Global effect of the COVID-19 pandemic on paediatric cancer care: a cross-sectional study

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Summary

Background Although mortality due to COVID-19 has been reportedly low among children with cancer, changes in health-care services due to the pandemic have affected cancer care delivery. This study aimed to assess the effect of the COVID-19 pandemic on childhood cancer care worldwide.

Methods A cross-sectional survey was distributed to paediatric oncology providers worldwide from June 22 to Aug 21, 2020, through the St Jude Global Alliance and International Society for Paediatric Oncology listservs and regional networks. The survey included 60 questions to assess institution characteristics, the number of patients diagnosed with COVID-19, disruptions to cancer care (eg, service closures and treatment abandonment), adaptations to care, and resources (including availability of clinical staff and personal protective equipment). Surveys were included for analysis if respondents answered at least two thirds of the items, and the responses were analysed at the institutional level.

Findings Responses from 311 health-care professionals at 213 institutions in 79 countries from all WHO regions were included in the analysis. 187 (88%) of 213 centres had the capacity to test for SARS-CoV-2 and a median of two (range 0–350) infections per institutution were reported in children with cancer. 15 (7%) centres reported complete closure of paediatric haematology-oncology services (median 10 days, range 1–75 days). Overall, 2% (5 of 213) of centres were no longer evaluating new cases of suspected cancer, while 43% (90 of 208) of the remaining centers described a decrease in newly diagnosed paediatric cancer cases. 73 (34%) centres reported increased treatment abandonment (ie, failure to initiate cancer therapy or a delay in care of 4 weeks or longer). Changes to cancer care delivery included: reduced surgical care (153 [72%]), blood product shortages (127 [60%]), chemotherapy modifications (121 [57%]), and interruptions to radiotherapy (43 [28%] of 155 institutions that provided radiotherapy before the pandemic). The decreased number of new cancer diagnoses did not vary based on country income status (p=0·14). However, unavailability of chemotherapy agents (p=0·022), treatment abandonment (p<0·0001), and interruptions in radiotherapy (p<0·0001) were more frequent in low-income and middle-income countries than in high-income countries. These findings did not vary based on institutional or national numbers of COVID-19 cases. Hospitals reported using new or adapted checklists (146 [69%] of 213), processes for communication with patients and families (134 [63%]), and guidelines for essential services (119 [56%]) as a result of the pandemic.

Interpretation The COVID-19 pandemic has considerably affected paediatric oncology services worldwide, posing substantial disruptions to cancer diagnosis and management, particularly in low-income and middle-income countries. This study emphasises the urgency of an equitably distributed robust global response to support paediatric oncology care during this pandemic and future public health emergencies.

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For the Spanish translation of the abstract see Online for appendix 1

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Introduction

To date, COVID-19 has resulted in 2·4 million deaths and strained hospitals and health-care systems worldwide.[1] Fortunately, most children have a milder disease course than do adults.[2] Initial reports suggested that patients with comorbidities were at higher risk of worse outcomes, causing widespread fear that children with cancer would develop severe disease. In a large international sample of paediatric oncology patients with confirmed COVID-19, death attributed to the infection is approximately 4%.[3] Although higher than reported in the general paediatric population,[4] this value is lower than the 13% in an analogous registry reporting outcomes of adults with cancer.[5] Studies of paediatric oncology centres have shown few cases among children with cancer even in COVID-19 prevalent areas.[6–8] However, SARS-CoV-2 infection is not the only threat to children with cancer. Paediatric oncology care is reliant on prompt evaluation and diagnosis, referral to tertiary centres, multidisciplinary subspecialised teams, timely and coordinated multimodal therapy, and access to supportive care, all of which have been affected by this pandemic.[9–11]

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Research in context

Evidence before this study

Previous studies examining the effect of the COVID-19 pandemic on paediatric cancer care have been national or regional in nature. We searched PubMed with no language restrictions for research articles published between Jan 1 and Sept 24, 2020, describing the effect of COVID-19 on paediatric oncology care using the terms: "paediatric," "cancer," "COVID-19," and synonyms. We found 470 articles, many of which have been published as brief reports. Existing literature shows substantial delays in presentation and care, including for chemotherapy, radiotherapy, and surgical services. Although these reports provide valuable and timely information during the emerging pandemic, no previous publications incorporated data collected from all regions.

Added value of this study

We report the first global assessment of the effect of the COVID-19 pandemic on paediatric oncology care, which includes data from 213 institutions in 79 countries. This assessment includes an analysis of the effect based on country income level and COVID-19 burden. Our results suggest that paediatric cancer care has been affected globally. This effect is more pronounced in low-income and middle-income countries and does not depend on institutional or national number of positive COVID-19 cases.

Implications of all the available evidence

Our findings emphasise the need for continued global prioritisation of paediatric cancer care and equitable distribution of global resources to support treatment continuity during the COVID-19 pandemic and future public health emergencies.

