Cardiology in the Young

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Influence of the COVID-19 pandemic on the congenital heart surgery service in Lithuania

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Original Article

Cite this article: Budrys D, Gegieckienė R, Lebetkevičius V, Sudikienė R, Tarutis V, and Jonas K (2024) Influence of the COVID-19 pandemic on the congenital heart surgery service in Lithuania. *Cardiology in the Young* **34**: 1260–1266. doi: 10.1017/S1047951123004420

Received: 28 November 2023
Revised: 9 December 2023
Accepted: 9 December 2023
First published online: 2 January 2024

Keywords:
Paediatric cardiac surgery; cardiothoracic surgery; CHDs; SARS-CoV-2; COVID-19; pandemic

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Abstract

Introduction: CHD is a unique group of medical pathologies. Literature worldwide reports significant decrements in the case volume of patients with these conditions due to the recent global pandemic of coronavirus disease 2019. The only centre providing congenital cardiac care for Lithuanian population is in a hospital which was the main medical institution for the sickest coronavirus disease 2019 patients. Hence, this centre had to maintain its service alongside the mobilisation of resources to tackle the crisis. *Aim of Study:* To evaluate the effect of the pandemic on the service of congenital heart surgery in Lithuania. *Methods:* The activity of a single centre providing congenital heart care working in a main coronavirus 2019 pandemic hospital during the pandemic was analysed and compared to a matched period of pre-pandemic activity. *Results:* The number of admitted patients was similar during both pre-pandemic and pandemic periods. During the pandemic period, younger patients were more often operated as urgent cases. Their postoperative length of stay was longer. However, there were no differences in early postoperative mortality between the two groups. *Conclusions:* It was possible to maintain an accessible and high-quality specialised congenital cardiac care for various age patients during global pandemic events, while working in the main pandemic hospital.

CHD is a unique group of pathologies because of its complex nature and the need of well-coordinated care from many different healthcare specialists, caregivers, and patients themselves. World-wide prevalence of CHD is estimated to be about 7–8 cases per 1000 live births (or ~ 1% of all newborns).[1–3] Despite relative rareness of these pathologies, the burden of CHD remains high. CHD-related admissions are distinguished from others by a significantly higher mortality risk, a tendency of disproportionately high healthcare resource utilisation, and, consequently, high costs of treatment.[4]

Recent coronavirus disease 2019 (COVID-19) pandemic has been a strenuous challenge for every healthcare system around the globe. Redistribution of human and material resources as well as lockdown restrictions led to a decrease in the volume of healthcare services for all non-COVID patients, which was especially visible in the beginning of the pandemic.[5] In the context of CHD, various studies not only report significant decrease in the volume of surgeries during the pandemic but also emphasise considerable psychological stress experienced by CHD patients and their relatives.[6–8]

In Lithuania, delivery of congenital heart surgery services was complicated by various governmental and institutional restrictions that were introduced to help manage the pandemic.

The only facility that provides congenital cardiac care for Lithuanian patients is Vilnius University Hospital Santaros Clinics, which was also the main COVID-19 hospital in Lithuania during the pandemic. Vilnius University Hospital Santaros Clinics had to redistribute its resources for COVID-19 management at the same time fulfilling the needs of CHD treatment, as no other institution in Lithuania could provide this care. The main motive of conducting this study was to analyse how were the accessibility and immediate postoperative outcomes of CHD treatment in Lithuania affected throughout the whole period of pandemic restrictions.

This study aims to provide a reflection on past events, to share our experience in maintaining high-quality CHD service during a pandemic event in a main hospital designated to deal with said pandemic, and to help better prepare for any upcoming healthcare disturbances in the future. Majority of scientific literature on this topic was published while the crisis was ongoing and still developing, hence it was concentrated on an interval rather than the whole period of the pandemic. Our study aims to help filling this knowledge gap, especially in the field of congenital heart care.

Materials and methods

Study design

This study is a retrospective analysis of the impact of COVID-19 pandemic to CHD treatment in a single tertiary CHD surgery centre working in the main pandemic hospital. The data for this study were gathered while performing an audit of clinical activity and outcomes of our centre. No information which could allow patient identification was accessible nor used by the researchers in this study. First case of COVID-19 infection in Lithuania was confirmed on 28 February 2020, and the last country-wide lockdown was lifted on 20 April 2022. This period was defined as the "pandemic period". A period between 1 April 2018 and 27 February 2020, during which a similar number of patients were treated was defined as a "pre-pandemic period" and acts as a control cohort in the analysis. To measure the impact of COVID-19 to CHD treatment availability and quality in our centre, we have compared our surgical activity and outcomes.

