Childhood, teenage and young adult cancer diagnosis during the first wave of the COVID-19 pandemic: a population-based observational cohort study in England

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ABSTRACT

Objective To investigate childhood, teenage and young adult cancer diagnostic pathways during the first wave of the COVID-19 pandemic in England.

Design Population-based cohort study.

Setting and participants QResearch, a nationally representative primary care database, linked to hospital admission, mortality and cancer registry data, was used to identify childhood, teenage and young adult cancers (0–24 years) diagnosed between 1 January 2017 and 15 August 2020.

Main outcomes Main outcomes of interest were: (1) number of incident cancer diagnoses per month, (2) diagnostic, treatment time intervals and (3) cancer-related intensive care admissions.

Results 2607 childhood, teenage and young adult cancers were diagnosed from 1 January 2017 to 15 August 2020; 380 were diagnosed during the pandemic period. Overall, 17% (95% CI −28.0% to −4.0%) reduction in the incidence rate ratio of cancers was observed during the pandemic. Specific decreases were seen for central nervous system tumour (−38% (95% CI −52% to −21%)) and lymphoma (−28% (95% CI −45% to −5%)) diagnoses. Additionally, childhood cancers diagnosed during the pandemic were significantly more likely to have intensive care admissions (adjusted OR 2.2 (95% CI 1.33 to 3.47)). Median time-to-diagnosis did not significantly differ across periods (+4.5 days (95% CI −20.5 to +29.5)), while median time-to-treatment was shorter during the pandemic (−0.7 days (95% CI −1.1 to −0.3)).

Conclusions Collectively, our findings of a significant reduction in cancer diagnoses and increase in intensive care admissions provide initial insight into the changes that occurred to childhood, teenage and young adult cancer diagnostic pathways during the first wave of the pandemic.

What is already known on this topic?

► Childhood, teenage and young adult cancers are a significant cause of cancer burden worldwide. Diagnostic delays are a long-standing challenge for cancers in this age group and now there is concern that this may be exacerbated due to the widespread disruptions to healthcare services during the COVID-19 pandemic.

What this study adds?

► In this population-based study, we observed significant falls in cancer detection and increase in intensive care admissions during the first wave of the pandemic.

How this study might affect research, practice or policy?

► Further research into changes to childhood, teenage and young adult cancer diagnostic pathways in subsequent waves is still required to identify any ongoing disruptions.

INTRODUCTION

The collateral impact of COVID-19 on cancer diagnosis has been a cause of great concern globally.[1] Significant disruptions in the provision of diagnostic cancer services have been observed, with several studies identifying delays in presentation.[2–5] Modelling studies have forecasted substantial increases in avoidable morbidity and mortality.[6 7] These findings have solely focused on adult cancers and little is known to what extent childhood, teenage and young adult (CTYA) cancer diagnoses have been affected.

CTYA cancers are a leading cause of mortality and morbidity worldwide.[8] Diagnostic delays have been a long-term challenge prior to the COVID-19 era[9] and there is a concern that extensive changes implemented to health services during the pandemic may disrupt established diagnostic pathways,[3 10 11] thereby introducing further delays. Yet, only three studies have explored the impact of the pandemic on diagnostic pathways for CTYA cancers,[12–14] all of which are limited by small hospital-based cohorts, and none of which capture changes in diagnostic patterns at a population level. More detailed exploration is needed to understand any disruptions and prevent additional long-term costs.