Access to quality care for children with cancer was inadequate before the COVID-19 pandemic in many countries,[12] and there were concerns about the impact of the pandemic on paediatric cancer care, such as delayed cancer diagnosis, chemotherapy shortages, and decreased access to surgery, radiation therapy, and supportive care.[13] Institutions in high-income countries such as the USA[14] and Italy[15] reported unusual critical presentations of paediatric cancer that were thought to be secondary to delayed diagnosis. Furthermore, reports from low-income and middle-income countries emphasised the impact of the pandemic on medication and personal-protective equipment (PPE) availability.[16]

Regional studies in low-income and middle-income countries have shown the substantial effect of the COVID-19 pandemic on care, including treatment disruptions and delays, even with the consistent application of published guidance documents.[10] In Latin America, these effects were shown to be independent of COVID-19 disease burden and national health-care expenditure.[11] As all analyses thus far have been either national or regional in scope, this study aimed to assess the effect of COVID-19 on paediatric cancer services globally, evaluate the relative effect on the basis of national indicators, and describe adaptations to care implemented by paediatric oncology providers.

Methods

Study design and participants

See **Online** for appendix 2

A cross-sectional survey with 60 items was designed to capture the global effect of COVID-19 on care for children with cancer (appendix 2 p 2). The survey was distributed through the St. Jude Global Alliance and International Society for Paediatric Oncology listservs and regional networks using an electronic link with direct input to a secure database. Recipients included professionals of all cadres who care for children with cancer. The survey was open from June 22 to Aug 21, 2020, and participation in the survey was voluntary. This study was exempted by the institutional review board at St. Jude Children's Research Hospital.

Procedures

Items were initially developed by the first author (DG) and a senior author (DCM), and iteratively revised by the research team. Survey items focused on broad domains comprising cancer care disruptions, including service closures and numbers of patients accessing or abandoning care; cancer care adaptations, such as new policies and areas that had received increased or decreased attention due to the pandemic; and resources, including staff, supplies and financial resources. Covariates included hospital characteristics such as country income group, type of hospital, and hospital funding, as well as information about COVID-19 including number of patients who had tested positive for COVID-19 at the institutions, and national indicators for COVID-19, including incidence and mortality. Items were formulated as multiple-choice questions with open text field answers available if necessary. Some items, mainly those evaluating cancer care adaptations, included categorical responses in which participants could select more than one option, if applicable.

Statistical analysis

Surveys were included for analysis if respondents answered at least two thirds of the items. This threshold was chosen as it indicated respondents answered questions pertaining to hospital characteristics, and cancer care disruptions and adaptations. Data were analysed at the level of the institution to minimise bias from institutions with multiple responses. If an institution had multiple responses, the unit director's responses were prioritised. If no unit director completed the survey,

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responses were selected on the basis of participant role following a logic that prioritised oncologists for cancer-associated questions and infectious disease specialists for questions specific to COVID-19. If multiple providers with the same role at an institution responded, the mean of their responses was used for numerical data and the mode of responses was used for categorical data. For questions regarding chemotherapy, only responses from paediatric hematologists-oncologists were included and these were analysed as individual responses. For multiple-choice questions with the possibility of more than one response, selected options from all respondents were included. Formal qualitative data analysis was not pursued; however, open text field answers to survey questions were used to clarify other data or missing data as much as possible.

Independent variables used included in univariate and multivariable analyses included country and hospital characteristics and COVID-19 burden, defined as the number of COVID-19 cases and COVID-related mortality rate within a country. National indicators were obtained from the World Bank Open Data platform and used to define country characteristics. Data regarding SARS-CoV-2 incident cases and mortality from July 22, 2020 (the mid-point of the survey timeframe) were extracted from the WHO Coronavirus Disease Dashboard. Institutions were grouped on the basis of country characteristics and COVID-19 burden. Descriptive statistics were used to analyse all items. Fisher's exact test and χ^2 tests were done to compare rates across groups. Univariate and multivariable logistic regression were used to identify factors affecting use of the health service. Factors significant in univariate analyses were included in the multivariable models and odds ratios and 95% CIs were calculated. A hierarchical logistics regression model was not deemed feasible due to small sample sizes when institutions were divided on the basis of country or hospital characteristics. For all analyses, a p value of less than 0·05 was considered statistically significant.

Analyses were done using SAS software, version 9.4, and R version 4.0.0.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

The survey was open from June 22 to Aug 21, 2020. Of 560 responses, 311 (56%) participants met the threshold of completion and were included for analysis. Among the 249 excluded responses, the median completion rate was 5% of survey items. Participants worked at 213 unique institutions in 79 countries from all WHO regions (figure 1). The responding institutions were mainly located in low-income and middle-income countries. Respondents were primarily paediatric haematologist-oncologists (220 [71%] of 311) but also included infectious disease specialists, other physicians, and nurses (table 1). Most institutions were public or government hospitals and provided care to adults as well as children. Most hospitals (195 [92%] of 213) had ward beds specifically dedicated to paediatric oncology, with a median of 22 beds. Additionally, 116 (54%) institutions reported seeing less than 100 new children with cancer each year.

For more on the **World Bank Open Data platform** see https://data.worldbank.org/

For the **WHO Coronavirus Disease Dashboard** see https://covid19.who.int/

187 (88%) of 213 institutions were able to test for SARS-CoV-2 (table 1). The number of paediatric patients with cancer testing positive for COVID-19 ranged from 0 to 350, with a median of two positive cases per institution.

