Received: 28 March 2023 | Accepted: 31 August 2023

DOI: 10.1002/emp2.13041

JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE
Open Access
WILEY

ORIGINAL RESEARCH

Imaging

Have the UK Pediatric Trauma Protocols resulted in a reduction in chest computed tomography imaging for children presenting with major blunt trauma?

Samantha Negus MBBS, MRCP FRCR[1] | **Omar Bouamra PhD**[2] | **Damian Roland FRCPCH PhD**[3,4]

[1]Radiology Department, East Surrey Hospital, Redhill, Surrey, UK

[2]The Trauma Audit & Research Network, University of Manchester, Manchester, UK

[3]Paediatric Emergency Medicine Leicester Academic (PEMLA) Group, Children's Emergency Department, Leicester Royal Infirmary, Leicester, UK

[4]SAPPHIRE Group, Health Sciences, Leicester University, Leicester, UK

Correspondence
Samantha Negus, MRCP, FRCR, Radiology Department, East Surrey Hospital, Canada Avenue, Redhill, Surrey, RH1 5RH, UK.
Email: samantha.negus@doctors.org

Funding and support: By *JACEP Open* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist.

Prior presentation: Virtual presentation at TARN DAY, Trauma Care, UK, June 5, 2023

Abstract

Objectives: To observe variation in imaging requests after publication of the Royal College of Radiologists UK Paediatric Trauma Protocols in 2014, recommending limited use of thoracic computed tomography (CT) to appropriately clinically risk stratified children.

Method: A retrospective observational study using data from the Trauma Audit & Research Network in the United Kingdom, for children (0–16 years of age) for the years 2012–2021. Percentages were calculated to facilitate comparison between year groups (under 1 year of age, 1–10 years of age, 11–15 years of age), and CT imaging categories reviewed: (1) whole-body CT (WBCT); (2) abdominopelvic CT (CTAP) with chest radiograph (CXR); (3) chest, abdomen, and pelvic CT (CTCAP) with CXR; (4) CTCAP without CXR; and (5) other imaging.

Results: Increased use of the recommended protocol (CXR with CTAP) was observed after guidance publication but was not sustained: infants under 1 year old, 0.0% in 2012, 7% in 2017, 0.0% in 2021; 1–10-year-olds, 4% in 2012, 13.9% in 2017, 5.5% in 2021; 11–15-year-olds, 7.1% in 2012, 10.2% in 2017, 6.6% in 2021. Requests for WBCT increased from 2012–2021 (all age groups, 2.4%, 2012, to 5.3%, 2021) and requests for CTCAP were consistently at a higher level than that of the recommended protocol.

Conclusion: The increased use of CXR with CTAP after publication of the guidelines, was not sustained with a decreasing trend observed from ~2017, raising concern for the ionizing radiation burden in this population.

Supervising Editor: Mike Wells, MBBCh, PhD

KEYWORDS
chest injuries, child, computed tomography, protocol compliance

1 | INTRODUCTION

1.1 | Background

The Trauma Audit & Research Network (TARN) is the mandated national clinical registry for traumatic injury and produces reports on the standards of care and outcomes of patients treated at all trauma receiving hospitals across England, Wales, and Ireland. It is the largest registry in Europe, with over 1 million patient records, and as such is able to support trauma research both nationally and internationally. TARN allows an assessment of the impact of trauma guidance and one such area, where there has been known variability, is imaging for children.

In 2014 Royal College of Radiologists the (RCR) produced the Paediatric Trauma Protocols[1] to give direction on the most appropriate imaging methods for children presenting to the emergency departments in the United Kingdom, acknowledging that "children are not small adults."

With regards to imaging of the thorax, the guidance recommended different protocols for more or less injured children. For unconscious children or those with a mechanism of injury suggesting a high likelihood of thoracic trauma, the recommendations were for imaging with whole-body computed tomography (WBCT). During high-velocity crashes the relatively elastic tissues, and comparatively pliable ribcage, allow for marked mediastinal mobility, resulting in serious injury of tissues and organs with or without rib fractures.[2] However, for low-velocity crashes the increased musculoskeletal flexibility is relatively protective and imaging protocols were aimed at avoiding thoracic CT, knowing that thoracic aortic injury and traumatic diaphragmatic rupture are comparatively uncommon.[3–6] In addition, the soft tissues of the chest (notably the thyroid and breast tissue) are particularly sensitive to the effects of ionizing radiation (IR), with an overall estimated risk of radiation-induced cancer as high as 1/500 exposed children.[7]

The recommendations were supported by studies that showed that information obtained from CT examinations did not change patient management.[8,9] However, the results may have been skewed to those with a lower probability of thoracic injury, emphasizing the need for careful triage, clinical review, and patient selection.