Surgical activity was defined as the number of patients treated during each period. It is a compound variable and includes the total number of treated patients, the number of neonates, infants, children, and adults with CHD treated, the total number of surgical procedures performed, the total number of elective (sum of elective primary (closures of atrial and septal defects, repairs of the patent ductus arteriosus, anomalous pulmonary vein returns, atrioventricular communications, tetralogies of Fallot, routine pacemaker implantations, routine repairs of the aorta and/or aortic valve, routine repairs of the pulmonary artery, and/or valve of the pulmonary artery) and elective re-do (second- and third-stage palliations of hypoplastic left heart syndrome, repeated pacemaker procedures, repeated septal myectomies, implantations of pulmonary artery conduits and similar) procedures), the total number of urgent (procedures performed immediately after decision to operate due to clinical deterioration of the patient, such as heart transplant surgeries, connections of the extracorporeal membrane oxygenation machines or ventricular assist devices, urgent arterial switch operations, stage 1 palliations of hypoplastic left heart syndrome, urgent Blalock–Thomas–Taussig shunt procedures, repairs of the anomalous left coronary artery from pulmonary artery, implantations of pacemakers and catheters for peritoneal dialysis, plications of the diaphragm) and revision (surgical re-explorations for bleeding, delayed chest closures after stage 1 palliation of hypoplastic left heart syndrome or other complex CHD repair requiring delayed chest closure and similar) procedures. If a patient was stabilised prior to the surgery, stage 1 palliations of hypoplastic left heart syndrome and arterial switch operations were not classified as urgent.

The primary outcome of our analysis was the surgical mortality (which includes operative and early 30-day postoperative mortality), and the secondary outcome was the length of hospital stay.

Also, we used procedures per admission ratio to better illustrate the quality of treatment. To calculate this ratio, the total number of all procedures, including revisions, performed throughout a period of time, was divided by the number of all inpatient admissions in the same period. Ideally, if one surgery is performed for each admitted patient, the ratio is equal to one. As more repeated procedures (e.g., revisions or re-do surgeries on the same admission) are performed, the ratio increases. Together with the surgical mortality and the length of hospital stay, the procedures per admission ratio can give more insight into the quality of CHD care.

Statistical analysis

The distribution of quantitative data was tested by comparing the central tendency (mean, median, and mode) and by calculating the Shapiro–Wilk criterion of each variable. Quantitative data are reported as a mean ($\bar{x}$) and standard deviation (SD) or a median ($\tilde{x}$) and interquartile range according to the distribution. Qualitative data are reported as counts and percentages. The data between the two periods were compared using student's *t*-test, Mann–Whitney U, Kruskal–Wallis H, X^2, and Fisher's exact tests according to the variable type and distribution. Statistical analysis was performed using the R statistical software (R Core Team, R Foundation for Statistical Computing: Vienna, Austria, 2018).[9] Level of statistical significance was chosen to be 0.05.

Restrictions imposed by the government

Among the restrictions imposed by the Lithuanian government, some were especially relevant for congenital cardiac care during the pandemic. Control of citizens' mobility across the country[10] complicated CHD patients' arrival to the hospital for surgery or follow-up visits. For the whole pandemic, elective hospital admissions were available only with a negative COVID-19 test[11] or, later, a positive vaccination status. If a CHD patient was sick with COVID-19 at the time of a planned visit, his or her admission would have to be postponed for unclear future. Vaccines quickly became a keystone in the management of the pandemic. Only adult CHD patients could benefit from public vaccination against COVID-19 in the initial phase. Younger patients, who comprise the majority of CHD population, had to wait until the vaccines were registered for use in their age groups. European Medicines Agency recommendations for the vaccination of 5–11 years old and older than 6 months patients, respectively, were issued almost one and two years after the approval of the first COVID-19 vaccine in Europe.[12–14]

Restrictions imposed by the institution

There were some restrictions imposed by the hospital administration as well. Our institution experienced increased demand of material and human resources to accommodate the pandemic needs. Some units were reorganised to work distinctively with COVID-19 patients, which consequently reduced capabilities of therapeutic and surgical work in other hospital departments. In our case, the number of intensive care beds for patients after CHD repair was significantly reduced due to the lack of equipment which was lent to COVID-19 units, or medical staff (doctors, intensive care and surgical nurses, and nursing assistants) who were transferred to work with COVID-19 patients. Visiting of patients was prohibited, and abilities to stay in hospital together with a child were limited, which was problematic both for our patients and their families. Our hospital continuously worked as a leading clinic in the pandemic context; however, it still aimed to meet the needs of other patients, including the ones with CHD, who could not receive care elsewhere.