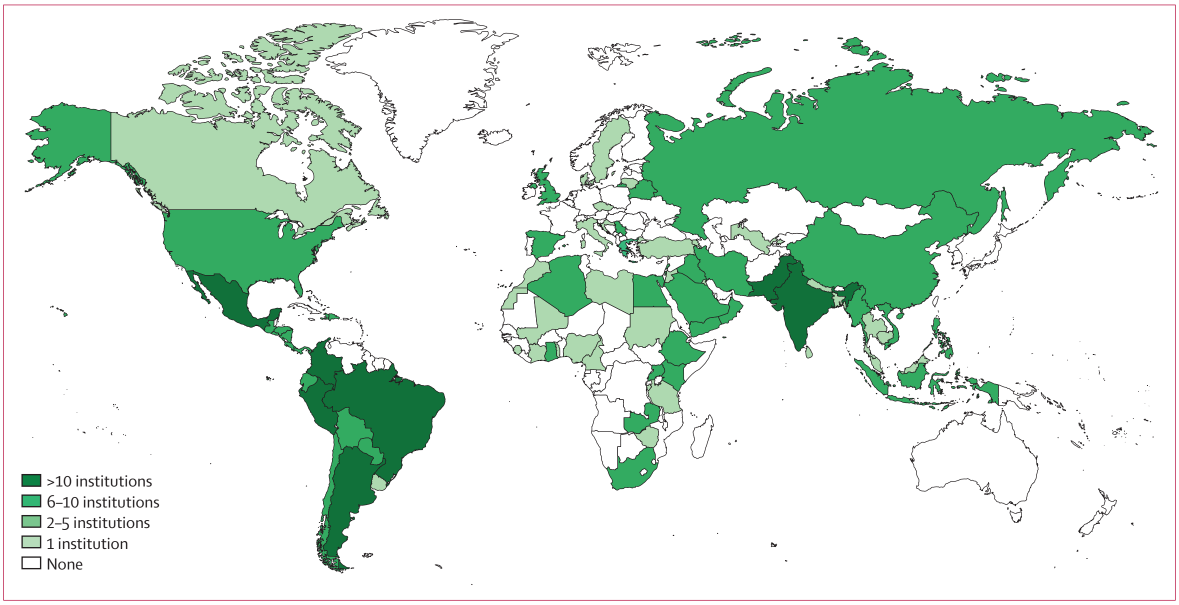

Figure 1: **Countries from which survey responses were received**

	n (%)
Respondent role	
Paediatric haematologist-oncologist (medical staff)	144/311 (46%)
Paediatric haematologist-oncologist (unit director)	76/311 (24%)
Infectious disease specialist	12/311 (4%)
Trainee (resident, fellow)	8/311 (3%)
Other physician	36/311 (12%)
Nurse	23/311 (7%)
Nurse director	4/311 (1%)
Other	8/311 (3%)
Work Bank group of responding institutions	
Low-income countries	13/213 (6%)
Lower middle-income countries	58/213 (27%)
Upper middle-income countries	105/213 (49%)
High-income countries	37/213 (17%)
Type of hospital	
General and general oncology	142/213 (67%)
Paediatric and paediatric oncology	71/213 (33%)
Hospital category	
Public or government	151/213 (71%)
Private or for-profit	62/213 (29%)
Average number of children diagnosed with cancer annually at each hospital	
<20	21/213 (10%)
20–49	47/213 (22%)
50–99	48/213 (23%)
100–299	59/213 (28%)
≥300	31/213 (15%)
Unsure	7/213 (3%)
Availability of COVID-19 testing at institutions	
Yes	187/213 (88%)
No	22/213 (10%)
Missing	4/213 (2%)
Routine screening for SARS-CoV-2	
Symptoms or exposure	189/213 (89%)
Temperature check	143/213 (67%)
SARS-CoV-2 testing	105/213 (49%)
No screening	10/213 (5%)
Patients positive for COVID-19 at institutions	
<10	42/187 (22%)
10–100	27/187 (14%)
>100	57/187 (30%)
Missing	33/187 (18%)
Unsure	28/187 (15%)

Data are n/N (%).

Table 1: **Respondent and institution characteristics**

52 (24%) institutions reported no confirmed cases of SARS-CoV-2 in children with cancer. 52 (24%) institutions reported perceived or explicit censorship on reporting patients with COVID-19.

167 (78%) of 213 institutions reported that COVID-19 had an effect on the capacity to provide care for children with cancer, with disruptions to patient support (psychological, social, financial support and education for patients and families), cancer-directed treatment, and availability of clinical staff being the most frequently cited effects (figure 2A). 15 (7%) hospitals reported complete closure of their paediatric haematology-oncology services, with a median closure time of 10 days (range 1–75 days). 41 (19%) of 213 institutions noted a reduction in available paediatric oncology beds during this time. Of the included institutions, 2% (5 of 213) were no longer evaluating new cases of suspected cancer, while 43% (90 of 208) of the remaining centers described a decrease in newly diagnosed paediatric cancer cases. 73 (34%) of 213 institutions reported a decrease in treatment continuation (ie, increase in treatment abandonment), defined as failure to initiate cancer therapy or a delay in care of 4 weeks or longer.[17] In addition to the effect on diagnoses and ongoing treatment, 59% (126 of 213) of institutions reported a decrease in surveillance evaluations for patients who had completed therapy (figure 2B).

About half of the institutions (106 of 213) included in this survey noted a decrease in resources (financial or otherwise) since the start of the pandemic. About a third of institutions (68 of 213) described decreased financial support from public or governmental institutions. 141 (66%) of 213 institutions also described a reduction in the availability of clinical staff and 41 (19%) described a decrease in the number of available paediatric oncology beds. The main reasons for decreased staffing availability in 141 institutions included COVID-19 infection among staff (85 [60%]) and quarantine due to exposure (105 [74%]). 18 (8%) of 213 hospitals reported a death from COVID-19 in staff that cared for children with cancer and 107 (50%) institutions reported not always having the necessary PPE for staff.

