

Impact of COVID-19 pandemic on pediatric cardiac services in India

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ABSTRACT

Background : COVID-19 pandemic has disrupted pediatric cardiac services across the globe. Limited data are available on the impact of COVID-19 on pediatric cardiac care in India.

Aims : The aims are to study the impact of COVID-19 pandemic on the care of children with heart disease in India in terms of number of outpatient visits, hospitalizations, catheter-based interventions, and cardiac surgeries.

Settings and Design : This is a retrospective, multicentric, observational study.

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How to cite this article: Choubey M, Ramakrishnan S, Sachdeva S, Mani K, Gangopadhyay D, Sivakumar K, *et al.* Impact of COVID-19 pandemic on pediatric cardiac services in India. *Ann Pediatr Card* 2021;14:260-8.

Access this article online

Quick Response Code:



Website:

www.annalspc.com

DOI:

10.4103/apc.apc_133_21

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Submitted: 06-Jul-2021

Revised: 18-Jul-2021

Accepted: 21-Jul-2021

Published: 26-Aug-2021

- Methods** : We collected monthly data on the number and characteristics of outpatient visits, hospitalizations, catheter-based interventions, and cardiac surgeries and major hospital statistics, over a period of 5 months (April to August 2020), which coincided with the first wave of COVID-19 pandemic in India and compared it with data from the corresponding months in 2019.
- Results** : The outpatient visits across the 24 participating pediatric cardiac centers decreased by 74.5% in 2020 ($n = 13,878$) as compared to the corresponding period in 2019 ($n = 54,213$). The reduction in the number of hospitalizations, cardiac surgeries, and catheterization procedures was 66.8%, 73.0%, and 74.3%, respectively. The reduction in hospitalization was relatively less pronounced among neonates as compared to infants/children (47.6% vs. 70.1% reduction) and for emergency surgeries as compared to elective indications (27.8% vs. 79.2%). The overall in-hospital mortality was higher in 2020 (8.1%) as compared to 2019 (4.8%), with a higher postoperative mortality (9.1% vs. 4.3%).
- Conclusions** : The current COVID-19 pandemic significantly impacted the delivery of pediatric cardiac care across India with two-third reduction in hospitalizations and cardiac surgeries. In an already resource-constrained environment, the impact of such a massive reduction in the number of surgeries could be significant over the coming years. These findings may prove useful in formulating strategy to manage subsequent waves of ongoing COVID-19 pandemic.
- Keywords** Congenital heart disease, grown up with congenital heart disease, low- and middle-income countries, severe acute respiratory syndrome and cardiac surgery

INTRODUCTION

The current COVID-19 pandemic has resulted in widespread disruption of clinical care of all the non-COVID illnesses. Hospitalization for various cardiac ailments including acute myocardial infarction and heart failure is significantly reduced across the globe^[1-4] until recently, India has reported over 30 million COVID-19 cases and is the second most affected country.^[5] Indian studies have reported a 34% reduction in admissions for acute myocardial infarction^[6] and 69% reduction in acute heart failure^[4] admissions during the pandemic period as compared to corresponding prepandemic period. Reasons for such a reduction include a stricter nationwide lockdown, fear due to the pandemic, long travel distances to reach a hospital, lack of adequate ambulance services, restrictions by the local administrations for elective admissions in hospitals, and the conversion of major hospitals to COVID care facilities. Pediatric cardiology and cardiovascular surgery remain niche specialties and these specialized centers are mostly limited to selected cities.^[7] Hence, the magnitude of disruption caused by the pandemic in the hospitalization rates for children needing emergent pediatric cardiac care could be even more pronounced. Most of the congenital heart diseases (CHD) that require intervention in the neonatal period or infancy have high mortality and morbidity if not treated in time. Hence, the disruptions of service due to COVID-19 pandemic could result in more fatalities among children with heart disease.

