where the overuse of radiological tests is greater in low-income and middle-income countries despite limited resources.[19] CT scans account for a substantial radiation exposure compared with other radiological tests, partly due to overuse. For example, nearly 68% of the collective radiation dose in the UK is attributable to CT scans.[20] Overusing CT scans has been ascribed to several reasons, including fear of malpractice litigation, insufficient guideline development and adherence, and a CT preference over alternative imaging tests.[21–23] More specifically, head CT scans are the most requested type of CT for paediatric patients, yet most head CT results are normal.[16 24] One study revealed that approximately 75% of the requested CT scans showed normal findings.[16]

In Palestine, research on the pattern of CT use is scarce. A study examined CT scan ordering practices, reporting unwarranted patterns of CT requests for emergency indications.[25] Another single-centre study conducted in Gaza found that most requested head CT scans lacked documentation of medical history and physical examination, with over 58% yielding normal results.[26] These studies were either limited to adult populations, included both traumatic and non-traumatic cases presenting just during evening and night shifts, or were conducted only in the Gaza Strip. This is in addition to another unpublished study that investigated abdominal and pelvic CT and reported a high rate of unjustified requests.[27] However, none of these previous studies have explored head CT requests for non-traumatic paediatric cases. Therefore, the present study aimed to describe the pattern of head CT scans requested for non-traumatic paediatric cases, including physician-reported reasons for requesting head CT scans, patient presentations and the rate of head CT scans requested to check for contraindications to lumbar puncture (LP). By describing the patterns of head CT use for the vulnerable paediatric age groups, this study can inform the design and implementation of interventions and guidelines to reduce radiation exposures, risks and costs associated with potential CT overuse.

METHODS

Study design and settings

This was a retrospective, cross-sectional study based on desk review. It was conducted from June 2024 to September 2024 in five major hospitals in five central Palestinian governorates in the West Bank: three in the north, one in the middle and one in the south. The population distribution in the West Bank is uneven, with the largest population in the north. Approximately 40% of the Palestinians in the West Bank reside in the northern region, particularly in major cities such as Nablus, Jenin and Tulkarem. Nearly one-third of Palestinians live in the central region, which includes places such as Ramallah and al-Bireh. The southern region, which encompasses Hebron and Bethlehem, is home to the remaining population.[28] The Strengthening the Reporting of Observational Studies in Epidemiology statement was adopted to report the research study.[29]

Population and inclusion and exclusion criteria

The records of paediatric patients aged 14 years or younger who presented to one of the five included hospitals with non-traumatic complaints and underwent a head CT scan were eligible for inclusion. The inclusion criteria were limited to 14 years old because this is the threshold of the paediatric age group under which a patient is considered a paediatric case in Palestinian governmental hospitals. Records reporting inaccurate diagnoses, symptoms and indications were excluded, and other ambiguous yet interpretable records were discussed among the researchers and reported accordingly. Records were excluded in the following cases: the documented diagnosis does not meet the study inclusion criteria (eg, a case with a history of traumatic injury but listed as a non-trauma case), all recorded symptoms were unrelated to CT use and lacked a relevant indication, or the CT indication falls outside the scope of non-traumatic assessment (such as preoperative planning). The study was limited to government hospitals because they serve as the primary healthcare provider for most of the population, making the findings more generalisable to the broader public healthcare system. Furthermore, governmental hospitals employ a specific health information system (HIS) and serve a population with specific characteristics. Therefore, excluding nongovernmental health facilities helps ensure consistency in data and context, which is vital for developing actionable, context-specific recommendations. A comprehensive sampling method was used to review all accessible records from the five hospitals. Permission to access those records was obtained from the Palestinian Ministry of Health (PMOH).