Multiple elements of paediatric cancer management were affected across institutions (figure 2C). Among 121 institutions describing changes to chemotherapy management, 84 (69%) reported a decrease in dose intensity, 59 (49%) reported a modification from intravenous to oral formulations, and 25 (21%) reported a complete discontinuation of chemotherapy for patients. 127 (60%) of 213 institutions reported less availability of blood products, and 11 (9%) centres categorised this shortage as critical (ie, less than 25% of transfusions could be done). 153 (72%) institutions described decreased availability of surgical services, with 13 (6%) describing the complete discontinuation of surgical procedures. Of the 155 centres (73%) providing radiotherapy before the pandemic, 15 (10%) reported a complete discontinuation of radiotherapy and 31 (20%) stated that only urgent radiotherapy was being administered. 38 (18%) of 213 hospitals stated that paediatric patients with cancer had additional barriers to accessing life-saving interventions (eg, transfer to intensive care) during the pandemic. When assessing the overall effect of the pandemic, participants at 54 (25%) institutions believed that a child at their institution had suffered a severe complication that would not have happened before the pandemic, while respondents from 42 (20%) centres thought a patient death had occurred as a result of the pandemic. Delayed presentation to hospitals was the most frequently mentioned cause of these complications.

Although most (13 [87%] of 15) hospitals that completely closed their paediatric oncology units during the pandemic were located in low-income and middle-income countries, two closures were reported in high-income countries. Institutions in low-income and middle-income countries were more likely to report decreases in the financial support they received from their governments during this time (p=0·0004; table 2). However, institutions in countries of all income groups reported reductions in paediatric oncology beds (p=0·31) and decreases in the number of suspected (p=0·27) or newly diagnosed cancer patients (p=0·14). The availability of PPE also did not vary on the basis of country income group (p=0·46). Treatment abandonment was reported more frequently in low-income and middle-income countries (p<0·0001). Additionally, treatment modifications, including chemotherapy interruptions due to lack of medication (p=0·022) and limited access to radiotherapy (p<0·0001) were more frequently reported in low-income and middle-income countries. Institutions in these countries reported a greater effect on routine laboratory testing (p=0·016), although overall access to pathology services did not vary by income level (p=0·37). Access to supportive care, and specifically blood products (p=0·021), was more limited in low-income and middle-income countries, with 1 (8%) of 13 low-income countries surveyed stating that less than 25% of desired transfusions could be done. Institutions in low-income and middle-income countries also reported additional barriers to life-saving interventions (p=0·019), more severe complications (p=0·0059), and more deaths (p<0·0001), all of which would not have occurred without the pandemic.

Similar associations were seen based on country health expenditure, either as a percentage of gross domestic product (appendix 2 p 9) or per-capita spending (appendix 2 p 10). Notably, although institutions reporting increased cases of COVID-19 were more likely to report reductions in clinical staff (p=0·039), chemotherapy modifications due to unavailability of agents (p=0·0032), and decrease in pathology services (p=0·019), the effect on other health services did not