In the UK, although access to population-level, high-quality cancer data is available through national cancer registries, it often takes 18 months for official reporting, making time-critical research during the COVID-19 pandemic not possible using

Table 1 Baseline characteristics of study population for pandemic (1 February 2020–15 August 2020) and restricted pre-pandemic time periods (1 February 2019–15 August 2019, 1 February 2018–15 August 2018, 1 February 2017–15 August 2017)

	2017–2019 (Col %)	2020 (Col %)	P value
Total	1287	380	
Age	15 (6–21)	14 (6–21)	
Age group			
0–15 years	654 (50.8)	205 (53.9)	0.38
16–24 years	633 (49.2)	175 (46.1)	
Sex			
Female	588 (45.6)	168 (44.2)	0.73
Male	699 (54.4)	212 (55.8)	
Ethnicity			
White	652 (50.6)	185 (48.7)	0.75
Asian	121 (9.4)	27 (7.1)	
Black	57 (4.4)	11 (2.8)	
Other	78 (6.0)	25 (6.6)	
Not recorded	378 (29.7)	136 (34.7)	
Townsend quintile			
1 (lowest deprivation)	245 (19.0)	72 (18.9)	0.67
2	248 (19.1)	83 (22.8)	
3	278 (21.6)	71 (18.6)	
4	264 (20.5)	82 (21.6)	
5 (highest deprivation)	234 (18.2)	70 (18.4)	
Not recorded	18 (1.3)	4 (1.0)	
Region			
East Midlands	49 (3.9)	13 (3.8)	0.24
East of England	58 (4.3)	10 (3.1)	
London	312 (24.1)	101 (25.9)	
North East	19 (1.5)	10 (2.5)	
North West	188 (15.5)	55 (15.0)	
South Central	171 (13.5)	43 (11.2)	
South East	124 (9.4)	50 (12.9)	
South West	150 (11.6)	45 (11.7)	
West Midlands	161 (12.0)	40 (10.4)	
Yorkshire and Humber	55 (4.1)	13 (3.5)	

these registries. A unique and alternative approach is the use of large-scale national primary care datasets linked to hospital records, which offer access to individual-level data from the general population, with information on cancer diagnostic pathways closer to real time. Accordingly, using these linked electronic healthcare records, we sought to explore CTYA cancer diagnostic pathways during the pandemic by investigating changes in (1) rate of diagnoses, (2) diagnostic and treatment time intervals, and (3) cancer-related intensive care admissions between pre-pandemic and pandemic periods.

METHODS

Data sources

QResearch Database (V.45) is a national representative database consisting of 35 million anonymised health records from approximately 1300 general practices across England,[15] representing 20% of the population. The database has been extensively used for epidemiological, including COVID-19, research.[16]

Primary care medical records consist of patient-level demographic information and clinical records available through Read and SNOMED-CT codes. These records are linked to:

1. Hospital admission data in England via Hospital Episode Statistics (HES).[17]
2. Civil registration data, through Office for National Statistics.[18]
3. Cancer diagnosis/treatment via the National Cancer Registry and HES.

Data are linked at individual patient level using an anonymised identifier based on the National Health Service (NHS) number. The NHS number is valid and complete in 99.8% of primary care and civil registry data, as well as 98% of hospital admissions data.[15]

Study population and design

We undertook an open cohort study. The population was selected from a QResearch cohort of 5 099 095 CTYAs aged 0–24 years old (2 982 462 0–15 years and 2 116 633 16–24 years).

Any CTYAs with a diagnosis of the following cancers between 1 February 2017 and 15 August 2020 in England were identified: (1) central nervous system (CNS) tumours, (2) lymphomas (Hodgkin's and non-Hodgkin's), (3) leukaemias, (4) sarcomas (bone and soft tissue) and (5) renal tumours. Read, SNOMED-CT codes and International Classification of Diseases-10 (ICD-10) codes, which matched the cancer classifications defined by the International Classification of Diseases for Oncology,[19] were used to formulate each cancer group (online supplemental table 1).

Diagnoses between 1 February and 15 August 2020 were categorised as 'pandemic period' and between 1 January 2017 and 31 January 2020 as 'pre-pandemic period'.

As cancer registry data are not reported for 2020, we evaluated the completeness of the study population by investigating ascertainment, which we defined as the percentage of diagnoses reported by the national cancer registry captured through primary care and hospital records in 2017–2018. A total of 99.7% (868 of 871) of diagnoses reported by the cancer registry were captured by the combination of both records, indicating a high level of completeness. Accordingly, we used data available from primary care and hospital records to identify our cases.

