









Rate and severity of radiological features of physical abuse in children during the first UK-wide COVID-19 enforced national lockdown

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ABSTRACT

Rate and severity of radiological features of physical abuse in children during the first UK-wide COVID-19 enforced national lockdown.

Objective To assess the number, type and outcome of radiological investigations for children presenting to hospital with suspected physical abuse (SPA; including abusive head trauma) during the first national COVID-19 enforced lockdown compared with the prelockdown period.

Design Multicentre, retrospective, observational, interrupted time series analysis.

Setting Eight secondary/tertiary paediatric centres between January 2018 and July 2020 inclusive.

Participants 1587 hospital assessed children undergoing radiographic skeletal surveys (SkS) and head CT imaging performed for SPA/child protection concerns.

Main outcome measures Incidence and severity of fractures identified on SkS; head injury (composed of incidence rates and ratios of skull fracture, intracranial haemorrhage (ICH) and hypoxic ischaemic injury (HII)) on head CT imaging; and ratio of antemortem and postmortem SkS.

Results 1587 SkS were performed: 1282 (81%) antemortem, 762 (48%) male, and positive findings in 582 (37%). Median patient age was 6 months. There were 1.7 fractures/child prelockdown versus 1.1 fractures/child during lockdown. There was no difference between positive/negative SkS rates, the absolute ratio of antemortem/postmortem SkS or absolute numbers of head injury occurring between January 2018 and February 2020 and the lockdown period April–July 2020. Likewise, prelockdown incidence and rates of skull fracture 30/244 (12%), ICH 28/220 (13%) and HIE 10/205 (5%) were similar to lockdown, 142/1304 (11%), 171/1152 (15%) and 68/1089 (6%), respectively.

Conclusion The first UK COVID-19 lockdown did not lead to an increase in either the number of antemortem or postmortem radiological investigations performed for SPA, or the number or severity of fractures and intracranial injuries identified by these investigations.

INTRODUCTION

Factors that increase individual and societal stress and inequities have been amplified by the COVID-19 pandemic and consequent lockdowns. These have been summarised and discussed by several authors worldwide^{1,2} and include (among others) isolation

What is already known on this topic?

- Lockdown due to COVID-19 may have increased children's exposure to domestic violence.

What this study adds?

- The rate of radiologically identified abusive head trauma in the first lockdown period did not increase.
- On the basis of this radiological study, there was no increased incidence in postmortem imaging or live imaging for skeletal trauma, severity of skeletal injury nor head injury during lockdown, when compared with the preceding 2 years.
- The multifactorial drivers for physical abuse resulting in radiological investigation of children in England were not compounded or exacerbated by the first national lockdown.

and reduced access to support systems, financial strain and parental depression. In one study, total aggression score and individual scores for all four domains of physical aggression, verbal aggression, anger and hostility were shown to have increased during the COVID-19 lockdowns.³

A rapid systematic review⁴ found that children are particularly vulnerable during the COVID-19 pandemic as increased parental stress resulting from enforced national lockdowns and reduced access and presentation to 'mandated reporters' may increase rates of child maltreatment.

This increased stress in the home could lead to an increase in incidence of domestic violence and child abuse,^{3–5} prompting development of guidelines for child safeguarding during the COVID-19 pandemic, such as those published in the UK by the Royal College of Paediatrics and Child Health.⁶ However, during the most recent (COVID-19) pandemic surges, studies have generally shown no effect, or reduced effect of lockdowns/crises on the incidence of paediatric trauma and physical child abuse in regards to traumatic injury that is seen presented to healthcare institutions. For example, in the USA and Canada,



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studies have shown an overall reduction in childhood trauma volume during lockdown with a reduction in non-violent trauma,⁷ no increases in inflicted injury,^{8–10} an increase in sexual abuse,¹⁰ but reduced numbers of children investigated for abuse.^{9,10} However, Salt *et al*,¹⁰ when comparing child abuse and neglect encounters before and after school closings due to SARS-CoV-2, found that episodes of abuse increased in severity with a resultant increase in inpatient admissions.