Measures taken to mitigate the pandemic effect on the congenital heart surgery service in Lithuania

Several measures were taken by the CHD team to confront the pandemic challenges. First, a separate entrance and a corridor were given to CHD patients to prevent cross-contamination. Everyone

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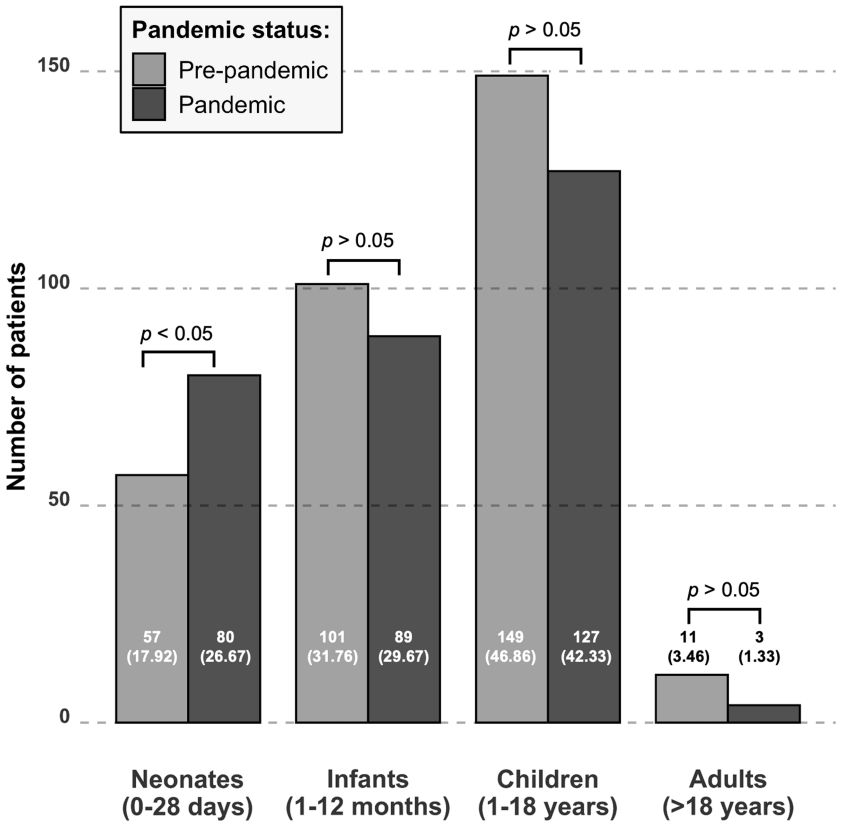

Figure 1. Patients grouped by their age on the day of surgery in both periods.

in the CHD team used to work in constant teams of two-three colleagues. This was done to limit potential spread of the virus and prevent collapses of the activity of the whole centre. Interactions between staff and patients were reduced. Whenever possible, patient discussions and multidisciplinary consults would be organised remotely, only the crucial staff would participate in procedures and patient exams. With impaired accessibility of outpatient care in the whole country, our team took a different approach on discharging patients from the hospital in the period of pandemic restrictions. CHD patients would be released from hospital in the best possible health, for example, with wounds healed and sutures removed. In addition, during the pandemic, patients who could, under normal circumstances, wait until surgery or be managed conservatively for some time, were admitted for surgery in order to prevent potential complications (for example, older patients with atrial septal defects were operated in order to prevent development of pulmonary hypertension and Eisenmenger syndrome).

Results

The pandemic period (from 28 February 2020 to 20 April 2022) had 783 days. During this time, 290 admissions to the CHD department were observed. 354 procedures were performed during this period, including 54 revisions. The pre-pandemic period (from 1 April 2018 to 28 February 2020), similarly, had a span of 689 days. Throughout this period, 310 patients were admitted, and a total of 388 procedures were performed, including 70 revisions. Differences in the number of admissions and procedures between both periods were not statistically significant ($p > 0.05$).