Abdominal injury, and in particular solid organ injury (notably hepatic, splenic, and renal), is relatively common in children, and the RCR guidelines advocate early imaging with contrast-enhanced CT. Ultrasound examination is readily accessible but the reported negative predictive values of 50%–63% for FAST (Focused Assessment with Sonography for Trauma) scans in unstable patients[10] were not considered sufficient to justify inclusion in the national guidelines, although local protocols may vary. The advised protocol in stable children is CXR with abdominopelvic CT (CTAP), but for those clinicians who remain concerned about missing subtle thoracic injury on the chest radiograph (CXR), it is reported that 91% of clinically relevant pathology may be identified in an abdominal CT, if imaging is commenced 1 cm above the level of the diaphragm, avoiding a full thoracic CT and reducing the IR dose.[11]

After development of the guidelines, the protocols were disseminated to all Trauma Units and Major Trauma Centres, published in *Clinical Radiology*,[12] and discussed at the Royal College of Emergency Medicine (United Kingdom), with further educational material distributed by social media.

1.2 | Importance

Both at the time of developing the UK Pediatric Trauma Protocols and more recently, studies have confirmed that early imaging with CXR, in combination with the clinical examination, is appropriate and safe when investigating thoracic trauma in children and adheres to the ALARA principle (as low as reasonably achievable), with a reduction of IR dose to radiosensitive tissues.

1.3 | Goals of this investigation

The study aimed to evaluate whether the RCR Pediatric Trauma Protocols (2014) had resulted in an observable and sustained reduction in the use of pediatric CT chest across the United Kingdom when imaging for trauma.

2 | METHODS

2.1 | Study design and setting

This was a retrospective observational study using the TARN database for information related to children (0–16 years of age) for the years 2012–2021, inclusive, before and after the release of the guidance in August 2014. The time period commenced in 2012 at the time of national service development for trauma centers, with production of the RCR standards for imaging in severely injured patients, and was limited to 2021 due to incomplete data set from 2022.

Children were included on the TARN database if they were injured and either admitted to hospital for more than 72 h, admitted to an ICU, or died in hospital; submissions to the TARN registry were carried out by trained TARN programers linked to the ED at the admitting hospital. The outcome (lived or died) was recorded either on discharge from

hospital or at 30 days, but patients who died at the scene of the incident, and not transported to hospital, were not reported to TARN.

Individual injuries were classified according to the Abbreviated Injury Scale (AIS), which allowed an overall Injury Severity Score (ISS) to be calculated retrospectively; it was not used in the acute setting. The ISS is an anatomical score that measures the overall severity of injured patients, giving a score between 0 to 75; scores are calculated by adding together the squares of the 3 highest AIS scores in 3 predetermined regions of the body. Conventionally a child with an ISS of >15 is classified as "major trauma"with an ISS of 25 or more being the most severe of injuries. Both the AIS and the ISS score were determined by trained coders within a quality assurance program using the information sent to TARN from the admitting hospital.

2.2 | Selection of patients

There were approximately 4 million children presenting to EDs (major trauma unit or trauma unit) each year between 2012–2021, with about half of these after an injury, most of which were minor; data for patients collected by TARN annually ranged between 2306 to 2836 children in this time period.

All children (0–16 years of age) on the TARN data were included in the study. The raw data were reviewed, duplicates entries identified and removed by a senior TARN statistician, and percentages calculated to facilitate comparison between the year groups.

2.3 | Measurements

Children were divided into 3 age categories (under 1 year of age, 1–10 years of age, 11–15 years of age) and the following CT imaging categories were reviewed:

1. WBCT
2. CTAP with CXR
3. Chest, abdomen, and pelvic CT (CTCAP) with CXR
4. CTCAP without CXR
5. Other imaging

"Other imaging" refers to a combination of abdominal CT, or pelvic CT, or chest CT, or abdominal radiograph, or pelvic radiograph on their own, associated with CXR but without WBCT, and includes 2 by 2 combinations for example, CXR and no WBCT, or abdominal CT and chest CT and so forth, that are not described in the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology). They have been grouped together because of the complexity of describing all the possible image combinations in an audit directed to review trends in imaging of WBCT and CTCAP, against the advised protocol of CXR with CTAP.

The Bottom Line

In this study, the authors aimed to determine the adherence to imaging guidelines for pediatric trauma victims in the United Kingdom. An analysis of an existing trauma registry revealed that these recommendations were not being followed and that pediatric trauma patients were potentially being exposed to radiation from unnecessary computed tomography scans. This is an important finding with critical patient safety implications.