A cross-sectional retrospective observational study from Brazil¹¹ in individuals less than 18 years of age found that while there was a decrease in the absolute numbers of presentation of children to the emergency department during the COVID-19 pandemic when compared with the same quarterly time points over the preceding 3 years, there was a significant increase in the relative percentage of the number of visits due to violence. There was no association between the incidence of physical violence and socioeconomic and demographic factors.

No case of child abuse presented to the Emergency Department of the University Hospital of Central Friuli during Italy's first period of strict lockdown—a lockdown that extended over 2 months and 1 week from 9 March–10 May 2020.¹² In France, one study that specifically assessed emergency department attendances showed that the lockdown confinement increased the incidence of burns but not of any other childhood trauma.¹³ Indeed, the significant reduction in supervision orders issued between March and May 2020 (24) compared with the same period for 2019 (136), prompted authors of another French study to question whether cases of child abuse were being undetected during lockdown.¹⁴

One exploratory study examining police referrals from domestic abuse before and during the first enforced national lockdown in South Wales, UK, found increased third party of reporting by children.¹⁵ While this may suggest an increased exposure to domestic violence, the absolute number of reports by children were small and may not be applicable to other parts of Wales or the rest of the UK. Moreover, researchers in the UK reported an overall decrease in paediatric trauma and child protection medical examination referrals during lockdown when compared with prelockdown periods.^{16,17}

While several studies in many countries across the world have shown that the 2020 COVID-19 pandemic lockdowns did not increase the incidence of child physical abuse, they questioned whether abuse severity may have increased or indeed gone undetected.

An interrupted time series study in the USA found that there was a significant decrease in the presentation of children with traumatic injuries (physical abuse) to tertiary children's hospitals during the COVID-19 pandemic.¹⁸ However, the cases of those children less than 5 years of age that were presented were more likely to be severe in nature with increased odds of requiring an intensive case admission and suffering a traumatic brain injury.

A further study in the USA found a significant decrease in abusive head trauma (AHT) admissions in children less than 5 years of age across 49 children's hospitals during the COVID-19 pandemic during the 11 March–30 September 2020 lockdown period when compared with the same time points over the preceding 3 years.¹⁹ They found that hospitalised children with AHT had a shorter length of stay and lower mean monthly admission. Moreover, there were no significant differences among the percentage of intensive case stays, ventilator use, subdural haemorrhages, retinal haemorrhages and mortality.

In contrast, the UK authors, Sidpra *et al*,²⁰ reported a 1493% increase in the number of children referred to their centre with suspected AHT between 23 March and 23 April 2020, compared

with the previous 3 years. If this is a true reflection of the situation, then there would be resultant significant policy implications.

The authors of this paper are practising clinical and academic radiologists across eight major paediatric centres in England, UK. They have an interest in child protection both clinically and in their research, as well as providing expert witness evidence to Her Majesty's Courts in cases of suspected child abuse. The majority are active members of the North of England Child Protection Peer Review group that ran virtually during the lockdown period. It was not the subjective feeling of the authors that there had been a significant increase in AHT (or other forms of physical child abuse) in any of the participating peer review centres; however, in light of the Sidpra *et al*²⁰ paper, it was felt that this subjective view required validation.

We sought to determine the number of children (under the age of 18 years) presenting to multiple hospitals across England with suspected inflicted trauma. This multicentre, retrospective, observational interrupted time series analysis compared the investigation rate for, and severity of, injury (on the basis of imaging findings alone) during the first UK-wide COVID-19 enforced national lockdown (23 March–4 July 2020) with prelockdown rates. We used radiographic skeletal surveys (SkS) and head CT imaging findings as surrogate markers to extrapolate rates and severity of injury over the period of the first lockdown in the UK, compared with rates and severity of injury immediately preceding lockdown and extending back to 1 January 2018.

METHODS

Patient and public involvement

This observational study was based on data acquired as routine standard of care with information extracted from the routine healthcare radiology records. No patients or members of the public were directly involved. Following NHSX (National Health Service user eXperience) guidance, the use of patient data for this COVID-19 related project was allowed without consent or the requirement for Confidentiality Advisory Group approval (<https://www.hra.nhs.uk/covid-19-research/guidance-using-patient-data/>).