Outcomes and exposure variables

Outcomes of interest were:

1. Number of incident cancer diagnoses per month: identified through Read/SNOMED-CT and ICD-10 codes. For duplicate recordings, the earliest date of diagnosis was used.
2. Intensive care unit (ICU) admissions: ICU admissions ≤14 days prior or on the day of diagnosis were defined as cancer-related ICU admissions.
3. Diagnostic time intervals: diagnostic time intervals were defined as the time from first medical presentation in primary care to confirmed diagnosis (ie, systemic time intervals).[9] Only a list of established pre-diagnostic symptoms (as detailed in the National Institute for Health and Care Excellence(NICE) Guideline for Suspected Cancer[20]) within 6 months from diagnosis was used to define 'first medical presentation' (online supplemental table 2).
4. Treatment time intervals: treatment time intervals were defined as the time from diagnosis to first date of treatment (chemotherapy, radiotherapy or surgery) within 30 days from diagnosis.

For outcomes 2–4, to ensure comparability across periods, the 'pre-pandemic period' was restricted to three time periods for selected analyses: 1 February−15 August 2017−2019.

Exposure variables previously found to be associated[21] with diagnostic time intervals in CTYA cancers were predefined and identified through primary care records. These were age (0–15 years for childhood cancers, 16–24 for TYA cancers), sex (female/male) and deprivation level. Deprivation level was assessed using the Townsend Deprivation Score.[22 23]

Statistical analysis

We carried out an interrupted time-series analysis across the full study period, by fitting a Poisson regression model, to explore cancer diagnosis incidence rates. The model included a time variable and dummy 'pandemic' variable (separating pre-pandemic and post-pandemic periods). We investigated the immediate effect of the pandemic on the number of cancer diagnoses per month. The model was assessed for overdispersion, autocorrelation or heteroskedasticity. To account for seasonality, we carried out a sensitivity analysis using two Fourier terms in our model. Further, we used Poisson regression in a sensitivity analysis using the restricted three pre-pandemic periods.

For analyses investigating ICU admissions, logistic regression was used to compare admissions across pandemic and restricted three pre-pandemic periods. Sensitivity analyses using the full study period as well as excluding surgical ICU admissions were also carried out. Univariable models and multivariable models were adjusted for the following a priori defined variables: age, sex, tumour type and deprivation level. All models accounted for the correlation due to clustering of children within practices through a robust variance estimator.

For analyses exploring diagnostic and treatment time intervals, 25th centile, median and 75th centile time-to-diagnosis were calculated using quantile regression with bootstrap method for SEs. Quantile regression was chosen due to the non-normal distribution of diagnostic and treatment time intervals in our cohort. A sensitivity analysis using the full study period was also carried out.

Analyses were carried out using R (V.4.0) and STATA (V.16, StataCorp).

Our study was conducted in line with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.[24]

RESULTS

There were 2607 individuals with a CTYA cancer diagnosis during our study period (1 January 2017–15 August 2020); 380 diagnosed during the pandemic and 1287 diagnosed during the restricted three pre-pandemic periods (table 1, online supplemental table 3). Across the pandemic and pre-pandemic periods, there was a similar distribution of female sex, deprivation level, ethnicity and geographical region in CTYA diagnosed with cancer (table 1).

There was a median of 60.8 CTYA cancer diagnoses per month in the pre-pandemic period compared with 55.8 CTYA cancer diagnoses per month in the pandemic period (table 2, figure 1). The pandemic was associated with a 17% (95% CI −28.0% to −4.0%, p=0.009) relative reduction in all cancer diagnoses per month. Specifically, there was a 38% reduction (95% CI −52% to −21%, p<0.001) for CNS tumour diagnoses across all ages, with a 41% reduction (95% CI −58% to −16%, p=0.003) noted in childhood CNS tumour diagnoses and 36% reduction (95% CI −55% to −8%, p=0.02) in TYA CNS tumour diagnoses per month (online supplemental figure 1). A 28% reduction (95% CI −45% to −5%, p=0.02) was observed for lymphoma diagnoses overall, with a 29% decrease (95% CI −49% to −2%, p=0.04) noted for TYA lymphoma diagnoses. We did not detect any significant change in incidence rates for leukaemias, sarcomas and renal tumours associated with the pandemic. We added two Fourier terms to account for seasonality and found that our results remained similar (online supplemental table 4). A sensitivity analysis comparing the restricted pre-pandemic periods with the pandemic period demonstrated similar results overall with an additional statistically significant