Primary and secondary outcomes

Data were collected from all records of potentially eligible patients who underwent head CT between January 2020 and September 2024. Admission, progress and radiological reports were reviewed to collect comprehensive data. An Excel spreadsheet containing all demographic and clinical variables was prepared for data collection. A pilot review of 100 records was conducted to ensure accurate and consistent data collection among researchers, including a unified approach to dealing with missing data and case exclusion. Additionally, a cross-checking criterion was developed to enhance accuracy and minimise bias related to data collection.

Data were collected for the following variables: age, both as a quantitative variable and categorical variable classified according to the National Institute of Child Health and Human Development classification with several modifications (<1 month as neonate; 1 month to 12 months as infant; 13 months to 2 years as toddler; 3 to 11 years as older child; and >11 years as adolescent)[30]; sex (male or female); hospital site (northern, middle or southern governorates); past medical condition(s); having a history of repeat CT in the current admission (yes/no); having a history of X-ray in the current admission (yes/no); having a history of at least one CT in a previous admission (yes/no); having a history of at least one X-ray in a previous admission (yes/no); having a history of prior exposure to medical ionising radiation (yes/no); symptom combination (each value included a maximum of three symptoms with which a patient presented to the hospital); type of CT (contrast or without contrast); CT positivity (positive or negative); CT results (if CT was positive); number of repeat CT within the same admission (quantitative variable); whether the CT was requested to exclude contraindications to LP (yes/no); decision made regarding LP after ruling out contraindications (eg, performed, not performed due to unknown reason or failed); and LP result (eg, meningitis or encephalitis). The values of variables were reported as recorded by physicians where relevant, as physicians' reporting patterns may have implications for public health practices, such as provider competence in using HIS.

Data analysis

Microsoft Excel was used to insert the data, which were then imported to the Statistical Package for the Social Sciences software (SPSS V.25, IBM) for data analysis. A complete case analysis was adopted by excluding cases with missing data from the final analysis. Descriptive and inferential statistics were employed to analyse the data. Frequencies and percentages were reported for categorical variables. The mean and SD were reported for age. At the bivariate level, the χ^2 test was used to test the differences between groups regarding CT positivity. A $p<0.05$ was selected to indicate statistical significance. These multiple subgroup comparisons using demographic, clinical and imaging-history variables aim to provide exploratory insights to identify associations for further investigation. False discovery rate (FDR) correction via the Benjamini-Hochberg procedure was employed to adjust for potential inflated associations caused by multiple comparisons, with FDR-adjusted p values indicating the expected rate of false positives among significant findings. Associations with an FDR-adjusted p value less than 0.05 were considered statistically significant. FDR correction was chosen because the study sought to explore a large set of potential associations with a positive CT result for future focused follow-up. At the multivariate level, a binary logistic regression model included variables that showed statistical significance at the bivariate level.

Patient and public involvement

In this study examining the overuse of head CT scans in non-traumatic paediatric cases, patient and public involvement was limited due to the retrospective nature of the research. While feedback from healthcare practitioners highlighted concerns about unnecessary radiation exposure, patients and the public were not directly involved in formulating research questions, study design or outcome measures.

RESULTS

Of the total 3715 patient records explored, 738 were excluded, with an exclusion rate of 20%. The final sample consisted of 2977 patient records. The most common reason for exclusion was trauma (77.6%), followed by a duplicated CT order (9.4%); considerable missing data following hospital admission (10.3%); ordered but unperformed CT imaging (1.7%) and ordered but a failed attempt of CT imaging (1%).

The average age of the participants was 4.3 years (SD±3.3). The majority of patients were older children (59.3%), followed by toddlers (25.2%), infants (10.4%) and adolescents (2.8%). Males comprised 59.3% and females comprised 40.7% of the final sample. Nearly one-half of the included records were extracted from hospitals located in northern governorates (47.7%), whereas the rest were in southern governorates (43.2%) and middle governorates (9.1%). A proportion of 9.5% had a repeated head CT request in the same admission, and 17.9% had at least one X-ray request in the same admission. Most patients had a history of prior exposure to medical ionising radiation (74.0%). Only 12.1% had a documented past medical condition. Among those, the most commonly reported condition was hydrocephalus needing a ventriculoperitoneal shunt (24.6%), followed by epilepsy (10.2%), unspecified seizure disorder (7.7%) and cardiac disease (7.2%) (see table 1).