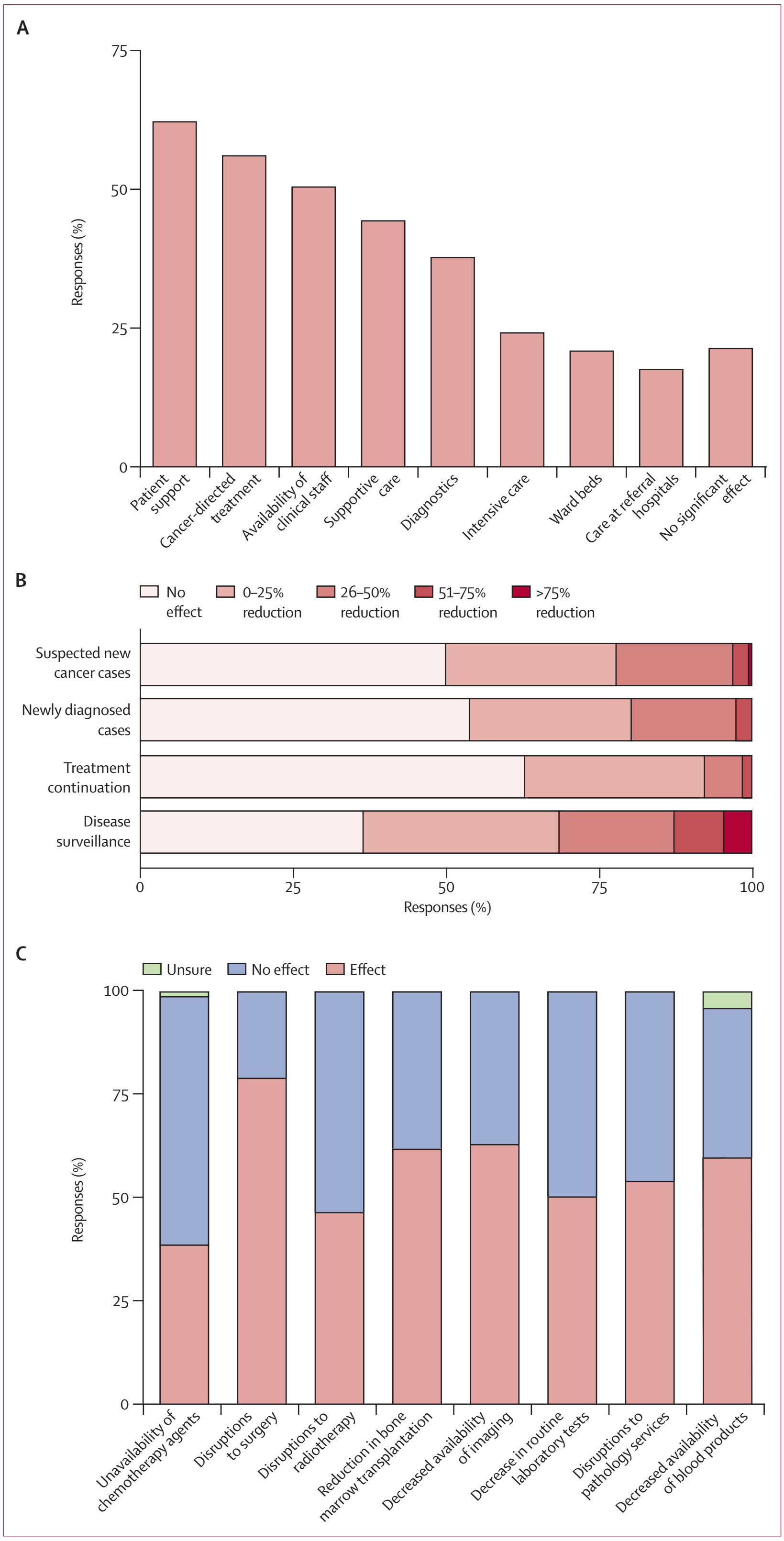

***Figure 2*: Effect of COVID-19 pandemic on paediatric cancer care**
(A) Most affected treatment areas. (B) Effect of COVID-19 pandemic on children with cancer at different stages in the care continuum. The light pink bars indicate no effect on the volume of patients and the shaded red bars are the percentage change compared with before the pandemic. (C) Effect of the COVID-19 pandemic on paediatric cancer services. Results are reported as a percentage of responses, including the institutions with access to radiotherapy (n=155) and bone marrow transplantation (n=115).

	Low-income countries (n=13)	Lower middle-income countries (n=58)	Upper middle-income countries (n=105)	High-income countries (n=37)	p value
Decrease in financial support	2 (15%)	30 (52%)	33 (31%)	3 (8%)	0·0004
Reduction of inpatient beds for paediatric oncology	0	13 (22%)	19 (18%)	9 (24%)	0·31
Personal protective equipment not always available	8 (62%)	32 (55%)	47 (45%)	14 (38%)	0·46
Decrease in suspected new cancer cases	5/13 (38%)	33/55 (60%)	46/103 (45%)	13 (35%)	0·27
Reduction in new paediatric cancer cases	6 (46%)	29/55 (53%)	45/103 (44%)	10 (27%)	0·14
Increase in treatment abandonment	5 (38%)	30 (52%)	35 (33%)	3 (8%)	<0·0001
Chemotherapy modifications due to unavailability of agents* (n=220)	4/10 (40%)	28/62 (45%)	48/120 (40%)	3/28 (11%)	0·022
Disruptions to radiotherapy (n=155)	7/9 (78%)	28/41 (68%)	34/74 (46%)	3/31 (10%)	<0·0001
Disruptions to surgical care	12 (92%)	47 (81%)	84 (80%)	25 (68%)	0·25
Reduction in bone marrow transplantation (n=115)	5/5 (100%)	22/26 (85%)	33/51 (65%)	11/33 (33%)	0·0001
Decrease in availability of blood products	8 (62%)	43 (74%)	59 (56%)	17 (46%)	0·021
Decrease in availability of routine laboratory tests	10 (77%)	31 (53%)	55 (52%)	11 (30%)	0·016
Decrease in availability of pathology services	9 (69%)	33 (57%)	57 (54%)	16 (43%)	0·37
Reduction in cancer surveillance evaluations	6 (46%)	43 (74%)	60 (57%)	17 (46%)	0·019
Decrease in access to life-saving interventions	1 (8%)	19 (33%)	17 (16%)	1 (3%)	0·0065
Presence of unexpected severe complications	2 (15%)	22 (38%)	22 (21%)	8 (22%)	0·0059
Presence of unexpected deaths	4 (31%)	21 (36%)	14 (13%)	3 (8%)	<0·0001

Data are n (%) or n/N (%), unless otherwise specified. Institutions were categorised on the basis of World Bank income group and responses with a perceived effect on health services are reported. Fisher's exact tests are used for comparison across the four groups. *Responses from only paediatric hematologists-oncologists were included and these were analysed as individual responses.

Table 2: **Effect of country income-status on use of the health service**

differ between institutions with or without COVID-19 cases. Furthermore, effects on paediatric cancer services did not differ on the basis of the national burden of COVID-19, either defined by the incidence (cases diagnosed per million people) or mortality (COVID-19 deaths per million people; appendix 2 pp 11–13).

Univariate and multivariable logistic regression analyses were done for seven factors affecting use of health-care services (table 3; appendix 2 pp 14–20). Except for reduction in new cancer cases, in both univariate and multivariable analyses, World Bank income group was significantly associated with changes in use of health-care services, specifically in low-income and middle-income countries (table 3; appendix 2 pp 14–20). Chemotherapy modifications due to lack of agents occurred less frequently in the high-income countries and in private or for-profit hospitals. Similarly, reductions in cancer surveillance evaluations were more common in low-income and middle-income countries and in larger hospitals. Decrease in access to life-saving interventions occurred more in low-income and middle-income countries and in general hospitals.