Among the patients admitted to CHD department during the pandemic period, there were 162 (55.86) males and 128 (44.14) females, and male-to-female ratio was 1.27:1. In the pre-pandemic period, 163 (52.58) males and 147 (47.42) females were admitted; male-to-female ratio was 1.11:1.

Patients in both cohorts were compared by their age at the day of surgery. Revisions were not included in this analysis. Median patient age at the day of surgery was significantly lower in the pandemic cohort, compared to the pre-pandemic one (237.5 (24–866.8) versus 385.6 (75.5–2024.8) days, $p < 0.05$). For a more detailed insight, patients in both cohorts were split into groups by age–neonates (0–28 days), infants (1–12 months), children (1–18 years), and adults (older than 18 years) (Fig. 1). Statistically significantly more neonates underwent surgical CHD repair during the pandemic period (80 (26.67%) versus 57 (17.92%) patients, $p < 0.05$). There was no significant different in the number of operated infants, children, and adults between the two periods. However, children, operated during the pandemic, were significantly younger compared to pre-pandemic cohort (median age 937 (1914–603) versus 1745 (3474–1037) days, respectively, $p < 0.05$) (Table 1).

Every surgery performed throughout the two periods was classified by its type. The categories were as follows: elective primary, elective re-do, urgent, revision. The cohorts were compared by the number of procedures in each category (Fig. 2). Significantly more patients underwent urgent procedures during the pandemic period (39 (11.02%) versus 23 (5.93%) patients requiring urgent procedures, respectively, $p < 0.05$). During the pandemic period, less patients underwent elective primary procedures (184 (51.98%) versus 229 (59.02%), $p = 0.05$) and more patients underwent elective re-do procedures (77 (21.75%) versus 66 (17.01%), $p = 0.05$).

https://doi.org/10.1017/S1047951123004420 Published online by Cambridge University Press

Table 1. Comparison of pandemic and pre-pandemic cohorts.

	Pandemic	Pre-pandemic	*p*-value
Admission characteristics			
Total (n, (%))	290 (100)	310 (100)	>0.05
Males (n, (%))	162 (55.86)	163 (52.58)	>0.05
Females (n, (%))	128 (44.14)	147 (47.42)	>0.05
Male-to-female ratio	1.27:1	1.11:1	>0.05
Neonates (n, (%))	73 (25.17)	53 (17.10)	<0.05
Infants (n, (%))	86 (29.66)	98 (31.61)	>0.05
Children (n, (%))	127 (43.79)	148 (47.74)	>0.05
Adults (n, (%))	4 (1.38)	11 (3.55)	>0.05
Age on surgery (days)			
Overall ($\tilde{x}$, (IQR))	237.5 (24–866.8)	385.6 (75.5–2024.8)	<0.05
Neonates ($\tilde{x}$, (IQR))	7 (4–17.3)	6 (4–11)	>0.05
Infants ($\tilde{x}$, (IQR))	141 (68–212)	130 (79–201)	>0.05
Children ($\tilde{x}$, (IQR))	937 (603–1914)	1745 (1037–3474)	<0.05
Adults ($\tilde{x}$, (IQR))	8250.5 (7335.8–9303)	11,362 (8178–12218)	>0.05
Total procedures (n, (%))	354 (100)	388 (100)	>0.05
LOS (days) ($\tilde{x}$, **(IQR))**	16 (11–26)	12 (8–24)	<0.05
Surgical mortality (n, (%))	13 (4.48)	15 (4.83)	>0.05