Data about the disruption caused by the pandemic on pediatric cardiac admissions are scarce and most of the published studies have focused only on neonatal and infantile pediatric cardiac surgeries.^[8,9] The number of surgeries reportedly reduced by 52% in Italy and 8%–75% in China^[10] during the early waves of the pandemic. A single tertiary care center from North India reported two-thirds reduction in admissions related to CHD.^[11] The reduction in hospitalization across India is expected to be heterogenous due to differences in the availability and accessibility of pediatric cardiac care centers across the country, especially during the pandemic times. Further, the timing of the peak of COVID-19 pandemic varied across the different states that could have resulted in a varied time course of reduction in the hospitalization rates. Hence, the Pediatric Cardiac Society of India (PCSI) initiated this retrospective, multicentric study with an objective to study the impact of COVID-19 on the care of children with heart disease in India in terms of number of outpatient visits, hospitalizations, catheter-based interventions, and cardiac surgeries, both emergent and nonemergent. We also intended to study the heterogeneity across India and the factors predictive of changes in the cardiac surgery rates for children with CHD and grown-up CHD (GUCH). This information could be useful in planning for successive waves of this pandemic and future pandemics.

METHODS

We retrospectively collected data from all the participating pediatric cardiac centers of India between 01 April and

August 31, 2020, which coincided with the beginning to the peak of the first wave of COVID-19 in India. The data from the corresponding 5-month period in 2019 (April-August 2019) served as control group for comparison. We included consecutive children (<18 years) with any form of heart disease and GUCH group, seen in the outpatient departments or hospitalized in the participating pediatric cardiac facilities across India. GUCH group was defined as patients with any form of operated or unoperated CHD aged ≥ 18 years.

Ethical clearance was obtained from ethical committees at each of the participating institutions. In a few smaller centers without an ethics committee, a no objection certificate was obtained from the hospital administration. Being a retrospective study not involving individual patient-specific data, the requirement for individual consent was waived off. The study is registered prospectively in the Clinical Trials Registry-India (CTRI) database (registration number CTRI/2020/10/028251). We followed the Indian Council of Medical Research guidelines for ethical standard in clinical research and good clinical practice guidelines.

The study was conducted under the aegis of PCSI. All major pediatric cardiovascular centers of the country, including public as well as private sector hospitals, were invited to participate in the study. The hospitals needed to have medical records of patients, including outpatient department footfalls, all admissions, catheter-based interventions, and surgeries available for the study period, as well as for the same period in 2019, and had to agree to participate in the study. We invited all the members of PCSI and individually contacted 35 established large pediatric cardiac centers for participation. Twenty-four centers (17 private, 04 public) from 9 states of India agreed to participate in the study [Figure 1]. Inability to process ethical/administrative approval ($n = 6$), nonavailability of the 2019 data ($n = 3$), and lack of manpower due to COVID-19 ($n = 2$) were the reasons cited by the centers that could not participate in the study. We classified the hospitals according to the geography of location (north, south, east, and west) and into tier of city according to the Government of India classification used for house rent allowance calculation with Ahmedabad, Bengaluru, Chennai, Delhi, Hyderabad, Kolkata, Mumbai, and Pune being the tier-1 cities.^[12] Majority of participating centers are located in the tier-1 metropolitan cities ($n = 15$, 62.5%). Majority of these hospitals are in southern India ($n = 11$, 45.8%) or northern India ($n = 7$, 29.2%). Eastern and western India are represented by 4 and 2 centers, respectively [Figure 1]. The participating hospitals have a cumulative bed capacity of 949 beds dedicated to pediatric cardiology and cardiac surgery, including 289 intensive care beds.