Clinical presentation and CT scan findings

The most common combination of symptoms with which patients presented was fever and convulsion (8.2%), followed by convulsions only (7.7%); fever, headache and vomiting (6.5%); headache only (5.1%) and fever only (5.1%) (see table 2). Most patients underwent a CT scan without contrast (96.9%), while the rest underwent CT with contrast (3.1%). Only 12.9% of performed CT scans showed positive findings. The most common finding was dilated ventricles (19.3%), followed by sinusitis (18.8%), brain oedema (12.9%), brain mass (11.1%), mastoiditis (8.2%) and low-set tonsils (5.5%).

Table 1 The demographic and clinical characteristics of the sample	
Variable	**n (%)**
Age (years)	
Neonate	69 (2.3)
Infant	310 (10.4)
Toddler	751 (25.2)
Older child	1765 (59.3)
Adolescent	82 (2.8)
Sex	
Male	1764 (59.3)
Female	1213 (40.7)
Hospital site	
North governorates	1421 (47.7)
Middle governorates	271 (9.1)
Southern governorates	1285 (43.2)
Past medical condition(s)	
Yes	361 (12.1)
No	2616 (87.9)
Repeat CT scan in the same admission	
Yes	282 (9.5)
No	2695 (90.5)
Having a history of at least one X-ray in the same admission	
Yes	533 (17.9)
No	2444 (82.1)
Having a history of at least one CT in a previous admission	
Yes	833 (28.0)
No	2144 (72.0)
Having a history of at least one X-ray in a previous admission	
Yes	2038 (68.5)
No	939 (31.5)
Having a history of CT and/or X-ray in a previous admission	
Yes	2204 (74.0)
No	773 (26.0)

CT and LP

Nearly two-thirds of the CT scans were requested to check for possible contraindications to LP before performing the procedure (67.1%). Of those, only a tiny minority had a positive CT finding, constituting a contraindication to LP (4.1%). In contrast, other minorities did not undergo LP for non-medical reasons, such as absence of reported reason (6.7%), LP refused by parents (3.6%) or a failed attempt of LP (3.5%). Only 25.8% of performed LP cases had positive cerebrospinal fluid findings, with the vast majority diagnosed with meningitis or partially treated meningitis (90%) (see table 3).

Table 2 Most common presenting symptoms

Symptom combination	n (%)
Fever, vomiting and lethargy	93 (3.1)
Fever, headache and vomiting	194 (6.5)
Fever, headache and photophobia	69 (2.3)
Fever, headache and lethargy	57 (1.9)
Fever and lethargy	95 (3.2)
Fever and vomiting	93 (3.1)
Fever and convulsion	244 (8.2)
Fever and headache	76 (2.6)
Headache only	152 (5.1)
Fever only	152 (5.1)
Convulsion only	229 (7.7)
Gait disturbance only	90 (3.0)
Slurred speech only	84 (2.8)
Rash only	75 (2.5)
Lethargy only	72 (2.4)
Vomiting only	64 (2.1)
Dysuria only	45 (1.5)
Fever and cough	61 (2.0)
Weakness only	60 (2.0)
Loss of consciousness only	45 (1.5)
Other combination	934 (31.4)

The symptom combinations were reported as written in records.