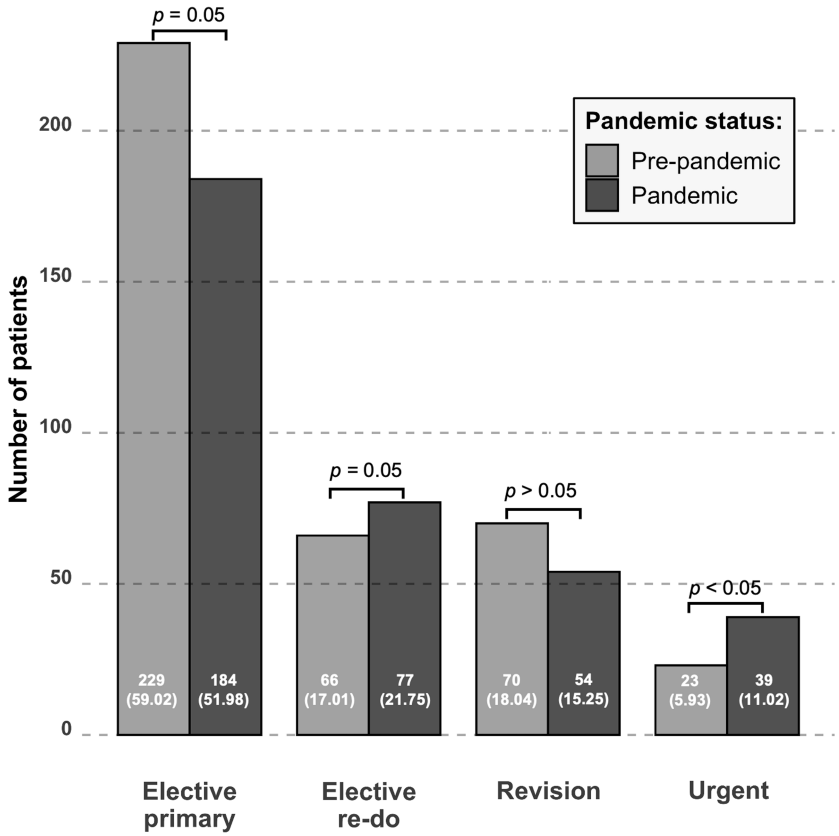

Figure 2. Surgery types among cohorts in both periods.

https://doi.org/10.1017/S1047951123004420 Published online by Cambridge University Press

Table 2. Surgical mortality among different age groups inside both cohorts.

Age group	Surgical mortality (n, (%))		p-value
	Pandemic	Pre-pandemic	
Neonates	9 (11.25)	5 (8.77)	>0.05
Infants	4 (4.49)	9 (8.91)	>0.05
Children	0 (0)	1 (0.67)	>0.05
Adults	0 (0)	0 (0)	–

Table 3. Length of hospital stay (LOS) among different age groups in both cohorts.

Age group	LOS (days) ($\tilde{x}$, (IQR))		p-value
	Pandemic	Pre-pandemic	
Neonates	25 (18–37)	27.5 (20–34)	>0.05
Infants	16 (13–29)	17 (11–29)	>0.05
Children	12 (9–18)	9 (8–13)	<0.05
Adults	24 (17.75–31.75)	13 (5.5–14.5)	<0.05

Pandemic impact on the quality of CHD treatment

Quality of CHD treatment is represented by the primary and secondary outcomes of this study – surgical mortality and length of hospital stay.

Despite the shift of CHD treatment towards urgent care during the pandemic, which was mainly caused by the imposed governmental pandemic management measures, the COVID-19 impact on surgical mortality in our centre was statistically insignificant (Tables 1 and 2). Overall, surgical mortality was similar in the pandemic and pre-pandemic period (13 (4.48) versus 15 (4.83) patients, respectively, $p > 0.05$). Findings after more detailed comparison in different age groups also showed no statistical significance (Table 2).

The overall median length of hospital stay was significantly longer during the pandemic period compared to the pre-pandemic period (16 days versus 12 days, respectively, $p < 0.05$) (Table 1). A more detailed comparison of the length of hospital stay among age groups in both cohorts was performed. In the pandemic period, children had significantly longer median hospital stay than in the pre-pandemic period (12 and 9 days, respectively, $p < 0.05$) (Table 3). Same was observed in the adult group (24 and 13 days, $p < 0.05$) (Table 3). The reason for these differences was the need to discharge patients in their best possible health, as the access to healthcare unrelated to COVID-19 was virtually unavailable during the pandemic period.

To better illustrate the quality of CHD treatment, a procedures per admission ratio was calculated for all age groups separately and overall. As seen in Table 4, the said ratio remained similar in all age groups and overall.

Discussion

In this study, the whole period of pandemic restrictions was analysed from the perspective of one highly specific patient group in one country. During the pandemic, the only specialised CHD centre in Lithuania happened to be in the main pandemic hospital responsible for the management of the pandemic crisis and taking care of the sickest COVID-19 patients. Our study compared a cohort of CHD patients who underwent surgical repair during the pandemic period to a similar cohort of patients treated prior to the crisis.