Following confirmation of participation, each center was required to nominate a site investigator from the hospital. The site investigator was responsible for data collection using the study pro forma [Supplementary Appendix 1]. Online meetings and virtual training sessions were held for the site investigators using the data collection forms,

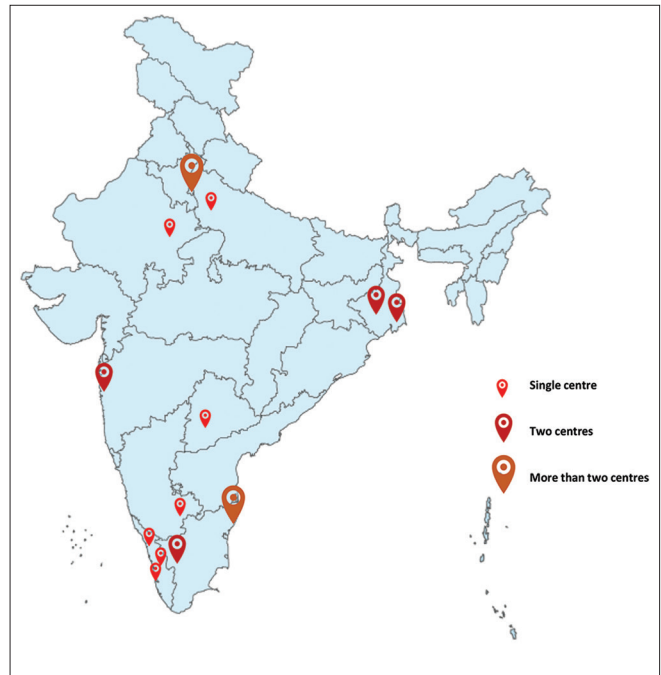


Figure 1: Location of participating pediatric cardiac centres across India

to ensure uniformity and quality of data collection. A group of state coordinators assisted the process. The study was overseen by a national study group, consisting of eminent pediatric cardiologists and cardiac surgeons across the country. Once the data collection process from an institute was completed, it was scrutinized by the state coordinators and checked for internal consistency. Inconsistencies were identified and rectified with the site investigators. The scrutinized data were submitted to the steering committee for analysis and publication.

We collected monthly data on outpatient visits, hospitalizations, procedures in catheterization laboratory, and cardiac surgery during the study period in 2019 and 2020 [Supplementary Appendix 1]. We also obtained the above information stratified according to age, i.e., in neonate, infants, children, and GUCH population. The information on the number, characteristics, and outcomes of common cardiac surgeries and catheterization laboratory procedures were collected [details including definition of outcome measures in Supplementary Appendix 1]. The data for the year 2020 also included 94 patients with COVID-19 infection reported separately.^[13]

Statistical analysis

Categorical variables are presented as frequency and percentages. Continuous variables are presented as mean \pm standard deviation or median with interquartile range as appropriate. All the categorical and continuous variables between the two time periods were compared using Chi-square test/Fisher's exact test and Wilcoxon rank-sum test, respectively. We used a univariate analysis followed by a stepwise logistic regression analysis to find the independent predictors of percentage

reduction in cardiac surgery in 2020 with entry and removal probability of 0.05 and 0.25, respectively. The results are presented as odds ratio and 95% confidence interval. We used Stata 16.0 (StataCorp LLC, TX, USA) for all statistical analysis. A $P < 0.05$ was considered as statistically significant.

RESULTS

Outpatient visits

The outpatient visits in the participating centers reduced by 74.4% in 2020 (total no = 13,878) as compared to the corresponding period in 2019 (total no = 54,213) [Table 1 and Figure 2a]. This reduction was significant across all the age groups, namely neonates (total no = 2561 in 2020 and 6231 in 2019, 58.9% reduction), infants/children (total no = 9912 in 2020 and 42,281 in 2019, 76.6% reduction), and GUCH patients (total no = 1405 in 2020 and 5701 in 2019, 75.4% reduction). A statistically significant reduction in both the new patient (total no = 6268 in 2020 and 20,589 in 2019, 69.7% reduction) and the follow-up registrations (total no = 7610 in 2020 and 33,624 in 2019, 77.4% reduction) contributed to the overall reduction.