Institutions around the world have put new policies and guidelines in place to provide paediatric cancer care during the COVID-19 pandemic. Most hospitals reported new or adapted checklists for patient and staff safety (146 [69%] of 213), new processes for communication with patients and families (134 [63%]), and new guidance on essential services (119 [56%]). Institutions also described existing areas that received increased attention during the pandemic, including infection prevention and control at the hospital (171 [80%]) and for families in the community (107 [50%]), back-up and contingency staffing plans (112 [52%]), essential equipment supply chains (95 [45%]), and psychosocial support for staff, patients, and families (75 [35%]). Although 137 (64%) hospitals had not previously used telemedicine for paediatric cancer care, 111 (52%) institutions used it during the pandemic for the assessment and counselling of patients undergoing cancer-directed therapy, and 99 (46%) institutions used it for surveillance visits for patients who had completed treatment.

Many of the reported institutional adaptations were perceived positively. For example, about half (49 [49%] of 101) of hospitals that identified changes in roles and responsibilities during the pandemic thought this was a positive change and described it as enabling better use of scarce staff and improvement in self-care among staff. Furthermore, respondents reported positive views about modifications to care, including increased use of technology (149 [92%] of 162), strengthening of referral pathways (55 [73%] of 75), and decreased planned hospital admissions (84 [61%] of 137), with potential for application beyond the pandemic.

Discussion

The COVID-19 pandemic has considerably changed the care of children with cancer worldwide by creating barriers throughout the care continuum. Hospital prioritisation for patients with COVID-19, combined with border lockdowns and restricted public transportation, have contributed to delayed childhood cancer diagnoses.[6,18–21] For patients who make it to a treatment centre, the pandemic has created additional obstacles to obtaining quality care, including enrolment in clinical trials.[9] This global survey demonstrates that the effect is larger than previously described in single-region studies,[10,11] and is particularly marked in centres located in low-income and middle-income countries. Importantly, the effects of the pandemic on paediatric cancer care are largely independent of the number of COVID-19 cases at either the institution level or the national level. Notably, a portion of respondents mentioned censorship in reporting COVID-19 cases, which might have influenced the number of cases stated by institutions

	Decrease in financial support	Reduction in new paediatric cancer cases	Chemotherapy modifications due to lack of agents	Disruptions to radiotherapy	Reduction in cancer surveillance evaluations	Decrease in access to life-saving interventions	Presence of unexpected deaths
Income group							
Low income countries	1·5 (0·2–10·2)	··	6·1 (1·1–35·2)	27·5 (3·8–200·7)	0·9 (0·2–3·6)	23·8 (0·7–815·1)	4·2 (0·7–24·4)
Lower middle-income countries	10·2 (2·7–39·0)	··	8·1 (2·2–30·0)	17·7 (4·5–69·8)	3·8 (1·4–10·9)	16·7 (2·0–138·8)	6·3 (1·6–24·2)
Upper middle-income countries	4·4 (1·2–16·1)	··	7·1 (2·0–25·2)	7·3 (2·0–26·5)	1·5 (0·7–3·5)	5·6 (0·7–45·5)	1·3 (0·3–5·1)
High-income countries	1 (ref)	··	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
p value	0·0014	··	0·017	0·0002	0·045	0·011	0·0013
Hospital category							
Public or governmental	0·6 (0·3–1·3)	0·5 (0·3–0·9)	2·4 (1·2–4·9)	··	··	··	··
Private or for-profit	1 (ref)	1 (ref)	1 (ref)	··	··	··	··
p value	0·190	0·046	0·014	··	··	··	··
Hospital type							
General and general oncology	··	··	··	1 (ref))	··	1 (ref)	··
Paediatric and paediatric oncology	··	··	··	0·4 (0·2–1·0)	··	0·3 (0·1–0·8)	··
p value	··	··	··	0·058	··	0·016	
Hospital size*							
<20	··	0·3 (0·1–0·9)	··	··	2·2 (0·6–7·4)	··	1·5 (0·4–6·1)
20–49	··	1 (ref)	··	··	1 (ref)	··	1 (ref)
50–99	··	0·4 (0·2–0·9)	··	··	3·3 (1·4–8·0)	··	1·3 (0·4–4·3)
100–299	··	0·4 (0·2–0·9)	··	··	3·5 (1·4–8·5)	··	1·2 (0·3–4·0)
>300	··	1·2 (0·5–3·3)	··	··	4·9 (1·6–15·2)	··	3·4 (1·0–11·7)
p value	··	0·0097		··	0·015	··	0·30

Data are odds ratio (95% CI) unless otherwise specified. P values indicate trend. Categories were included as predictors in the multivariable model if they were significant in the univariate analysis . *Average number of children diagnosed with cancer annually.

***Table 3:* Multivariable analyses of factors affecting use of health services**

and is also a concerning reflection of the broader pandemic management.