Table 2 Interrupted time-series Poisson regression analysis for the impact of the COVID-19 pandemic on number of cancer diagnoses per month, *statistically significant <0.05

	2017–2019 (n, 95% CI)	2020 (n, 95% CI)	IRR (95% CI)	P value
All ages				
All tumour types	60.8 (58.4 to 63.4)	55.8 (50.0 to 62.1)	0.83 (0.72 to 0.96)	0.009*
CNS tumours	20.3 (18.8 to 21.8)	16.5 (13.4 to 20.1)	0.62 (0.48 to 0.79)	<0.001*
Lymphomas	15.4 (14.1 to 16.7)	14.0 (11.2 to 17.3)	0.72 (0.55 to 0.95)	0.02*
Leukaemia	14.9 (13.7 to 16.2)	17.0 (13.9 to 20.6)	1.07 (0.81 to 1.39)	0.6
Sarcoma	11.4 (10.3 to 12.5)	8 (5.9 to 10.6)	0.81 (0.57 to 1.16)	0.2
Renal tumours (inc. Wilm's)	2.7 (2.2 to 3.3)	2 (1.0 to 3.5)	1.11 (0.53 to 2.33)	0.7
Childhood cancers (age range 0–15 years)				
All tumour types	30.9 (29.2 to 32.7)	30.2 (25.9 to 34.9)	0.91 (0.75 to 1.1)	0.3
CNS tumours	10.8 (9.8 to 11.9)	8.7 (6.5 to 11.4)	0.59 (0.42 to 0.84)	0.003*
Lymphomas	4.1 (3.4 to 4.8)	4 (2.6 to 6.0)	0.76 (0.45 to 1.28)	0.3
Leukaemia	10.4 (9.4 to 11.5)	11.8 (9.2 to 14.9)	1.13 (0.82 to 1.56)	0.5
Sarcoma	5.5 (4.8 to 6.4)	5.3 (3.6 to 7.5)	0.97 (0.61 to 1.55)	0.6
Renal tumours (inc. Wilm's)	2.2 (1.8 to 2.8)	1.3 (0.6 to 2.6)	1.03 (0.43 to 2.49)	0.9
Teenage and young adult cancers (age range 16–24 years)				
All tumour types	29.9 (28.1 to 31.7)	25.8 (21.9 to 30.2)	0.76 (0.62 to 0.94)	0.009*
CNS tumours	9.4 (8.5 to 10.5)	7.8 (5.8 to 10.4)	0.64 (0.45 to 0.92)	0.02*
Lymphomas	11.3 (10.3 to 12.5)	10.0 (7.6 to 12.9)	0.71 (0.51 to 0.98)	0.04*
Leukaemia	4.5 (3.9 to 5.3)	5.2 (3.5 to 7.3)	0.93 (0.57 to 1.50)	0.8
Sarcoma	5.9 (5.1 to 6.7)	2.7 (1.5 to 4.3)	0.60 (0.34 to 1.08)	0.09

CNS, central nervous system; IRR, incidence rate ratio.