2.4 | Data analysis

An interrupted time series analysis[13] was conducted to assess the impact of the RCR guidelines and the period corresponding to the first lockdown on the baseline trend use of CT on pediatric trauma patients. A segmented regression model based on a generalized linear model, predicting the use of CT was estimated and a discontinuity in the gradient (trend) or intercept (level) of the fitted model was tested for at the quarterly time point of implementation of each tested period (Q3-2014 and Q1-2020).

The percentage of children imaged with WBCT was determined as raw data and as a percentage of all children submitted to TARN, both within and between the age groups. The percentages within each year were undivided except for 2020/21, where the data were subdivided into calendar months to observe whether a change in WBCT percentage of use had occurred during the 3 UK COVID-19 lockdown periods; the lockdown periods were noted.

For comparison of the 5 imaging subsets, both between and within the 3 age groups, the data were formatted into a percentage of "all imaging" (denominator) for each imaging category per year studied. The percentage calculation was to allow proportional comparison, in this descriptive observational study.

For simplicity all imaging abbreviations (WBCT, CXR with CTCAP, CTCAP etc.) refers to the percentage of each unless stated otherwise.

All analyses were performed with the software Stata 16 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC).

3 | RESULTS

The ISS varied for each year. The most common ISS was 9–15 (Table 1), which varied between 52% and 56.5% of the total, with a mean of 54.3% (ISS 1–8, mean 12.8%; ISS >15, mean 32.6%).

The total number of children submitted to TARN annually varied between 2306 and 2836 of whom only a small percentage were imaged