Hospitalizations

Inpatient statistics also showed an overall reduction by 66.8% during the pandemic period (total no = 1910 in 2020 and 5766 in 2019) [Table 2 and Figure 2b]. Largest contributor to this reduction was the reduction

in the admission of infants and children (total no = 1242 in 2020 and 4154 in 2019, 70% reduction). Neonatal admissions reduced by 47.6% (total no = 458 in 2020 and 875 in 2019) and admissions for GUCH reduced by 71.5% (total no = 210 in 2020 and 737 in 2019) [Table 2].

Cardiac surgery

Consequent to the decrease in outpatient visits and inpatient admissions, we observed a significant reduction in the total number of cardiac surgeries performed in 2020 (total no = 1238 in 2020 and 4,586 in 2019, 73% reduction) [Table 3 and Figure 2b]. Major share of this reduction was due to reduction in elective surgeries ($n = 840$ in 2020 and 4034 in 2019, 73% reduction). Emergency surgeries reduced only by 27.8% ($n = 398$ in 2020 and 552 in 2019), this was not statistically significant. When analyzed based on the age groups, maximum reduction was observed in the GUCH surgeries (total no = 54 in 2020 and 416 in 2019, 87% reduction). Surgeries done on infants and children reduced by 73.9% (total no = 924 in 2020 and 3539 in 2019) and neonates by 58.8% (total no = 260 in 2020 and 631 in 2019). While surgeries for all types of CHD showed a reduction, it was most pronounced for atrial septal defect closure and fontan operation and least for arterial switch operation [Table 4]. The risk adjustment for congenital heart surgery category 1 was less represented and category 3 more represented in 2020 as compared to 2019, indicating more complex nature of operations performed during the pandemic times [Supplementary Table 1].

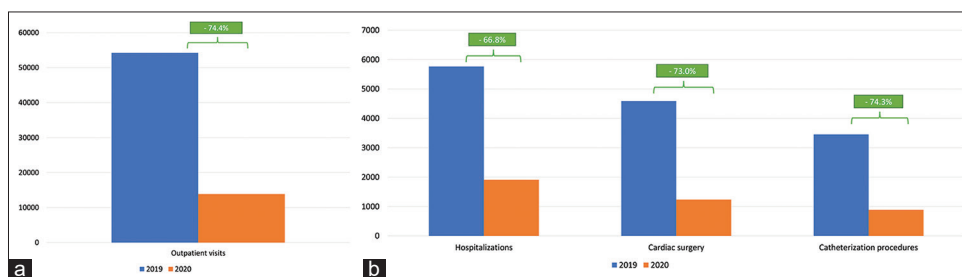


Figure 2: (a) Changes in outpatient numbers in 2020 as compared to 2019 (b) Changes in various parameters in 2020 as compared to 2019

Table 1: Changes in the average outpatient visits per center over a 5-month period in 2020 as compared to 2019

Characteristic, mean±SD Median (IQR)	2019	2020	P	Percentage change
Total OPD visits	2258.8±2065.3 1798.5 (902.5-2640.5)	578.2±565.3 359.5 (144.5-695.5)	<0.001	-74.4
OPD visits by age groups				
Neonate	259.6±381.1 93.0 (49.0-325.5)	106.7±173.6 41.0 (19.5-93.0)	<0.001	-58.9
Infants	1761.7±1572.0 1410.5 (763.0-1990.5)	413.0±417.5 286.5 (106.0-555.0)	<0.001	-76.6
GUCH	237.6±267.8 94.0 (60.5-400.5)	58.5±69.3 25.5 (8.0-84.5)	<0.001	-75.4
Type of OPD visit				
New visits	857.9±891.2 640.0 (353.5-872.5)	261.2±297.5 161.0 (74.5-292.5)	<0.001	-69.6
Follow-up visits	1401.0±1269.6 1147.0 (429.5-1668.0)	317.1±298.9 215.0 (70.0-433.5)	<0.001	-77.41

SD: Standard deviation, IQR: Interquartile range, OPD: Outpatient department, GUCH: Grown-up congenital heart disease

Table 2: Changes in the average number of hospitalizations per center over a 5-month period in 2020 as compared to 2019