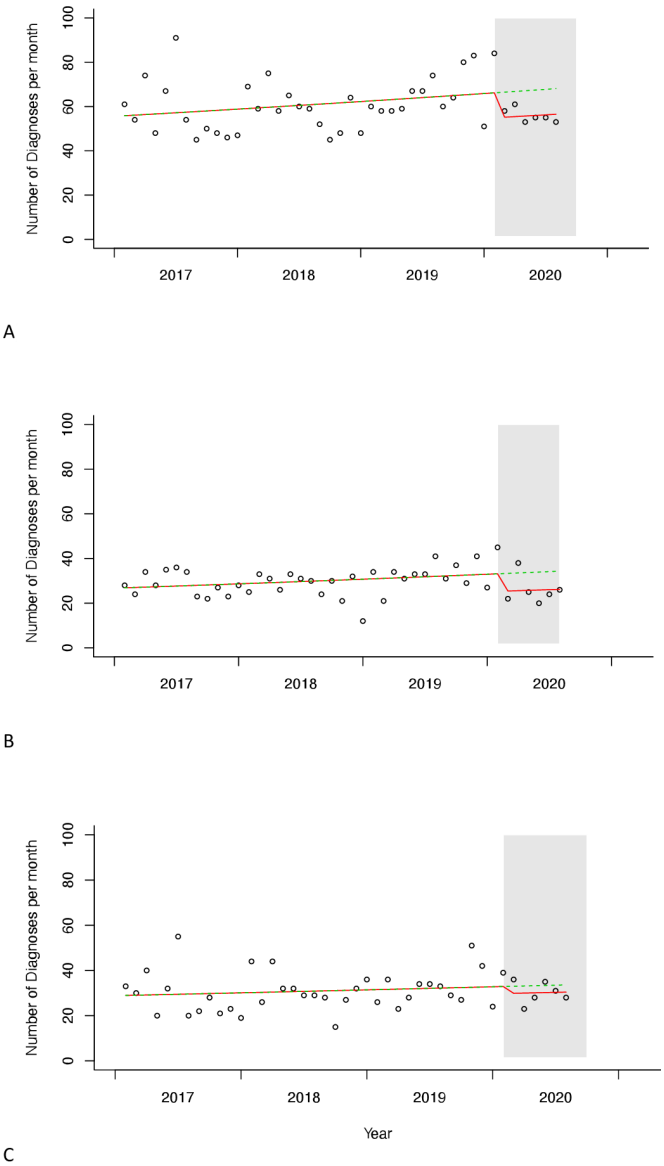

Figure 1 Interrupted Poisson regression time-series analysis of incident cancer diagnoses per month in England before and during the COVID-19 pandemic. (A) All cancer diagnoses, (B) TYA cancer diagnoses, (C) childhood cancer diagnoses. TYA, teenage and young adult.

decrease observed in sarcoma diagnoses per month (online supplemental table 5).

There were 215 CTYAs with a diagnosis of cancer who had a recorded medical presentation in primary care records prior to a diagnosis of cancer (table 3). The median time-to-diagnosis did not significantly differ between pre-pandemic or pandemic periods in univariable (+7 days (95% CI −18.1 days to 32.7 days)) or adjusted models (+4.5 days (95% CI −20.5 days to +29.5 days)). Similarly, no significant difference was observed when cancer type was stratified (haematological: −6.5 days (−29.1 days to +16.1 days) and solid tumour: +8 days (−26.3 days to +42.3 days), respectively) or when the full study period was used (online supplemental table 6).

There were 1127 CTYA cancer diagnoses with a recorded first treatment given within 30 days from diagnosis (table 4). The median time-to-treatment was 2 days in the pre-pandemic and 1 day in the pandemic period. The median time-to-treatment was shorter in the pandemic period in adjusted models (−0.7 days (95% CI −1.1 days to −0.3 days), p=0.006). Time-to-treatment at the 75th centile similarly was shorter in the pandemic compared with the pre-pandemic period in adjusted models (−3.3 days (95% CI −4.4 days to −2.2 days), p<0.001). No significant difference was observed when the full study period was used (online supplemental table 7).