Gender distribution among CHD patients varies depending on the exact disease and aetiology;[15] however, there is evidence of slight overall male predominance among CHD patients.[16,17] This was also true in our study, as the number of male and female patients was similar in both pandemic and pre-pandemic periods.

During the pandemic, a significant increase in urgent procedures was observed. It correlates with other findings in literature, not only from the field of cardiothoracic surgery, supporting a trend towards urgent surgical procedures during the pandemic due to limited hospital resources, lack of blood products, need to minimise the risk of patient exposure.[18,19] An increase in the number of urgent surgeries could be also connected to the challenges in maintaining the quality of outpatient CHD care during the pandemic. In one study, reflecting the situation of patients with rare diseases during the pandemic, patients reported challenges accessing healthcare, cancelled medical appointments, shortages of medical supplies, etc.[20] However, such statements cannot be validated with our study as it was concentrated exclusively on inpatient CHD care. Despite the said fluctuations, there was no significant decrease in the overall number of admissions and procedures between both periods. It suggests that due to immense efforts from the CHD team, the availability of CHD treatment in Lithuania was not impacted by COVID-19 pandemic. This finding did not correspond to overall tendencies in scientific literature, which mostly reported significant decrements in case volume and utilisation of CHD care.[21–23]

CHD patients are diagnosed and treated at a very young age.[24] In our study, median patient age at the day of surgery was significantly lower during the pandemic. This finding is possibly connected to another observation that significantly more neonate patients underwent surgical repair in the pandemic cohort. Also, it can be related to the higher number of urgent procedures among patients in the pandemic cohort, as these patients are usually presented to the emergency department being less than 1 year old.[25,26]

Median length of hospital stay was significantly longer in the pandemic group. When split into different age groups, neonates had the longest median length of hospital stay and children had the shortest, which was true for both cohorts. Hence, our study supports the view that young age of CHD patient is a predictor of prolonged hospital stay.[27] While a shift towards younger patients and urgent procedures did have an impact to increased median length of hospital stay,[28,29] the main reason for this was that, during the pandemic, our team aimed to discharge patients in the best possible health (e.g., after the wound was completely healed and the sutures were removed), because discharged patients had virtually no access to healthcare until the pandemic restrictions were alleviated.[23,24]

Despite all fluctuations in CHD care faced during the pandemic, immediate postoperative mortality remained similar in both cohorts.

Relevance of the results

Majority of the articles on this topic concentrate on one interval of the pandemic, as they were published while the crisis was still ongoing. There is still a lack of studies that evaluate quality of healthcare services throughout the whole period of COVID-19 pandemic. We hope that our study will contribute to filling this gap of knowledge, especially in the specific field of CHD care.

https://doi.org/10.1017/S1047951123004420 Published online by Cambridge University Press

Table 4. Procedures per admission ratio among different age groups in both cohorts.

	n (procedures) / n (admissions)		Ratio		
Age group	Pandemic	Pre-pandemic	Pandemic	Pre-pandemic	p-value
Neonates	119/73	90/53	1.63	1.70	>0.05
Infants	95/86	122/98	1.10	1.25	>0.05
Children	136/127	164/148	1.07	1.11	>0.05
Adults	4/4	12/11	1	1.09	>0.05
TOTAL	354/290	388/310	1.22	1.25	>0.05