Identification of absolute numbers of children presenting to hospital with possible physical abuse

Participating centres included Alder Hey Children's Hospital (Liverpool), Birmingham Children's Hospital, Bristol Children's Hospital, Leeds Children's Hospital, Nottingham University Hospitals NHS Trust, Pennine Acute Hospitals NHS Trust, Royal Manchester Children's Hospital and Sheffield Children's Hospital. Each of the eight participating unit's computerised radiology information systems (CRIS) was queried to provide lists of all radiographic SkS performed between January 2018 and July 2020 inclusive in any patient under 18 years of age. For each SkS identified (initial and follow-up), the issued radiology reports were retrieved and manually reviewed by the authors, all paediatric radiologists/paediatric neuroradiologists with an interest and expertise in child protection imaging. In accordance with national guidelines in the imaging investigation of suspected physical abuse in children,²¹ in all participating centres, each SkS had been double reported by consultant paediatric radiologists whose day-to-day practice includes the reporting of SkS for suspected inflicted trauma. This double reporting practice is confirmed as having continued during the lockdown period. The source imaging data was not rereviewed for the purposes of this study.

SkS that had been undertaken for reasons other than suspected inflicted trauma, for example, those performed for assessment of a possible skeletal dysplasia, were excluded. In addition, cases were excluded if there was uncertainty from the CRIS record as to why the SkS had been undertaken. Finally, the CRIS system was searched to identify which children undergoing a SkS also had a contemporaneous head CT examination as part of their suspected inflicted trauma investigations as per the UK national guidelines on the imaging investigation in cases of suspected inflicted traumatic injury in children.²¹

Potential for confounding effect of injury severity

The number of children requiring hospital assessment in the form of a SkS was used as a surrogate marker for the number of cases of inflicted trauma in the community. To capture the severity of abuse, we recorded whether the SkS were conducted antemortem or postmortem and the number of fractures per child. We also recorded features of intracranial injury identified on head CT imaging. The full dataset is found in online supplemental table 1. In cases where there were differing findings on follow-up imaging, for example, new fractures not seen on the initial SkS (one of the primary reasons for undertaking such follow-up imaging in this cohort of patients), the absolute total number of fractures for each child was recorded against the time point at which the initial SkS occurred. If a child presented and was investigated for suspected physical abuse more than once over the study period, each separate investigation was recorded.

Statistical analysis

Time periods of analysis

Retrospective data collection between January 2018 and July 2020 inclusive was performed. The data could be considered as a time series with multiple possible change points, given that some restrictions began on the 16 March 2020, with full lockdown occurring on 23 March 2020. Hence, we considered the whole

of the month of March 2020 as a changing period (rather than a point) to allow the separation of data before and after lockdown. Given the possibility for a ‘rebound effect’ following cessation of lockdown, we also collected data for July 2020. Thus, data for January 2018–February 2020 (‘prelockdown’) was compared with that from April–July 2020 (‘lockdown’).

The time series were tested for autocorrelation and seasonality with comparison by t-test. Segmented linear regression was used to evaluate the effect of lockdown on the level and trend of SkS numbers or abnormal SkS. Analyses were performed in R (R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>)

Specific data analysis

We analysed the number of SkS, rate of abnormal SkS, rate of postmortem SkS and the number of fractures identified on SkS. Regarding head injury, we collected the incidence rates of skull fracture, intracranial haemorrhage and hypoxic ischaemic injury to the brain, as identified on head CT imaging. As well as analysing the ratios of each individual feature of head injury, these findings were amalgamated into a combined feature of ‘head injury’, where positivity was defined as at least one feature being positive for a single child.