There were 108 (8.4%, (108 of 1287)) recorded cancer-related ICU admissions during the pre-pandemic and 48 (12.6%, (48 of 380)) during the pandemic period (table 5, online supplemental table 8). Most admissions were related to CNS tumour diagnoses (pre-pandemic=67% (72 of 108), pandemic=63% (30 of 48)) and leukaemia diagnoses (pre-pandemic=14% (15 of 108), pandemic=25% (12 of 48)). Childhood cancers diagnosed in the pandemic period were significantly more likely to have had an ICU admission prior to diagnosis (adjusted OR 2.2 (95% CI 1.33 to 3.47), p=0.002). ICU admissions for TYA cancers were comparable across the pre-pandemic and pandemic periods (adjusted OR 1.1 (95% CI 0.54 to 2.2), p=0.8). A sensitivity analysis excluding surgical ICU admissions showed similar odds of ICU admissions prior to childhood cancer diagnosis (adjusted OR 2.0 (95% CI 1.15 to 3.55), p=0.01).

DISCUSSION

This is the first population-based study to explore CTYA cancer diagnostic pathways during the first wave of the COVID-19 pandemic. This study reports on outcomes related to cancer diagnostic pathways in the UK while accounting for relevant sociodemographic confounders.

The main finding of our study is the statistically significant decrease in incident number of CTYA cancers observed during the COVID-19 pandemic. This decrease has previously been reported for paediatric cancers in single-institution studies based in the USA, Italy and Norway,[12–14] and across several population-based adult cancer studies in the UK[3 25] and Europe.[5] Our study adds to these findings through a nationally representative and larger cohort, inclusive of teenage and young adult cancers. The underlying reasons for this observed fall in CTYA cancer diagnoses are likely to be complex. In the UK, for example, a large nationally representative survey identified substantial changes in health-seeking behaviour in adult patients with cancer, due to a combination of patient concern and barriers to primary care access, which resulted in diagnostic delays.[26]

In our study, we observed that the fall in incident cancer diagnoses was particularly apparent in TYA. The underlying reasons for this observation are also likely to be multifactorial. First, TYAs more commonly seek initial medical advice from primary care prior to a cancer diagnosis[27] and have referral pathways more similar to adult cancer services, such as the 2-week wait referral system.[28] This is in contrast to children with suspected cancer, who are more frequently referred immediately to the emergency department.[29] We also found that the fall in incident diagnoses was specific to certain tumour types, including CNS tumours and lymphomas. These tumour types, particularly TYA lymphomas, are known to have protracted patient intervals and subsequent delays in presentation.[21 30] Pandemic-related changes in health-seeking behaviour could provide an explanation to our findings.

We also identified increased odds of cancer-related intensive care admissions during the pandemic. This is despite the well-documented pressures on intensive care settings.[31] There are several reasons why CTYA get admitted to ICUs prior to a

Table 3 Comparison of diagnostic time intervals for all, haematological and solid CTYA cancers across pre-pandemic (February–August 2017–2019) and pandemic (February–August 2020) periods using quantile regression (results presented for 25th, 50th and 75th percentiles)

	Time from first presentation to diagnosis		Model estimates			
Percentile	2017–2019 (days, 95% CI)	2020 (days, 95% CI)	Unadjusted (days, 95% CI)	P value	Adjusted* (days, 95% CI)	P value
Any cancer (n=215)						
25th	8 (5 to 10)	6 (3 to 14)	−2 (−9.9 to +5.9)	0.6	+3.6 (−6.1 to +8.1)	0.8
50th	23 (11 to 29)	29 (13 to 50)	+7 (−18.1 to 32.7)	0.6	+4.5 (−20.5 to +29.5)	0.5
75th	64 (57 to 80)	69 (42 to 105)	+5 (−16.7 to +26.7)	0.8	+8.3 (−15.7 to +42.2)	0.4
Haematological cancers (n=84)						
25th	6 (3 to 14)	4 (1 to 12)	−2 (−9.5 to +5.51)	0.8	−1 (−23.3 to +21.3)	0.9
50th	20 (11 to 30)	13 (4 to 57)	−6 (−39.2 to +27.2)	0.7	−6.5 (−29.1 to +16.1)	0.6
75th	72 (32 to 110)	60 (17 to 106)	−10 (−77.7 to +57.7)	0.5	−12 (−45.2 to +21.2)	0.5
Solid cancers (n=131)						
25th	9 (6 to 14)	13 (1 to 12)	+5 (−4.0 to +14.0)	0.5	+6 (−10.1 to +22.1)	0.2
50th	23 (19 to 42)	31 (15 to 72)	+9 (−26.4 to +44.4)	0.6	+8 (−26.3 to +42.3)	0.6
75th	64 (57 to 79)	83 (39 to 128)	+14 (−30.2 to +58.3)	0.8	−10 (−54.6 to +34.7)	0.7