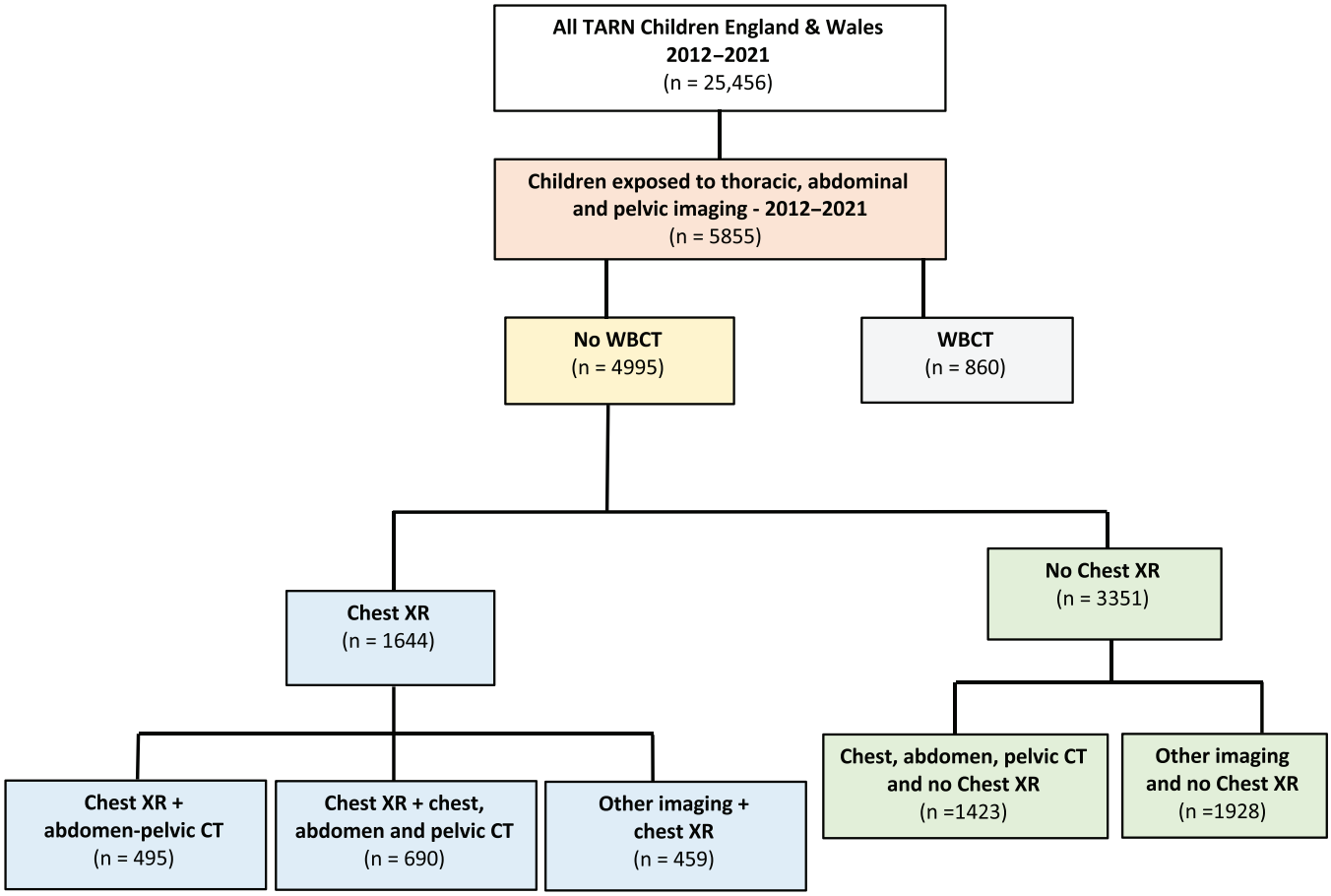

FIGURE 1 STROBE reporting guideline. Abbreviations: CT, computed tomography; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; TARN, Trauma Audit & Research Network; WBCT, whole-body computed tomography; XR, radiograph.

with WBCT, but this percentage doubled (2.4% in 2012, to 5.3% in 2021) (Table 2).

For all children imaged with WBCT the majority were in the 11–15-year-old age group, with, consistently, <12% being infants, reflecting the small number of infants under 1 year of age submitted to the TARN database. As a percentage of children imaged within each age group the figures are more closely aligned between the 1–10-year-old age group and the 11–15-year-old age group; infants under 1 year of age show relatively high percentages possibly skewed by the small numbers.

The introduction of the RCR guideline was associated with a drop in the level of WBCT use (−0.76; 95% confidence interval [CI]:−1.61 to 0.09) (Figure 1) but did not reach statistical significance ($P = 0.079$) although a statistically significant decreasing trend was observed up to the end of the fourth quarter of 2019 ($P = 0.013$) (−0.14; 95% CI: −0.25 to −0.03). An increase in the level of WBCT use was observed at the beginning of the first quarter of 2020 (1.49; 95% CI:−0.23 to 3.20) (which corresponded to the time frame of the UK COVID-19 lockdown) but not reaching statistical significance ($P = 0.088$). A reversal in trend (increasing) was then observed, although not reaching statistical significance ($P = 0.481$) (0.144; 95% CI: −0.27 to 0.56).

The data for WBCT were refined for 2020/21 with the UK COVID-19 lockdown periods marked. Two spikes in activity were observed that corresponded to post-lockdown months. The ISS for the corresponding months were reviewed; the median ISS interquartile range remained at 9 (range 9–19 for all months) for the years 2020/21.

TABLE 1 Percentage distribution of injury severity score per year.

ISS	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1–8	13.2	11.7	12.3	12.4	13.9	13.2	13.1	13.7	11.7	12.9
9–15	55.7	56.1	56.5	56.1	53.9	54.2	52.2	52.4	52.0	54.0
>15	31.1	32.2	31.2	31.5	32.2	32.6	34.7	34.0	33.1	33.1

Abbreviation: ISS, injury severity score.

3.1 | Infants under 1 year of age

Imaging with WBCT increased overall between 2012 to 2021, with a slight reduction after 2014, between 2015 to 2019 (Table 3). Use of CXR with CTAP was highest prepublication and ranged 3%–7% post-publication but fell to zero in 2021. Use of CXR with CTCAP showed 2 peaks (prepublication, 2012, and postpublication, 2018). There was a wide range in percentages for infants imaged with CTCAP (8%–33.3%)

TABLE 2 Total number of children submitted to the trauma audit & research network database, the total number of whole-body computed tomography per year, and percentage of children imaged with whole-body CT per year.

		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
All TARN submissions		2415	2435	2472	2663	2544	2836	2629	2733	2423	2306
Total number of WBCT		59	78	83	88	56	74	82	93	125	122
%WBCT		2.4	3.2	3.4	3.3	2.2	2.6	3.1	3.4	5.2	5.3
WBCT <1 year old	between	6.8	9.0	7.2	5.7	10.7	8.1	4.9	9.7	9	11
	within	18	28	31	20	24	20	12	24	48	35
WBCT 1–10 years	between	35.6	47.4	47.0	36.4	32.1	36.5	31.7	33.3	40.8	41.8
	within	10	14.4	17.4	13	8	11.4	12	13.2	22	23
WBCT 11–15 years	between	57.6	43.6	45.8	58.0	57.1	55.4	63.4	57.0	50.4	47.5
	within	12.8	12.8	13.7	15.1	10	10.2	14.8	13.8	18.2	16.7

Further subdivision of WBCT by age group. For each age category the upper row (between) refers to WBCT undertaken relative to the age categories. For each age category, the lower row (within) refers to WBCT compared to "all imaging."
Abbreviations: CT, computed tomography; TARN, Trauma Audit & Research Network; WBCT, whole-body computed tomography.