Characteristic, mean±SD Median (IQR)	2019	2020	P	Percentage change
Total admissions	240.2±127.3 220.5 (148.5-358.0)	79.5±46.4 75.0 (39.1-113.5)	<0.001	-66.8
Hospitalization by age Groups				
Neonate	36.5±40.7 30.5 (14.5-43.5)	19.1±11.8 17.0 (11.0-24.0)	<0.001	-47.6
Infants/children	173.1±93.9 167.5 (101.5-250.5)	51.8±32.4 50.5 (28.0-73.5)	<0.001	-70.1
GUCH	30.7±45.3 16.0 (10.0-31.0)	8.8±8.9 6.0 (2.0-13.0)	0.01	-71.5
Hospitalization by hospital category				
In South India	254.0±143.7 250.0 (109.0-360.0)	87.3±58.7 84.0 (33.0-143.0)	0.001	-60.7
Other parts of India	228.6±116.4 178.0 (157.0-276.0)	73.1±33.9 72.0 (65.0-104.0)	<0.001	-60.7
Public hospitals	240.8±116.5 216.5 (148.5-333.0)	68.8±57.2 70.0 (19.5-118.0)	<0.001	-75.1
Private hospitals	240.2±132.2 220.5 (146.0-358.0)	81.8±45.4 75.0 (46.0-108.5)	0.0125	-57.8
In tier-1 cities	265.6±117.7 250.0 (168.0-364.0)	79.2±43.9 78.0 (33.0-113.0)	<0.001	-69.3
In nontier-1 cities	198.0±138.3 161.0 (100.0-331.0)	80.2±53.1 67.0 (45.0-114.0)	0.019	-46.3

SD: Standard deviation, IQR: Interquartile range, OPD: Outpatient department, GUCH: Grown-up congenital heart disease

Table 3: Changes in the average number of procedures per center over a 5-month period in 2020 as compared to 2019

Characteristic, mean±SD Median (IQR)	2019	2020	P	Percentage change
Total surgeries	191.1±149.3 164.5 (97.5-246.5)	51.6±39.7 36.5 (23.5-68.5)	<0.001	-73.0
Emergency surgeries	23.0±28.8 11.5 (2.0-38.5)	16.6±19.4 9.5 (1.5-25.5)	0.11	-27.8
Elective surgeries	168.1±130.9 150.5 (73.5-225.0)	35.0±29.2 27.0 (13.0-48.5)	<0.001	-79.2
Number of surgeries by age groups				
Neonate	26.3±29.8 17.0 (13.0-30.0)	10.8±8.4 7.5 (5.5-14.0)	<0.001	-58.8
Infants	147.5±113.8 136.0 (54.0-194.5)	38.5±32.9 26.0 (14.0-51.0)	<0.001	-73.9
GUCH	17.3±19.7 12.0 (6.0-20.0)	2.3±2.4 2.0 (0-3.0)	<0.001	-87.0
Catheterization laboratory procedures				
Total number of procedures	143.9±104.4 107.0 (64.0-201.5)	37.0±30.0 36.0 (13.0-51.0)	<0.001	-74.3
Diagnostic procedures	48.9±46.6 37.5 (11.5-73.0)	9.7±11.5 8.0 (0.5-11.5)	<0.001	-80.4
Elective procedures	83.2±63.0 78.5 (35.5-114.5)	19.0±16.9 18.5 (4.0-27.0)	<0.001	-78.1
Emergency procedures	11.8±15.4 4.0 (1.5-19.5)	8.3±7.7 8.0 (1.0-14.0)	0.20	-28.7
Number of catheterization laboratory procedures by age groups				
Neonates	15.0±18.9 7.0 (2.0-23.5)	9.3±8.6 10.0 (3.0-12.0)	0.08	-38.3
Infants/children	96.8±75.5 85.0 (34.0-122.5)	21.9±18.8 19.5 (7.5-32.5)	<0.001	-77.2
GUCH	32.8±57.7 13.0 (3.0-33.5)	5.8±6.9 2.5 (0-10.5)	<0.001	-82.2