*Adjusted for age, sex, deprivation level for haematological and solid cancers; adjusted for age, sex, deprivation level and tumour type for all cancers.
CTYA, childhood, teenage and young adult.

cancer diagnosis, ranging from reasons independent of disease severity (eg, surgery for full-excision biopsy of solid tumours), to management of time-critical emergencies.[32] To specifically explore ICU admissions related to disease severity, we carried out a sensitivity analysis excluding surgical ICU admissions. We still report a statistically significant increased likelihood of cancer-related ICU admissions in children. One possible explanation is more severe baseline disease at diagnosis, which may result from delayed presentations. Similarly, delayed presentation during the pandemic have also been implicated in other childhood-onset diseases, such as type 1 diabetes in the UK.[33] COVID-19 infections may represent another possibility for ICU admission, however previous studies have shown that CTYAs undergoing cancer treatment do not get more severe COVID-19.[34] Further studies specifically exploring cancer-related ICU admissions are needed to provide further insight into our findings.

We did not identify a significant difference in diagnostic time intervals in CTYA during the pandemic period. In addition, we found that treatment time intervals were in fact marginally shorter during the pandemic. Collectively, these results may reflect that for CTYA cancer pathways, systems-level primary and secondary care intervals were similar across pre-pandemic and pandemic periods. Unlike adult cancer services, childhood and adolescent cancer services remained operational during the pandemic in the UK, which may explain these findings. Nevertheless, we cannot fully explore all systems-level intervals in this study, as we were unable to investigate diagnostic time intervals in CTYA who presented directly to secondary care (eg, emergency department).

Our study has important limitations. First, as CTYA cancers are rare and our cohort is representative of 20% of the population, we may not have sufficient power to capture changes in diagnostic pathways for rarer tumour types such as renal tumours. Second, we only had data available for the first wave of the pandemic. Evaluation of subsequent waves is still required. Third, due to limited understanding of presenting features of CTYA cancers, we were unable to capture all associated pre-diagnostic symptoms and decided to use an established but concise list of symptoms provided by NICE. This might result in the underascertainment of CTYA cancers presenting via the primary care route and affect our findings on diagnostic time intervals. Fourth, we were unable to capture delays in patient intervals, as this is not recorded in electronic health records. Fifth, our datasets did not provide cancer stage information, which is crucial to determining disease severity. Finally, as this study is an observational study based on linked datasets, it is not possible to generate causal

Table 4 Comparison of treatment time intervals for all CTYA cancers across pre-pandemic (February–August 2017–2019) and pandemic (February–August 2020) periods, using quantile regression (results presented for 50th and 75th percentiles)

	Time from diagnosis to first treatment		Model estimates			
	2017–2019 (days)	2020 (days)	Unadjusted (days, 95% CI)	P value	Adjusted* (days, 95% CI)	P value
Any cancer (n=1127)						
50th	2	1	−1 (−1.43 to −0.56)	<0.001†	−0.7 (−1.13 to −0.33)	0.006†
75th	7	3.75	−4 (−5.2 to −2.85)	<0.001†	−3.3 (−4.40 to −2.20)	<0.001†
Haematological cancers (n=682)						
50th	3	1	−2 (−2.96 to −1.03)	<0.001†	−0.94 (−2.1 to +0.2)	0.1
75th	8	4	−4 (−6.0 to −1.8)	<0.001†	−4.3 (−6.2 to −2.30)	<0.001†
Solid cancers (n=449)						
50th	1	1	0 (−0.81 to +0.81)	1	−0.6 (−1.3 to +0.10)	0.09
75th	5	3	−2 (−3.15 to −0.85)	0.001†	−2.1 (−4.18 to −0.07)	0.04†