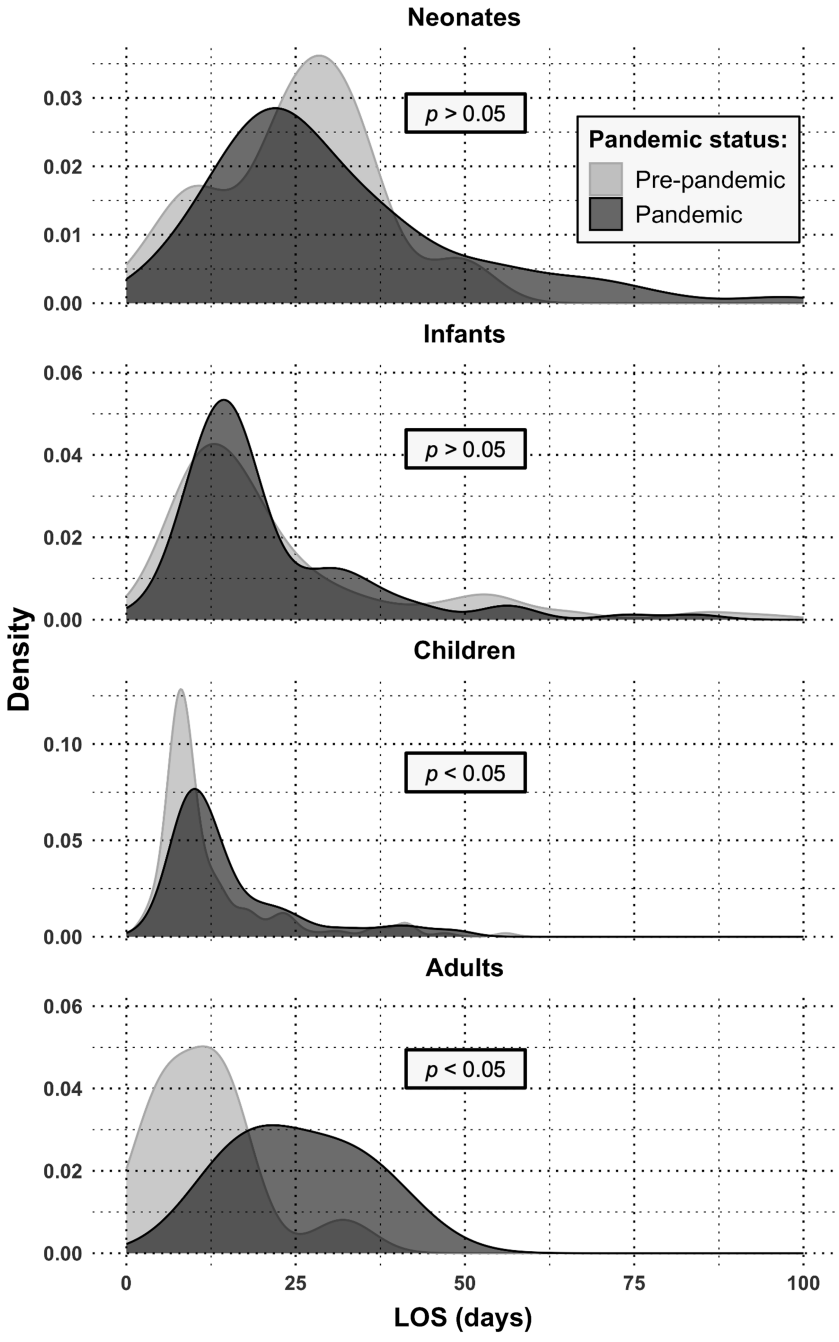

Figure 3. Tendencies in the length of hospital stay (LOS) among different age groups in both periods.

https://doi.org/10.1017/S1047951123004420 Published online by Cambridge University Press

Conclusions

All around the globe, recent pandemic of COVID-19 has heavily impacted accessibility of healthcare services. In this case, Lithuania was no exception. However, CHD team in Vilnius University Hospital Santaros Clinics Center of Cardiothoracic Surgery managed to maintain accessibility and quality of highly specialised congenital heart care.

Limitations of the study

As this study is retrospective, it poses all limitations characteristic to retrospective studies. The main limitation is that this study analyzes a single centre's experience and involves a small number of study subjects treated for congenital heart defects during a global pandemic crisis. As one cannot predict when a global pandemic crisis will occur, it is impossible to perform a prospective randomised control study to estimate the effect that the said pandemic may impose on availability and quality of surgical CHD treatment during that pandemic. However, this study shows that despite inherent limitations, a small congenital heart surgery centre employed by dedicated personnel is able to provide quality surgical CHD care for patients during global pandemic events.

Acknowledgements. The authors would like to express their gratitude to all fellow colleagues, nurses, and other medical personnel whose contribution to our patients and centre's activity cannot be overestimated. Also, to all colleagues who relentlessly worked in the frontlines of the pandemic while the personnel of our centre was putting their effort deliver best possible care to CHD patients.

Financial support. None.

Competing interests. None.

Ethical standards. Written consent for surgery was obtained from parent or legal guardian of all underaged patients, or from adult patients. Per Lithuanian law this project does not require approval by a Lithuanian Biomedical Research Ethics Committee as this publication reports only anonymous summarised retrospective audit data.

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