SD: Standard deviation, IQR: Interquartile range, GUCH: Grown-up congenital heart disease

Catheterization laboratory procedures

Trends in catheterization laboratory procedures paralleled those of surgeries, with an overall reduction of 74.3% (total

no = 887 in 2020 and 3454 in 2019), majorly contributed by reduction in elective procedures (total no = 457 in 2020 and 1997 in 2019, 78.1%) [Table 3 and Figure 2b]. Emergency procedures in 2020 reduced by 28.7% (n = 199

Table 4: Number of cardiac procedures performed for congenital heart disease during the study period

Characteristic	2019	2020	Percentage change
Total surgeries			
VSD closure	1271	416	-67.2
ASD closure	946	245	-74.1
PDA ligation	151	68	-55.0
PA band	125	47	-62.4
Arterial switch surgery	237	186	-21.5
TAPVC repair	256	165	-35.5
TOF repair	967	359	-62.8
BT shunt	145	56	-61.3
Glenn	267	90	-66.3
Fontan	143	35	-75.5
Coarctation of aorta	130	74	-43.1
Valve surgeries	253	121	-52.2
Common major interventions			
ASD device closure	1004	214	-78.7
PDA device closure	839	253	-69.8
VSD device closure	458	136	-70.3
PVBD	172	68	-60.4
AVBD	111	45	-59.5
BAS	49	33	-32.7

VSD: Ventricular septal defect, ASD: Atrial septal defect, PDA: Patent ductus arteriosus, PA: Pulmonary artery, TAPVC: Total anomalous pulmonary venous connection, TOF: Tetralogy of fallot, BT: Blalock-Taussig shunt, PVBD: Pulmonary valve balloon dilatation, AVBD: Aortic valve balloon dilatation, BAS: Balloon atrial septostomy

in 2020 and 283 in 2019), which was not statistically significant. The reduction was most pronounced in procedures performed in the GUCH population ($n = 140$ in 2020 and 788 in 2019, 82.2% reduction), followed by those in infants and children ($n = 525$ in 2020 and 2306 in 2019, 77.2% reduction). Neonatal catheterization procedures showed a reduction by 38.3% ($n = 222$ in 2020 and 360 in 2019), but this was statistically not significant. Trend of reduction in the procedures for individual CHDs also paralleled that of surgeries [Table 4]. Rates of major complications during the catheterization procedures were not significantly different between the study period in 2 years (0.4% vs. 0.8%) [Table 5].

Outcome and time-trends

For the admitted patients, the need for preoperative ventilation and preoperative mortality did not differ significantly, while the overall in-hospital mortality was significantly higher in 2020 (8.1%) as compared to 2019 (4.8%), influenced by an increase in the postoperative mortality [Table 5].

The monthly trends in the hospitalization numbers, cardiac surgeries, and outpatient visits are presented in Figure 3a-c. They are plotted against average new COVID cases per month, cumulative COVID-19 cases reported by the 15th of the respective months and average of stringency of lockdown as estimated by investigators from Oxford university.^[14] The reduction was maximum at the outset of the study, which coincided with a stricter lockdown, but with lesser COVID-19 cases.

The reduction in hospitalizations in 2020 was numerically more in the centers located in north India (71.0%

reduction) as compared to other parts of India (63.9%–66.9% reduction) [Figure 4].

We analyzed the factors associated with percentage reduction in cardiac surgeries in 2020 as compared to 2019. On univariate analysis, the reduction in surgery was significantly associated with neonatal ($\beta = 0.31$, $P < 0.001$), infant ($\beta = 0.95$, $P < 0.001$), and GUCH ($\beta = 0.53$, $P = 0.02$) admissions, reduction in outpatient visits ($\beta = 1.05$, $P = 0.02$) and hospitals located in nonmetro cities ($\beta = -26.8$, $P = 0.01$) but type of hospital ($\beta = 24.2$, $P = 0.09$) and geographical location ($\beta = 13.7$, $P = 0.21$) were not significant. A percent reduction in infant admissions and outpatient visits in 2020 compared to 2019 resulted in 0.95% and 1% differential reduction in cardiac surgery, respectively. On multivariate analysis, the significant independent predictors that affected the percent reduction in cardiac surgeries were percent reduction in neonatal ($\beta = 0.09$, $P < 0.001$) and infant ($\beta = 0.77$, $P < 0.001$) admissions.