Our results suggest that the effect of the COVID-19 pandemic on paediatric cancer care reflects the strength of health-care systems across the world. Before the pandemic, health systems in low-income and middle-income countries were strained with decreased resources and less access to care for children with cancer diagnoses.[12,22] Therefore, our findings that institutions in these countries report greater supply shortages, specifically resulting in treatment modification and a lack of supportive care, are not surprising. These institutions are less likely to have excess supply stores,[23] and border restrictions during the pandemic have affected supply chains and further reduced access to medication.[24] Limited shared resources, including PPE and supportive care medications such as antibiotics, have been diverted to the care of patients with COVID-19.[25] Additionally, decreased access to blood products could affect the administration of myelotoxic chemotherapy. As many institutions in low-income and middle-income countries rely on family members for blood donation, visitor restrictions and stay-at-home orders might have reduced the number of donors and thus the supply of blood products. Unlike other aspects of paediatric cancer care, access to surgical services did not vary by country income level, possibly because these are considered essential and are often urgent.[26] Thus, although institutions might have had limited or reduced total surgical availability, paediatric cancer cases might have been prioritised.

In addition to the impact on childhood cancer care delivery, our findings emphasise that treatment abandonment, which has always been more common in low-income and middle-income countries,[17] increased during the pandemic with a disproportionate effect in these countries. Importantly, the observed decrease of newly diagnosed children did not vary by country income status. These findings are consistent with reports from high-income countries describing a similar decrease in newly diagnosed cancer patients from population-based cancer registries,[27] and suggest this delay might be contributing to critical or advanced presentations.[14]

Although the effect of the pandemic has been devastating and widespread, health-care systems and providers have demonstrated resilience in response to these challenges. Institutions worldwide have implemented new policies, created checklists, and redistributed resources and staff to battle the pandemic. In our study, institutions reported new use of technology, improved practices around infection control, reprioritisation of the psychosocial needs of families and staff, and care transition to outpatient settings to allow for continued care delivery despite the pandemic. These adaptations, resulting from necessity, often led to the optimisation of existing resources, and might persist beyond the pandemic, resulting in long-lasting improvements in childhood cancer care. These insights should be used to plan for future health emergencies.

This study has several limitations. We did a cross-sectional survey of paediatric oncology providers, and our results reflect the knowledge and opinions of respondents at one timepoint during an evolving pandemic. Although countries were experiencing different stages of the pandemic at the time of the survey, we believe enough time had passed since the beginning of the pandemic to collect meaningful information. Additionally, the survey was in English and distributed to a convenience sample, potentially limiting the generalisability of our results to smaller, lower-resource settings where providers do not speak English and are not connected to the paediatric oncology networks of survey distribution. Convenient sampling might have influenced the number of responses from high-income countries, specifically in Europe and Oceania. Furthermore, small sample sizes when institutions were divided on the basis of national or hospital characteristics limited the depth of the statistical analyses and evaluation of dependencies between variables. We felt a cross-sectional survey was the most feasible way to quickly obtain insight into the effects of COVID-19 on paediatric cancer care across the world, although acknowledge that use of one data source to evaluate a complex and multifaceted problem poses limitations. Because the survey was distributed to different cadres of health-care professionals, unfamiliarity with some aspects of paediatric cancer care or the effect of the pandemic might have been captured by the responses. Similarly, the survey covered a range of topics and was quite extensive, requiring about 1 h to complete. This might have led to survey fatigue, resulting in the relatively high number of incomplete responses. The excluded responses had very limited information regarding the effect of the COVID-19 pandemic because a minimal portion of the survey had been completed. Ultimately, this analysis included data from more than 300 responses from 79 countries, suggesting we were able to provide a comprehensive report of the global effect of this pandemic on paediatric oncology care.

To our knowledge, this study provides the first global assessment of the effect of COVID-19 on paediatric cancer care. Our findings show the multiple challenges that the COVID-19 pandemic created for childhood cancer care in institutions of all resource levels. However, this effect appears to be unequal, disproportionately affecting paediatric oncology units in low-income and middle-income countries. Although the long-term effects of these challenges on childhood cancer outcomes are not yet clear, our results emphasise the need for a continued assessment of resource requirements over the course of the pandemic and the sharing of strategies that have mitigated the negative effects on paediatric cancer care. Ultimately, the study emphasises the urgency of an equitably distributed robust global response to support paediatric oncology care.

Contributors

DG, CRG, and DCM developed the idea. DG, RR, YC, MD, and DCM verified the data. RR, YV, YC, and MD did the data analyses. DG and DCM drafted the manuscript and prepared the tables and figures. All authors contributed to the interpretation of the findings, the editing of the article, and the approval of the final submitted version. All authors had full access to all the data in the study and accept responsibility for the decision to submit for publication.

Declaration of interests

GC receives personal fees from Bayer and Y-mAbs Therapeutics. All other authors declare no competing interests.

Data sharing

Individual survey response data will not be made available as answers were confidential.