TABLE 3 Children <1 year old: percentage in each imaging category per year.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
WBCT	18	28	31	20	24	20	12	24	48	35
CXR+CTAP	0.0	12	5	8	4	7	3	5.2	4.3	0.0
CXR+CTCAP	18	16	10.5	12	12	13.3	18.2	7.8	8.7	2.7
CTCAP	22.7	16	5.3	8	20	33.3	15	15.7	13	13.5
Other imaging	41.3	28	48.2	52	40	26.4	51.8	47.3	26	48.8

Abbreviations: CTAP, abdominopelvic computed tomography; CTCAP, chest, abdomen, and pelvic computed tomography; CXR, chest radiograph; WBCT, whole-body computed tomography.

TABLE 4 Children 1–10 years old: percentage in each imaging category per year.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
WBCT	10	14.4	17.4	13	8	11.4	12	13.2	22	23
CXR+CTAP	4	8	6.2	7.3	11.8	13.9	10.5	10.2	5.6	5.4
CXR+CTCAP	15	15.5	13.8	14.2	14.5	10.1	9.6	13.2	8.6	5.4
CTCAP	28.5	25.9	22.3	25.3	21.8	24.5	19.7	21.3	26.3	23.1
Other imaging	42.5	36.2	40.3	40.2	43.9	40.1	48.2	42.1	37.5	43.1

Abbreviations: CTAP, abdominopelvic computed tomography; CTCAP, chest, abdomen, and pelvic computed tomography; CXR, chest radiograph; WBCT, whole-body computed tomography.

over the 10-year period, although percentages were observed to be stable about 13%–16% from 2018–2021.

3.2 | Children aged 1–10 years old

WBCT fell to the lowest percentage in 2016 (8%) but increased in 2020/21 (22% and 23% respectively) (Table 4). Use of CXR+CTAP increased after 2014 (11.8% in 2016, and 13.9% in 2017) but reduced to preguideline levels in 2020/21 (5.6% and 5.4%). Use of CXR with CTCAP reduced after a peak in 2016. Use of CTCAP varied between 19.7% and 28.5% with no obvious trend. Use of both WBCT and CXR with CTAP appeared consistently lower than that of CTCAP.

3.3 | Children aged 11–15 years

Use of WBCT was 12.8% in 2012, 10% in 2016, and had risen to 16.7% in 2021 (Table 5). Use of CXR with CTAP rose slightly after publication reaching 10.2% in 2017, but the highest percentage use was in 2014,

TABLE 5 Children aged 11–15 years; percentage in each imaging category per year.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
WBCT	12.8	12.8	13.7	15.1	10	10.2	14.8	13.8	18.2	16.7
CXR+CTAP	7.1	8.3	11.9	9.4	9.5	10.2	7.9	8.6	8.4	6.6
CXR+CTCAP	14.3	13.2	12	9.7	13.2	17.2	11.4	8.3	5.5	11.8
CTCAP	22.7	24.5	20.6	24.6	24.6	21.9	30.7	27.7	29.5	23.9
Other imaging	43.1	41.2	41.8	41.2	42.7	40.5	35.2	41.6	38.4	41

Abbreviations: CTAP, abdominopelvic computed tomography; CTCAP, chest, abdomen, and pelvic computed tomography; CXR, chest radiograph; WBCT, whole-body computed tomography.

immediately before publication, at 11.9%; the trend was a reduction in use by 2021 at 6.6%. Use of CXR with CTCAP showed a relatively narrow change about a mean of 11.7%, with no obvious trend. Use of CTCAP shows a marginal and questionably sustained increased in use.

4 | LIMITATIONS

All children on the TARN registry were included, but those not fulfilling the TARN criteria (admitted to hospital for >72hours, admitted to an ICU, or died in hospital) were not included. Thus, children admitted, imaged, and discharged in under 72 hours would have been missed. It was not possible to retrogradely determine these figures from the registry, which would require prospective data collection of all children undergoing emergency imaging in the United Kingdom.

Penetrating injury makes up less than 5% of pediatric trauma in the United Kingdom,[14] but due to the method of data collection it was not possible to separate penetrating from blunt trauma, although the UK imaging recommendations for imaging are different.

The number of infants included on the registry was small, and percentage calculations were observed to have a wider range when compared to the other age groups, which made reviewing trends less accurate.

5 | DISCUSSION

In the years after guidance publication, local audits to assess compliance[15] showed improved adherence to the suggested protocols after dissemination and education.