Association between CT positivity and other demographic and clinical variables

After correction for multiple comparisons, a positive CT result was associated with age (p<0.001), being a neonate

Table 3 Reported results of performed CT scans

CT results	n (%)
Dilated ventricles	74 (2.5)
Sinusitis	72 (2.4)
Brain oedema	49 (1.6)
Brain mass	43 (1.4)
Mastoiditis	31 (1.0)
Low-set tonsils	21 (0.7)
Cellulitis	15 (0.5)
Hypodensity	11 (0.4)
Congenital anomaly	10 (0.3)
Brain atrophy	7 (0.2)
Brain cyst	7 (0.2)
Other diagnoses	40 (1.3)
Results not reported	2597 (87.2)
Total scanned	2977 (100.0)

The CT results were reported as written in records.

(p<0.001), hospital site (p=0.030), having a past medical condition (p<0.001), ordering CT before LP (p<0.001), repeated CT scan in the same admission (p<0.001), having a history of CT in a previous admission (p<0.001) and presenting with febrile convulsion (p<0.001), fever (p<0.001) and convulsions (p=0.028). All other variables did not show statistical significance with having a positive CT, including sex (p=0.635), having a history of X-ray in the same admission (p=0.408), X-ray in a previous admission (p=0.965), or prior exposure to medical ionising radiation (p=0.365), and presenting with headache (p=0.965), vomiting (p=0.590), weakness (p=0.139), loss of consciousness (p=0.966), lethargy (p=0.617), and photophobia (p=0.054). At the multivariate level, a positive CT result remained significantly associated with being a neonate (p=0.037), having a past medical condition (p=0.013), ordering CT before LP (p<0.001), and presenting with convulsions (p=0.005) (see table 4).

DISCUSSION

Overuse of ionising radiation modalities, such as CT, may lead to potential harms, such as contrast-induced injuries and allergies, direct damage to body tissues and increased cancer risk, especially in children. The global rate of CT scan use is high and unjustified, particularly in low-resource settings.[18] This study aimed to describe the patterns and reasons for performing CT scans on non-traumatic paediatric cases in the West Bank, Palestine. A minority of CT scans yielded positive results, with the most reported findings being dilated ventricles, sinusitis and brain oedema. Most CT scans were requested to check for a contraindication to LP, yet only 4.1% showed a radiologically confirmed contraindication. Positive CT findings were significantly associated with being a neonate, having a past medical condition, ordering CT to check for contraindication to LP and presenting with convulsions.

This study revealed that just 12.9% of requested CT scans yielded positive findings. While the absence of clinical guidelines might provide justifications and complicate judgments of appropriateness, most CT scans were requested to rule out contraindications to LP; however, the vast majority revealed non-serious diagnoses that did not justify the initial requests. Although diagnostic yield is not a definitive measure of overuse, the combination of a lack of justifications and low yield suggests potential overuse. Supporting data on the total number of children presenting with conditions potentially warranting CT are unavailable, limiting stronger conclusions about appropriateness. This reflects a broader methodological problem, as definitions of CT overuse are unstandardised, particularly in health systems lacking guidelines. A systematic review highlighted this definitional heterogeneity of CT overuse, which included duplicated scans and unnecessary, inappropriate or defensive imaging.[31] Therefore, the findings of this study should be viewed considering this methodological limitation, suggesting potential overuse rather than definitive proof and highlighting the need for clinical decision rules to guide practice.

The patterns revealed by the present study align with previous local and regional studies.[25 27] In a local study by Nazzal *et al*, nearly half of the CT scans ordered for adult patients were unjustified and lacked adherence to any guidelines.[25] Similar patterns have been reported across health systems in the region.[32] A study conducted in Bahrain found that only 12.1% of CT scans for minor head injury were positive, and 22.6% of CTs were overused according to Canadian guidelines.[33] In Iran, 37% of CT scans for minor head injury lacked clinical indication, with only 13.5% showing positive findings.[34] Moreover, overuse of CT, particularly to check for a contraindication to LP, is common globally.[10–16] In one study in the USA, 80% of patients with suspected meningitis underwent CT before LP.[35] Other studies conducted in the Netherlands and the UK found that most physicians request non-indicated head CTs, even when neuroimaging guidelines were in place.[32 36]