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References

1. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Inf Dis* 2020; **20:** 533–34.
2. Di Nardo M, van Leeuwen G, Loreti A, et al. A literature review of 2019 novel coronavirus (SARS-CoV2) infection in neonates and children. *Pediatr Res* 2020; published online July 17. https://doi.org/10.1038/s41390-020-1065-5.
3. The Global COVID-19 Observatory and Resource Center for Childhood Cancer. Global Registry of COVID-19 in pediatric cancer. 2020. https://global.stjude.org/en-us/global-covid-19-observatory-and-resource-center-for-childhood-cancer/registry.html (accessed Oct 31, 2020).
4. Gotzinger F, Santiago-Garcia B, Noguera-Julian A, et al. COVID-19 in children and adolescents in Europe: a multinational, multicentre cohort study. *Lancet Child Adolesc Health* 2020; **4:** 653–61.
5. Kuderer NM, Choueiri TK, Shah DP, et al. Clinical impact of COVID-19 on patients with cancer (CCC19): a cohort study. *Lancet* 2020; **395:** 1907–18.
6. Ferrari A, Zecca M, Rizzari C, et al. Children with cancer in the time of COVID-19: an 8-week report from the six pediatric onco-hematology centers in Lombardia, Italy. *Pediatr Blood Cancer* 2020; **67:** e28410.
7. André N, Rouger-Gaudichon J, Brethon B, et al. COVID-19 in pediatric oncology from French pediatric oncology and hematology centers: High risk of severe forms? *Pediatr Blood Cancer* 2020; **67:** e28392.
8. Wang SM, Tao F, Hou Y, et al. Screening of SARS-CoV-2 in 299 hospitalized children with hemato-oncological diseases: a multicenter survey in Hubei, China. *Curr Med Sci* 2020; **40:** 642–45.
9. Rubio-San-Simón A, Verdú-Amorós J, Hladun R, et al. Challenges in early phase clinical trials for childhood cancer during the COVID-19 pandemic: a report from the new agents group of the Spanish Society of Paediatric Haematology and Oncology (SEHOP). *Clin Transl Oncol* 2020; published online May 29. https://doi.org/10.1007/s12094-020-02399-3.
10. Saab R, Obeid A, Gachi F, et al. Impact of the coronavirus disease 2019 (COVID-19) pandemic on pediatric oncology care in the Middle East, North Africa, and West Asia Region: a report from the Pediatric Oncology East and Mediterranean (POEM) Group. *Cancer* 2020; **126:** 4235–45.
11. Vasquez L, Sampor C, Villanueva G, et al. Early impact of the COVID-19 pandemic on paediatric cancer care in Latin America. *Lancet Oncol* 2020; **21:** 753–55.
12. Rodriguez-Galindo C, Friedrich P, Alcasabas P, et al. Toward the cure of all children with cancer through collaborative efforts: pediatric oncology as a global challenge. *J Clin Oncol* 2015; **33:** 3065–73.

13 Kaspers GJL. COVID-19: how will this impact children with cancer, now and in the future? *Expert Rev Anticancer Ther* 2020; **20:** 527–29.

14 Ding YY, Ramakrishna S, Long AH, et al. Delayed cancer diagnoses and high mortality in children during the COVID-19 pandemic. *Pediatr Blood Cancer* 2020; **67:** e28427.

15 Parasole R, Stellato P, Conter V, et al. Collateral effects of COVID-19 pandemic in pediatric hematooncology: fatalities caused by diagnostic delay. *Pediatr Blood Cancer* 2020; **67:** e28482.

16 Slone JS, Ozuah N, Wasswa P. Caring for children with cancer in Africa during the COVID-19 crisis: implications and opportunities. *Pediatr Hematol Oncol* 2020; **37:** 549–53.

17 Friedrich P, Lam CG, Itriago E, Perez R, Ribeiro RC, Arora RS. Magnitude of treatment abandonment in childhood cancer. *PLoS One* 2015; **10:** e0135230.

18 Molica M, Mazzone C, Cordone I, Pasquale A, Niscola P, de Fabritiis P. SARS-CoV-2 infection anxieties and general population restrictions delay diagnosis and treatment of acute haematological malignancies. *Br J Haematol* 2020; **190:** e5–8.

19 Chiaravalli S, Ferrari A, Sironi G, et al. A collateral effect of the COVID-19 pandemic: delayed diagnosis in pediatric solid tumors. *Pediatr Blood Cancer* 2020: **67:** e28640.

20 Offenbacher R, Knoll MA, Loeb DM. Delayed presentations of pediatric solid tumors at a tertiary care hospital in the Bronx due to COVID-19. *Pediatr Blood Cancer* 2020; **68:** e28615.

21 Carai A, Locatelli F, Mastronuzzi A. Delayed referral of pediatric brain tumors during COVID-19 pandemic. *Neuro Oncol* 2020; **22:** 1884–86.

22 Rodriguez-Galindo C, Friedrich P, Morrissey L, Frazier L. Global challenges in pediatric oncology. *Curr Opin Pediatr* 2013; **25:** 3–15.

23 Angrup A, Kanaujia R, Ray P, Biswal M. Healthcare facilities in low- and middle-income countries affected by COVID-19: time to upgrade basic infection control and prevention practices. *Indian J Med Microbiol* 2020; **38:** 139–43.

24 Yaya S, Otu A, Labonté R. Globalisation in the time of COVID-19: repositioning Africa to meet the immediate and remote challenges. *Global Health* 2020; **16:** 51.

25 González-Montero J, Valenzuela G, Ahumada M, Barajas O, Villanueva L. Management of cancer patients during COVID-19 pandemic at developing countries. *World J Clin Cases* 2020; **8:** 3390–404.

26 Cai J, Zheng L, Lv D, et al. Prevention and control strategies in the diagnosis and treatment of solid tumors in children during the COVID-19 pandemic. *Pediatr Hematol Oncol* 2020; **37:** 620–29.

27 Dinmohamed AG, Visser O, Verhoeven RHA, et al. Fewer cancer diagnoses during the COVID-19 epidemic in the Netherlands. *Lancet Oncol* 2020; **21:** 750–51.