This study is the first national UK observational study using the TARN database spanning 10 years, including the UK COVID-19 lockdown periods. The study showed that the use of WBCT was a small percentage of those on the TARN database, which in turn was a small percentage of children presenting to the ED in the United Kingdom. However, by 2020-21, this percentage had increased from the prepublication figures for each age group (for all children combined: 3.2% in 2013, to 5.3% in 2021).

The interrupted time series of the quartile percentage use of WBCT during the study period showed a reduction after 2014, suggesting there was an impact from the guidelines, with the lowest use of WBCT observed in 2016. Between 2017–19, there was a no significant variation in WBCT, but a doubling of the prepublication levels was observed in 2020 (Figure 2). This corresponded to the months of the COVID-19 pandemic and UK lockdowns, even though the ISS of patients presenting to the ED remained close to the 10-year mean.

The timing of the increase activity in ED[16] after the opening up of society during the COVID-19 pandemic, when personal protection equipment (PPE) measures were still in place in health care settings, corresponded to the months that showed activity spikes for WBCT in Figure 3. A possible explanation was that wearing PPE hampered accurate assessment and triage, which translated into a tendency to inflate clinical concerns. Further work is needed to substantiate this hypothesis and support service development if validated.

The use of the suggested protocol (CXR with CTAP), although not suitable for all patients, fluctuated both within and between the different age groups over the 10-year period. Due to the limitations of the study, the percentages within the youngest age group were too small to reach a meaningful conclusion, but both the 1–10-year-old and 11–15-year-old age groups showed an increase in the percentages in the years post publication with a reduction in use by 2020-21. These post-guidance publication peaks and subsequent fall in use of the recommended protocol suggest that clinicians need reminding of the recommendations, with further information dissemination and education required both at a national and local level. A recent study showed that the use of a thoracic imaging decision tool reduced the use of CT in pediatric acute trauma by 50%[17] without an increase in missed, clinically significant, injuries.

The high percentage of children and young people imaged with a combination of WBCT, CTCAP, and CTCAP with CXR suggests that there is continued clinical reluctance to rely solely on the CXR to exclude clinically significant pathology despite multiple studies to the contrary.[18,19] Because this was an observational study of trend, the findings of a reduction in the use of the recommended imaging protocol, suggests an unnecessary IR burden on the pediatric population, raising concern for the development of IR-induced pathologies in this population.

This retrospective observational study of the UK national database from TARN (2012–2021) showed an initial fall followed by an increasing trend in the use of thoracic CT imaging for children presenting to the ED with trauma, whether this was with WBCT or CTCAP, with or