RESULTS

Cohort size and demographics

During the study period (1 January 2018–31 July 2020), 1587 children had a SkS performed due to child protection concerns across all participating centres. The estimated UK population served by these centres is 15 695 126. The number of SkS undertaken per month ranged from 36 to 74, with a mean of 51 per month averaged across all centres. Over the study period, 1282 SkS (81%) were performed in live children with the remaining 305 (19%) having been postmortem studies. The median

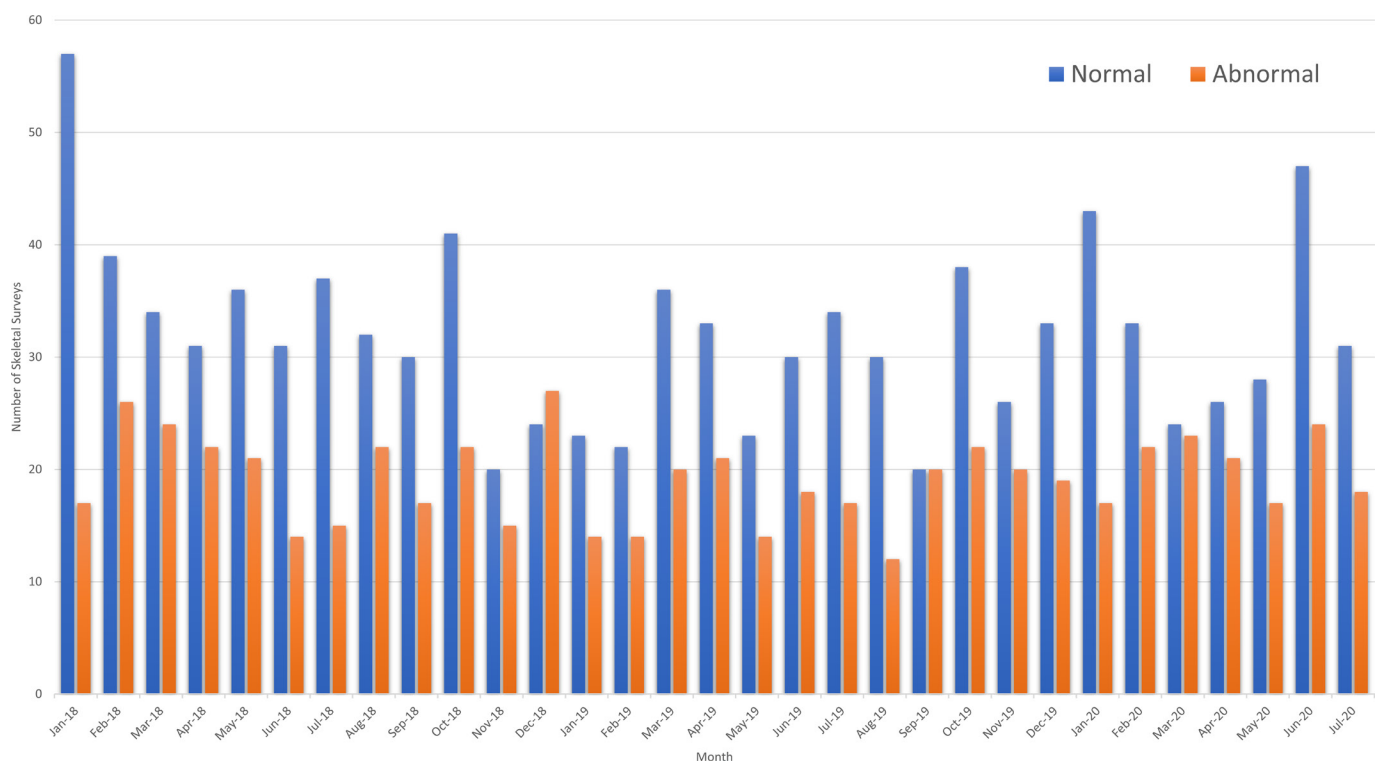


Figure 1 Direct comparison of absolute numbers of normal versus abnormal premortem and postmortem skeletal surveys.

Table 1 Summary time period findings prelockdown and during lockdown

	Before lockdown mean (SD)	After lockdown mean (SD)
	January 2018–February 2020 (n=26)	April–July 2020 (n=4)
Number of SkS	51.10 (9.70)	53.00 (12.10)
Rate of abnormal SkS	0.37 (0.06)	0.38 (0.05)
Rate of postmortem SkS	0.19 (0.09)	0.16 (0.05)
Total fractures	32.00 (14.80)	23.50 (12.60)
Fracture per child	1.72 (0.70)	1.12 (0.44)

The data were compared using a *t*-test and all *p* values >0.1. *n*=number of months. SkS, skeletal surveys.

patient age was 6 months (range 1 day–16 years). Male patients accounted for 762 (48%) of the study population. Across the whole study cohort, positive findings were identified in 582 cases (37%, online supplemental table 2).