The overuse of CT scans before LP has been a matter of debate, with a trend favouring reduction in CT use. For example, some previously published CT indications were removed in an update of the national Swedish guidelines, which was later found to be associated with better outcomes.[37] Several arguments were deployed against ordering CT before LP, including increased cancer risks, unnecessary costs and ensuing delays in treating conditions such as meningitis.[38 39] CT scans before LP have been found to increase admission-to-LP time and delay antibiotic administration.[35 37 40] For instance, one study reported that CT before LP increased waiting time by an average of 2 hours and 20 min.[40] Moreover, CT may fail to detect contraindications to LP and complications may occur despite a normal CT. A study reported that 36% of paediatric brain herniation cases had a normal CT scan.[41] On the other hand, clinical evaluation is more reliable in detecting these contraindications, as one study revealed that all positive CT abnormalities were suspected by clinical evaluation of meningitis.[42] Furthermore, even in high-income countries, neuroimaging is associated with substantial costs.[43 44] This may exacerbate health inequalities in Palestine, where the low-resource healthcare system often requires user fees for CT requests.[45–48]

The reasons for CT overuse in non-traumatic cases may vary by individual perceptions, healthcare settings and cultural factors.[21–23] These reasons include fear of malpractice litigation, lack of guidelines, in addition to patient expectations, anxiety and trust.[21–23 49] In the Palestinian context, the absence of clear guidelines contributes to CT overuse by leaving providers without standardised decision criteria. This is compounded by a fear of legal repercussions, especially when diagnostic uncertainty and cultural expectations for imaging are present.

In 2018, the PMOH published clinical protocols for radiological tests, developed based on consultation, utilisation data and the capacity of healthcare providers. However, these protocols included well-known indications

Table 4 Associations between a positive CT result and other demographic and clinical variables

	Characteristic	Positive CT n (%)	Negative CT n (%)	Total n (%)	Unadjusted p value	FDR adjusted p value	Multivariate analysis (p value)
Age (years)	Neonate	23 (33.3)	46 (66.7)	69 (2.3)	<0.001*	<0.001*	0.671
	Infant	52 (16.8)	258 (83.2)	310 (10.4)			
	Toddler	79 (10.5)	672 (89.5)	751 (25.2)			
	Older child	211 (12.0)	1554 (88.0)	1765 (59.3)			
	Adolescent	15 (18.3)	67 (81.7)	82 (2.8)			
Does the patient belong to the neonate age group?	Yes	24 (33.8)	47 (66.2)	71 (2.4)	<0.001*	<0.001*	0.037
	No	356 (12.3)	2250 (87.7)	2906 (97.6)			
Sex	Female	149 (12.3)	1064 (87.7)	1213 (40.7)	0.514	0.635	–
	Male	231 (13.1)	1533 (86.9)	1764 (59.3)			
Hospital site	North governorates	155 (10.9)	1266 (89.1)	1412 (47.7)	0.014*	0.030*	0.380
	Middle governorates	38 (14.0)	233 (86.0)	271 (9.1)			
	Southern governorates	187 (14.6)	1098 (85.4)	1285 (43.2)			
Having a past medical condition	Yes	80 (21.9)	286 (78.1)	366 (12.3)	<0.001*	<0.001*	0.013
	No	303 (11.6)	2308 (88.4)	2611 (87.7)			
Was CT requested to exclude contraindications to lumbar puncture (LP)?	Yes	171 (8.6)	1827 (91.4)	1998 (67.1)	<0.001*	<0.001*	<0.001*
	No	209 (21.3)	770 (78.7)	979 (32.9)			
Repeat CT scan in the same admission	Yes	75 (26.6)	207 (86.6)	282 (9.5)	<0.001*	<0.001*	0.176
	No	305 (11.3)	2390 (88.7)	2695 (90.5)			
Having a history of at least one X-ray in the same admission	Yes	79 (14.8)	454 (85.2)	533 (17.9)	0.272	0.408	–
	No	301 (12.3)	2142 (87.7)	2443 (82.1)			
Having a history of at least one CT in a previous admission	Yes	253 (18.4)	680 (81.6)	833 (28.0)	<0.001*	<0.001*	0.668
	No	277 (10.6)	1917 (89.4)	2144 (72.0)			
Having a history of at least one X-ray in a previous admission	Yes	261 (12.8)	1777 (87.2)	2038 (68.5)	0.919	0.965	–
	No	119 (12.7)	820 (87.3)	939 (31.5)			
Having a history of prior exposure to medical ionising radiation	Yes	291 (13.2)	1913 (86.8)	2204 (74.0)	0.226	0.365	–
	No	89 (11.5)	684 (88.5)	773 (26.0)			