DISCUSSION

In this large, multicentric, nationwide, retrospective study from 24 leading hospitals across India, we observed a major impact of COVID-19 pandemic on the delivery of pediatric cardiac services across India. As compared to pre-COVID times, there was nearly two-third reduction in the number of outpatient visits, hospitalizations, cardiac surgeries, and interventional procedures. The reduction in hospitalization was relatively less pronounced among neonates and for conditions that require emergent procedures.

A similar quantum of reduction in cardiac surgery has been reported from other parts of the world as well. Early reports from Italy,^[8] China,^[10] and Turkey^[15] reported nearly half to two-third reduction in congenital cardiac surgeries during the pandemic as compared to the preceding year. In a global survey,^[9] half of the interviewed participants reported >50% reduction in volume of CHD surgeries in their centers. According to the survey, 91.2% of the hospitals have canceled elective surgeries. Number of cardiac catheterization procedures for CHD also decreased and all elective cases were canceled among US hospitals.^[16] Congenital cardiac care plummeted across all the age groups, but the comparative outreach for neonatal cardiac care suffered the least, probably because the essential maternal child health and neonatal care services functioned optimally even during the lockdown period in India. Many guidelines^[17-19] have suggested methods of triaging and modified timing of interventions in CHD depending on the physiological and hemodynamic requirements of individual patients. From our data and others, it seems that such a triage has happened in the real-world scenario.

The major factors responsible for such a reduction across the globe include lack of transportation, closed facilities due to lockdown, COVID-19 infection in caregivers, hesitancy among the patients, parents and health-care personnel amidst the pandemic, changing hospital priorities and policies often necessitated by restrictions

Table 5: Comparison of major hospital statistics between 2020 and 2019

Statistics	2019 (%)	2020 (%)	P
Requirement for preoperative ventilation	8.5	9.2	0.35
Preoperative mortality rate	1.6	2.1	0.15
Postoperative mortality rate	4.1	9.3	<0.001
In-hospital mortality	4.8	8.1	<0.001
Catheterization laboratory major complication rate	0.4	0.8	0.13