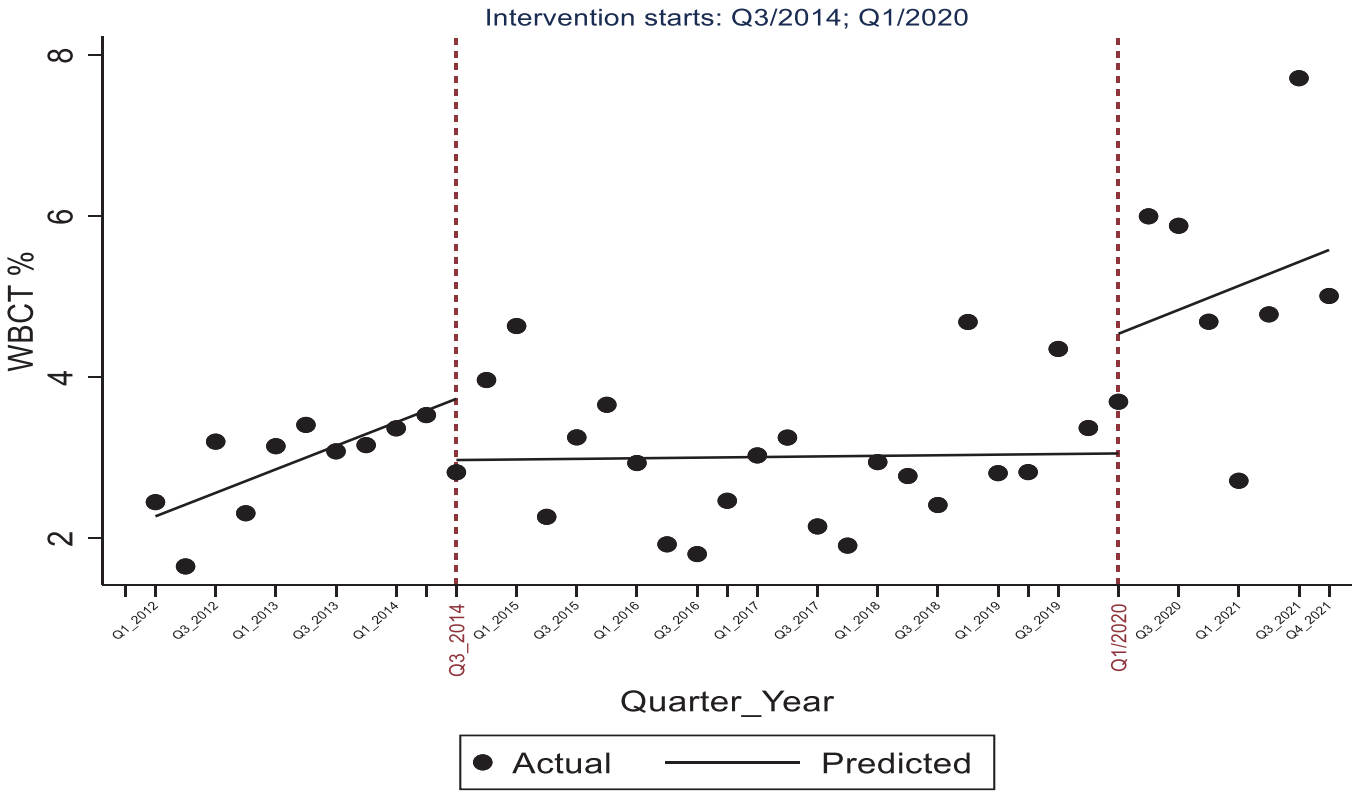

FIGURE 2 An interrupted time series shows the quarterly time series for the percentage use of WBCT over the period 2012 to 2021. Before the implementation of the RCR guideline, there is a statistically significant increasing trend of CT use ($P = 0.002$), (0.15; 95% confidence interval: 0.06–0.24). Abbreviations: CT, computed tomography; RCR, Royal College of Radiologists; WBCT, whole-body computed tomography.

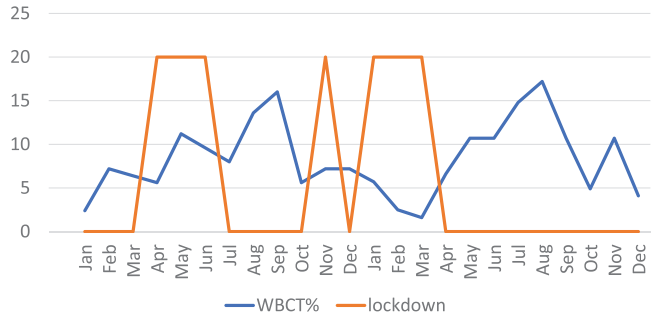

FIGURE 3 WBCT percentage of 2020/2021 during the 3 lockdown periods in the United Kingdom. The months of the lockdowns are indicated by the orange line. Abbreviation: WBCT, whole-body computed tomography.

without chest radiography. This is contrary to the RCR recommended pediatric protocol guidelines.

These observations, even with the limitations of this study, are concerning for an unnecessarily high IR population burden, with implications for the development of iatrogenic pathology in this radiosensitive group.

The authors recommend the use of image decision-making tools, the evidence-based pediatric trauma protocols, and starting abdominal CT examinations 1 cm above the level of the diaphragm, as suggested by Patel et al. (2010).

AUTHOR CONTRIBUTIONS

Samantha Negus: Conceptualization, data analysis, critical review and evaluation of results, primary authorship of the paper, review and editing of the paper, procurement of grant or other funding. Omar Bouamra: Data collection, data analysis, critical review and evaluation of results. Damian Roland: Critical review and evaluation of results, review and editing of the paper.

ACKNOWLEDGMENTS

TARN is thanked for supporting this project and for the grant toward Open Access. The authors are grateful to Professor Tim Coats and Antoinette Edwards at TARN for the grant toward Open Access.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ORCID

Samantha Negus MBBS, MRCP FRCR https://orcid.org/0009-0009-7646-5297

REFERENCES

1. The Royal College of Radiologists. *Paediatric Trauma Protocols*. The Royal College of Radiologists; 2014. Ref No. BFCR (14)8. C. https://www.rcr.ac.uk/publication/paediatric-trauma-protocols