Summary statistics

Considering the prelockdown time period of 1 January 2018–28 February 2020, there were 838 skeletal fractures in 491 children (1.7 fractures per child). This compared with 94 fractures in 80 children over the course of the lockdown period of April–July 2020 inclusive (1.1 fractures per child). [Figure 1](#) and online supplemental figure 1 show the absolute numbers of normal/abnormal SkS and premortem/postmortem SkS over the study period. The summary statistics for number of SkS, rate of abnormal SkS, rate of post-mortem SkS, number of fractures and number of fractures per child are presented in [table 1](#) with no prelockdown/lockdown comparison reaching statistical significance.

Combining skull fracture, intracranial haemorrhage and hypoxic ischaemic injury findings into a single diagnosis of ‘head injury’, there was again no significant difference (*p*=0.43) in terms of absolute positive events over the lockdown period compared with the prelockdown period ([table 2](#)). During lockdown, the incidence (which did not reach statistical significance) and rates of specific head injury features were skull fractures 30/244 (12%), intracranial haemorrhage 28/220 (13%) and hypoxic ischaemic injury 10/205 (5%). This was similar to the prelockdown rates of 142/1304 (11%), 171/1152 (15%) and 68/1089 (6%), respectively ([figure 2](#)).

Segmented linear regression

In regard to analyses over time, there was no statistical suggestion for autocorrelation or seasonality (all *p* values >0.05) for total number of SkS, rate of abnormal SkS, rate of postmortem SkS, average number of fractures per child or total number of fractures.

Examining the total number of SkS (online supplemental figure 2), there was a slow downward trend before lockdown. Although there seemed to be a change in trend after lockdown, this trend was not statistically significant with *p* value >0.1, and

the plot suggests that the numbers were rising prior to lockdown in around February 2019, with a large amount of fluctuation.

The plot for the rate of abnormal SkS over time ([figure 3](#)) shows no significant change in level or trend. In fact, the trend goes down after lockdown and up again after the lifting of restrictions, but no change is statistically significant.

Finally, considering the results for the rate of postmortem SkS, total fractures and average fractures per child (online supplemental figures 3–5) there appears to be a sharp downward change in trend after lockdown. Given the large amount of fluctuation over time, any trend must be interpreted with caution and again none of these reached statistical significance.

DISCUSSION

This study has shown that during the lockdown and immediate postlockdown period in England (April–July 2020), there was no increase in the numbers of SkS performed in children; no significant change in the ratio of SkS performed in live versus postmortem children (to indicate an increase in death rates in children attributable to a possible inflicted traumatic aetiology); no significant change in the rates of number of skeletal fractures per child (to indicate a change in severity of such injuries in a non-lethal setting); and no appreciable change in the incidence or severity of head injuries.

While several researchers have used differing metrics, they conclude that their respective 2020 COVID-19 induced lockdowns did not increase the absolute incidence of child physical abuse. This is the first study to analyse SkS referral patterns and findings (including both antemortem and postmortem) in a hospital setting to answer this question. Our findings are in keeping with those provided from other clinical domains, for example, accident and emergency department attendances of live children, mirroring the findings seen in several other countries. Given these results, how can we explain the reported increases in institutional referrals for suspected AHT between 23 March and 23 April 2020?²⁰ Explaining this disparity is vital if future clinical guidelines are to be appropriately evidence based. If such significant increase in cases were a true reflection of the situation, then there are also important national governmental policy implications.

In their correspondence, Sidpra *et al*²⁰ identified 10 cases of suspected AHT over the 1-month lockdown period compared with an average of 0.67 cases per month in the same period of the previous 3 years. During the first wave of the COVID-19 pandemic, significant pressures were placed on all local and regional healthcare units. To mitigate the increase in severely unwell adults who formed the overwhelming majority of cases admitted to hospitals in England, there was significant reorganisation of services on a district wide level. For example, because the impact of COVID-19 on the paediatric population was mercifully low, a significant proportion of paediatric intensive care beds at multiple participating paediatric units were converted to adult beds to support an adult healthcare service in danger of becoming overwhelmed.