*Adjusted for age, sex, deprivation level and tumour type for all cancers; sex, deprivation level and tumour type for subgroups of cancers.
†Treatment time interval was 0 at 25th centile for pandemic and pre-pandemic periods.
CTYA, childhood, teenage and young adult.

Table 5 Comparison of the number of ICU admissions diagnosed CTYA cancers across pre-pandemic (February–August 2017–2019) and pandemic (February–August 2020) periods for (1) all ages, (2) childhood cancers (0–15 years) and (3) TYA cancers (16–24 years)

	Number of ICU admissions		Model estimates			
	2017–2019 (n, %)	2020 (n, %)	Unadjusted (OR, 95% CI)	P value	Adjusted* (OR, 95% CI)	P value
All	**108/1287 (8.4)**	**48/380 (12.6)**	**1.53 (1.07–2.18)**	**0.02***	**1.73 (1.18–2.53)**	**0.005***
Tumour type						
CNS tumour	72/405 (17.8)	30/103 (29.1)	1.9 (1.16 to 3.12)	0.01*	2.12 (1.28 to 3.51)	0.004*
Lymphoma	14/300 (4.7)	3/96 (3.0)	0.6 (0.18 to 2.27)	0.5	0.6 (0.18 to 2.26)	0.5
Leukaemia	15/295 (5.1)	12/112 (10.7)	2.2 (1.01 to 4.95)	0.04*	2.4 (1.02 to 5.75)	0.04*
Sarcoma	3/232 (1.3)	3/51 (5.9)	4.8 (0.93 to 24.4)	0.06	3.2 (0.68 to 15.6)	0.1
Age category						
0–15 years	64/654 (9.8)	35/205 (17.1)	1.90 (1.23 to 2.93)	0.004*	2.2 (1.33 to 3.47)	0.002*
16–24 years	44/633 (7.0)	13/175 (7.4)	0.98 (0.52 to 1.85)	0.9	1.1 (0.54 to 2.2)	0.8
Surgical cases excluded						
All	60/1239 (4.8)	25/357 (7.0)	1.47 (0.91 to 2.40)	0.1	1.62 (0.97 to 2.71)	0.04*
0–15 years	43/633 (6.8)	23/193 (11.9)	1.85 (1.09 to 3.17)	0.02*	2.0 (1.15 to 3.55)	0.01*
16–24 years	17/606 (2.8)	2/164 (1.2)	0.43 (0.1 to 1.87)	0.3	0.47 (0.1 to 2.16)	0.3

*Adjusted for age, sex, deprivation level and tumour type for all cancers; adjusted for age, sex, deprivation level for tumour subtypes; adjusted for sex, deprivation level and tumour type for different age categories.
CNS, central nervous system; CTYA, childhood, teenage and young adult; ICU, intensive care unit.

interpretations. Residual confounding due to unaccounted confounders and information bias due to misclassification may exist, although cancer rate estimates on QResearch are representative of national cancer rates.[33]

Collectively, our findings of a significant reduction in cancer diagnoses and increase in intensive care admissions provide initial insight into the changes observed for CTYA cancer diagnostic pathways during the first wave of the pandemic. Ongoing investigation of these cancer diagnostic pathways in subsequent waves is still needed.

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Contributors DS, AH and JH-C contributed to study concept. DS, JH-C and JO contributed to the study design. DS led the data acquisition, data analysis and drafting of the manuscript. All authors contributed to the interpretation of the data and critical revision of the manuscript for important intellectual content. DS was supervised by JH-C and AH. DS and JH-C had full access to all the data in the study and act as guarantors, take responsibility for the integrity of the data and the accuracy of the data analysis.

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