Continued

Table 4 Continued

	Characteristic	Positive CT n (%)	Negative CT n (%)	Total n (%)	Unadjusted p value	FDR adjusted p value	Multivariate analysis (p value)
Presenting with febrile convulsion	Yes	365 (13.4)	233 (94.0)	248 (8.3)	0.001*	0.001*	0.114
	No	365 (13.4)	2364 (86.6)	2729 (91.7)			
Presenting with headache	Yes	85 (12.9)	575 (87.1)	660 (22.2)	0.921	0.965	–
	No	295 (12.7)	2022 (87.3)	2317 (77.8)			
Presenting with fever	Yes	195 (10.0)	1748 (90.0)	1943 (65.3)	<0.001*	<0.001*	0.453
	No	185 (17.9)	849 (82.1)	1034 (34.7)			
Presenting with convulsions	Yes	87 (10.3)	756 (89.7)	843 (28.3)	0.012*	0.028*	0.005
	No	293 (13.7)	1841 (86.3)	2134 (71.7)			
Presenting with vomiting	Yes	97 (12.0)	714 (88.0)	811 (27.2)	0.421	0.590	–
	No	283 (13.1)	1883 (86.9)	2166 (72.8)			
Presenting with loss of consciousness	Yes	15 (12.3)	107 (87.7)	122 (4.1)	0.874	0.966	–
	No	365 (12.8)	2490 (87.2)	2855 (95.5)			
Presenting with weakness	Yes	4 (5.8)	65 (94.2)	69 (2.3)	0.079	0.139	–
	No	376 (12.9)	2532 (87.1)	2908 (97.7)			
Presenting with neck stiffness	Yes	10 (13.7)	63 (86.3)	73 (2.5)	0.809	0.943	–
	No	370 (12.7)	2534 (87.3)	2904 (97.5)			
Presenting with lethargy	Yes	74 (13.7)	466 (86.3)	540 (18.1)	0.470	0.617	–
	No	306 (12.6)	2131 (87.4)	2437 (81.9)			
Presenting with photophobia	Yes	10 (6.8)	136 (93.2)	146 (4.9)	0.028*	0.054	–
	No	370 (13.1)	2461 (86.9)	2831 (95.1)			

FDR correction via the Benjamini-Hochberg procedure was used to adjust for potential inflated associations resulting from multiple comparisons.
Variables in the multivariate regression model: age, being a neonate, hospital site, having a past medical condition, ordering CT before LP, repeated CT scan in the same admission, having a history of CT in a previous admission and presenting with febrile convulsion, fever and convulsions.