Table 2 Rates of cranial/intracranial injury for prelockdown versus lockdown periods.

	Prelockdown			Lockdown		
	Number of diagnostic scans	Number abnormal	Rate (%)	Number of diagnostic scans	Number abnormal	Rate (%)
Fractures	1304	142	10.9	244	30	12.3
Intracranial haemorrhage	1152	171	14.8	220	28	12.7
Hypoxic ischaemic injury	1089	68	6.2	205	10	4.9

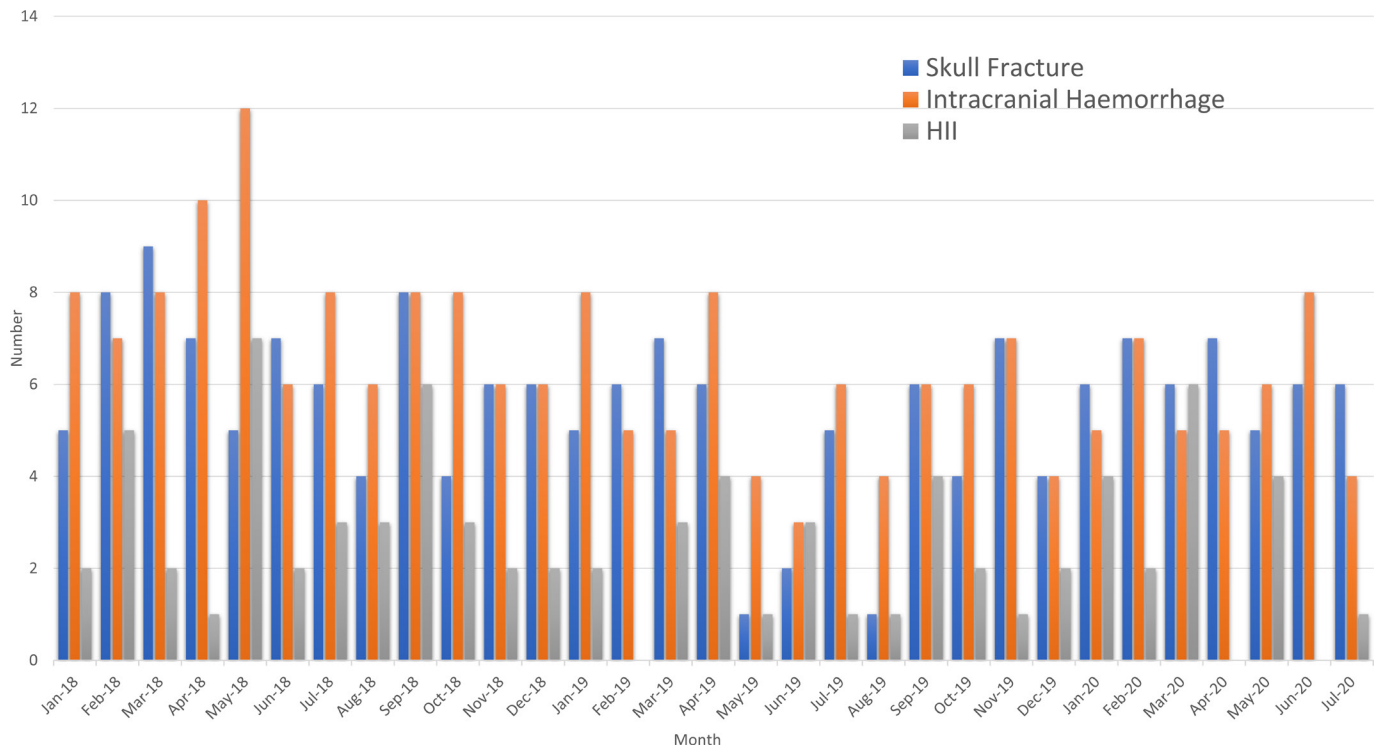


Figure 2 Comparison of absolute numbers of skull fractures, intracranial haemorrhage and hypoxic ischaemic injury (HII) from January 2018-July 2020 inclusive.