2. Alemayehu H, Aguayo P. Pediatric thoracic blunt trauma. *J Pediatr Intensive Care*. 2015;4:35–39. https://doi.org/10.1055/s-0035-1554987
3. Heckman SR, Trooskin SZ, Burd SR. Risk factors for blunt thoracic aortic injury in children. *J Pediatr Surg*. 2005;40:98-102. https://doi.org/10.1016/j.jpedsurg.2004.09.004
4. Donnelly LF. Imaging issues of CT of blunt trauma to the chest and abdomen. *Pediatr Radiol*. 2009;39(suppl 3):406e13. https://doi.org/10.1007/s00247-009-1219-4
5. Moore M, Wallace EC, Westra SJ. The imaging of paediatric thoracic trauma. *Pediatr Radiol*. 2009;39:485e96. https://doi.org/10.1007/s00247-008-1093-5
6. Elkbuli A, Meneses E, Shepherd A, et al. Traumatic diaphragmatic rupture successfully managed in 4-year-old patient: case report and literature review. *Int J Surg Case Reports*. 2020;72:237–240. https://doi.org/10.1016/j.ijscr.2020.06.026
7. Brenner DJ, Hall EJ. Computed tomography - an increasing source of radiation exposure. *N Eng J Med*. 2007;357:2277e84. https://doi.org/10.1056/NEJMra072149
8. Holscher CM, Faulk LW, Moore EE, et al. Chest computed tomography imaging for blunt pediatric trauma: not worth the radiation risk. *J Surg Res*. 2013;184(1):352–357. https://doi.org/10.1016/j.jss.2013.04.044
9. Ugalde IT, Prater S, Cardenas-Turanzas M, et al. Chest x-ray vs. computed tomography of the chest in pediatric blunt trauma. *J Pediatri Surg*. 2021;56:1039–1046. https://doi.org/10.1016/j.jpedsurg.2020.09.003
10. Holmes JF, Gladman A, Chang CH. Performance of abdominal ultrasonography in paediatric blunt trauma patients: a meta-analysis. *J Pediatr Surg*. 2007;42:1588e94. https://doi.org/10.1016/j.jpedsurg.2007.04.023
11. Patel RP, Hernanz-Schulman M, Holmes MA, et al. Paediatric chest CT after trauma - impact on surgical and clinical management. *Pediatr Radiol*. 2010;40:1246e53 https://doi.org/10.1007/s00247-009-1533-x
12. Negus S, Danin J, Fisher R, et al. Pediatric trauma imaging: why do we need separate guidance? *Clin Rad*. 2014;69(12):1209–1213. https://doi.org/10.1016/j.crad.2014.07.001
13. Kontopantelis E, Doran T, Springate DA, Buchan I, Reeves D. Regression based quasi-experimental approach when randomisation is not an option: interrupted time series analysis. *BMJ*. 2015;350:h2750. https://doi.org/10.1136/bmj.h2750
14. TARN – The Trauma and Audit Research Network. Severe injury in children report January 2019-December 2020. https://www.bspr.co.uk/news/tarn-4th-biennial-national-severe-injury-in-children-report-2019-20/
15. Vamadevan T, Sarvananthan T, Kho J, et al. Compliance with imaging guidelines for paediatric major trauma: results of second audit cycle. *Clin Rad*. 2016:71;S11eS25. https://www.clinicalradiologyonline.net/article/S0009-9260(16)30185-4/pdf
16. Royal College of Emergency Medicine. RCEM acute insight series: what's behind the increase in demand in emergency departments? 2021. https://rcem.ac.uk/wp-content/uploads/2021/11/RCEM_Why_Emergency_Department_Crowding_Matters.pdf
17. Downie K, McIntire A, Joseph T, Sanjay K, Mubeen J. Application of a thoracic CT decision rule in the evaluation of injured children: a quality improvement initiative. *J Trauma Nursing*. 2023;30(1);48–54. https://doi.org/10.1097/jtn.0000000000000692
18. Holl EM, Marek AP, Nyaard RM, et al. Use of chest computed tomography for blunt pediatric chest trauma: does it change clinical course? *Pediatr Emerg Care*. 2020;36(2):81-86. https://doi.org/10.1097/pec.0000000000002040
19. Golden J, Isani M, Bowling J, et al. Limiting chest computed tomography in the evaluation of pediatric thoracic trauma. *J Trauma Acute Care Surg*. 2016;81(2):271-277. https://doi.org/10.1097/ta.0000000000001110

How to cite this article: Negus S, Bouamra O, Roland D. Have the UK Pediatric Trauma Protocols resulted in a reduction in chest computed tomography imaging for children presenting with major blunt trauma? *JACEP Open*. 2023;4:e13041. https://doi.org/10.1002/emp2.13041

AUTHOR BIOGRAPHY

Samantha Negus, MRCP FRCR, is a pediatric radiologist. She works at East Surrey Hospital in Surrey, United Kingdom and is a TARNlet committee member