*P value is below the predetermined level of statistical significance (<0.05).
FDR, false discovery rate; LP, lumbar puncture.

for CT, addressed clinical scenarios in non-emergency contexts, or were undetailed and unspecific to cases and age groups.[50] For acute head injury, for example, these guidelines succinctly state that a CT scan must be requested only to 'rule out an associated acute cerebral condition' without providing further details.[50] Developing clear, detailed, evidence-based guidelines and clinical decision tools specific to different age groups and clinical cases is recommended, especially for paediatric neuroimaging. This should consider local epidemiology, resource availability and healthcare system capacities, and be informed by established guidelines from reputable organisations, such as the European Society of Clinical Microbiology and Infectious Diseases and the Infectious Diseases Society of America. Both guidelines state that head CT should be performed in patients beyond the neonatal period only if certain abnormalities are detected on clinical assessment.[51 52] However, these guidelines relied more on studies conducted among adults, which highlights the need for more research targeting children. Moreover, implementation should include clinician training sessions and the integration of decision support tools. Additional steps, such as expanding access to alternative diagnostic methods and clinical observation pathways, can also help reduce CT overuse. Promoting specialist consultation for CT orders is also an effective way to limit CT use.[53] Above all, national monitoring policies with benchmarks and audits are essential to ensure adherence, especially given the poor adherence to neuroimaging guidelines even in high-income settings.[32 36] In addition, a prospective, physician-targeting, follow-up study may provide insights into ordering behaviours to better inform policy making and guidelines development.

Additionally, this study revealed that physicians sometimes use free text reporting instead of formal clinical coding. For example, fever and convulsions were either reported separately or listed as 'febrile convulsions', leading to the possible use of two reporting forms often referring to the same clinical condition. Similarly, 'epilepsy' and 'unspecified seizure disorder' were used in multiple instances. Clinical coding streamlines healthcare processes, enhances communication of health information, improves healthcare management, reduces medical errors and facilitates research, audits and data analysis.[54–57] The Palestinian healthcare system has made substantial progress by introducing HIS in lieu of paper-based reporting despite multiple challenges, including scarce financial resources, difficulties in using new technologies and suboptimal terminology and interoperability.[58 59] Moreover, health services in Palestine are provided by four parallel health systems, each using a different HIS, limiting inter-system exchange of health information.[60] Improving standardisation and interoperability of HIS can improve data quality, research capacity and monitoring.

This study has several limitations, mainly related to information bias caused by inaccurate, missing or inconsistent data. Physicians often used subjective terminology in free-text reports, which led to variability in record accuracy. Missing data could not be obtained from alternative sources, frequently necessitating exclusion. Retrospective studies are inherently prone to information bias because the data were not originally collected for research purposes, which limits the ability to verify data accuracy and quality, thereby affecting validity and reliability. The lack of physician interviews further restricted the exploration of decision-making processes, workflow challenges and perceptions of appropriateness. Further, the study did not include those who were considered for neurological investigation but for whom CT was not requested, precluding the calculation of the overall CT utilisation rate as a potential indicator of appropriateness. Although the study included five major hospitals across the West Bank, the exclusion of several other hospitals, especially in the south, may affect the generalisability.[61] However, these five hospitals provide a substantial proportion of paediatric services, covering major Palestinian cities and ensuring a wide geographic representation. Additionally, this is, by far, the most extensive study examining practical radiation safety locally and among the largest in the region.

CONCLUSIONS

CT scans are commonly requested without sufficient justification, although ionising radiation modalities may pose acute and chronic harm to children as a vulnerable group. This study retrospectively reviewed paediatric records to examine the patterns and reasons for ordering CT scans in non-traumatic paediatric cases. In this study, CT results were positive in a minority of cases. Dilated ventricles, sinusitis and brain oedema were the most common reported results. Most patients had CT scans to rule out a contraindication to LP, with only a small minority having a radiologically confirmed contraindication.

Moreover, physicians' reporting of health information could have been more accurate and consistent. The high rate of CT requests to rule out contraindications to LP, with few radiologically confirmed contraindications, suggests unjustified overuse of CT scans. Developing clear, detailed and specific national guidelines is recommended, guided by established guidelines elsewhere and supported by additional measures, including training, decision support tools, alternative management pathways and specialist consultations. Additionally, improving the quality, accuracy and consistency of reporting health information using HIS is essential for monitoring radiological safety practices.

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