Caution is required in the interpretation of single institutional rates of AHT, particularly where such an institution is a major paediatric hospital in London, without an associated accident and emergency department and which only receives emergency cases as referrals from surrounding secondary level medical units. We hypothesise that the apparent increase in case numbers seen at this single institution over that period may be explained by transfer into their centre of paediatric cases from surrounding adult/paediatric units who had reorganised their services to cope with increasing demand for adult intensive care provision, in a similar manner to that undertaken at many of our own units.

The conclusion that the first lockdown was responsible for a significant increase in AHT as diagnosed by radiologists cannot be supported by this multicentre review. Indeed, this study shows

no evidence of an increase in any form of radiologically apparent inflicted injury (either skeletal or neurological) because of the first lockdown in England.

Strengths and limitations of study

Strengths of this analysis include the size of the study, covering a significant proportion of the major paediatric tertiary level units across England. Although NHS Hospital Trusts in London were not represented, given the size and findings presented here, in addition to the size of the major conurbations represented, we do not feel that the underlying validity of the study results are compromised in this regard. While the analyses tested for an immediate rebound effect after lockdown, they have not assessed for a delayed effect beyond July 2020. These results cannot necessarily be extrapolated to the other countries within the UK. This study can only comment on the surrogate markers of abuse identified in the form of children being presented to hospital. It cannot be used to extrapolate to other forms of domestic violence that may not have resulted in paediatric hospital admission or account for changes in referral patterns. Similarly, this study would not capture cases of children who have suffered from abuse but presented with a normal SkS or head CT scan (but the rate of suspected abuse was, in any case, compared between the two time frames and did not differ). However, future work will need to expand on this study by correlating with the results of the child protection medical process for each child and assessing the full referral pathway.

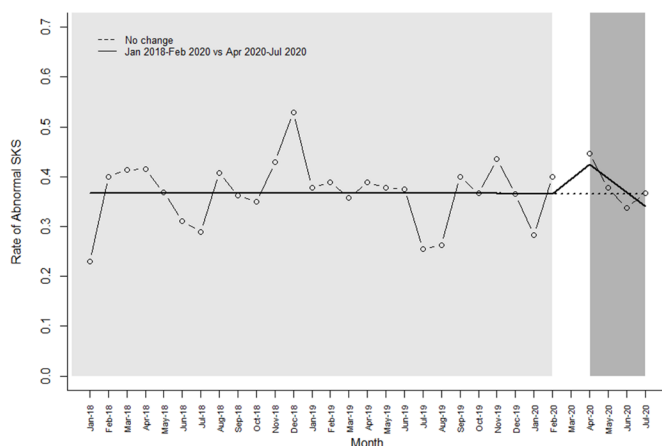


Figure 3 Time series demonstrating rate of abnormal skeletal surveys (SKS) over time with segmented trend both prelockdown and postlockdown implementation.

CONCLUSIONS

This study has not identified an increased incidence of death, incidence of skeletal trauma, severity of skeletal injury nor number or severity of head injury in children investigated for suspected abuse in England during the first lockdown period compared with the preceding 2 years. This radiological study mirrors the findings from studies in allied clinical disciplines across the globe

adding additional data regarding severity of abuse. Previous concerns regarding an increase in AHT as diagnosed by radiologists in the UK (based on a single-centre study) were likely due to the pressure on adult healthcare services necessitating reconfiguration of services to accommodate increasing numbers of adult patients and resulting in redeployment of paediatric care in a manner that would not have ordinarily occurred, hence resulting in a positive confounding effect.

Given these findings, it would appear that the multifactorial drivers for physical abuse of children in England leading to skeletal and/or brain injury were not compounded or exacerbated by the prolonged period of initial domicile lockdown. It will be important to confirm that these findings still hold true for further lockdowns in the UK and whether there was a rebound in such events following the full cessation of restrictions in the UK in August 2021. We suggest that a nationwide study may be beneficial in this regard.

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