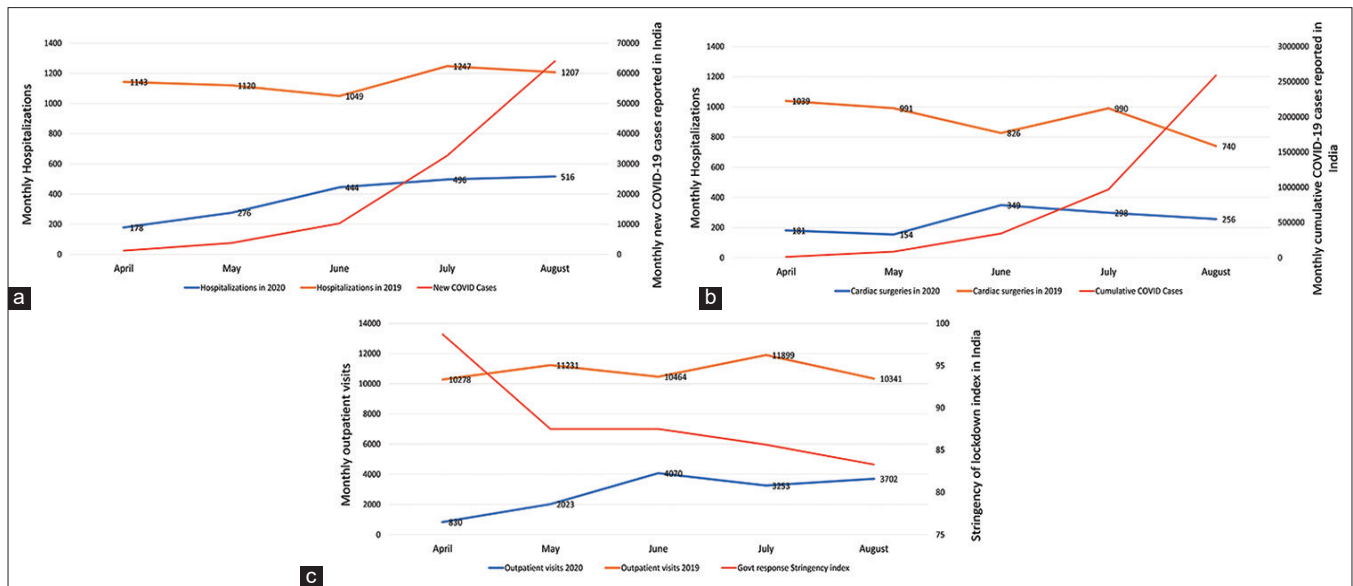


Figure 3: (a) Monthly trends in total hospitalizations compared to new COVID-19 cases in India (b) Monthly trends in cardiac surgeries compared to cumulative COVID-19 cases in India (c) Monthly trends in outpatient visits compared to stringency of lockdown index in India

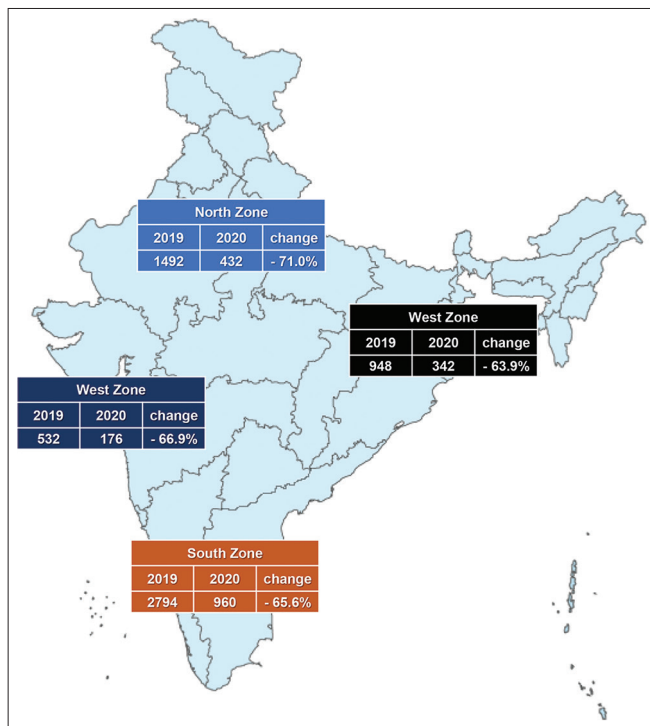


Figure 4: Decrease in hospitalizations in 2020 over the study period across various parts of India

posed by local governmental regulation, need to reallocate resources for managing an overwhelming number of

COVID-19 admission, health-care personnel safety, and need for social distancing. Problems specific to India and other low-and middle-income countries include need to travel longer distances to reach a CHD-care center, lack of ambulance services, and inability to manage out-of-pocket expenses in these pandemic ravaged times.

The postoperative mortality in our study was significantly higher in 2020 as compared to 2019. Studies from Italy^[8] and China^[10] do not report excess postoperative mortality during the pandemic. In contrast, a small study from Turkey^[15] reported 13.8% mortality among children undergoing cardiac surgery on an emergency basis during the pandemic. Comparing postoperative mortality of cardiac surgery across countries is a more complex exercise due to varying standards of systems, patient’s sickness, and expertise. Although we did not have the individual patient variables to analyze the reasons further, we identified a few factors that could have contributed to such an excess. A greater proportion of complex surgeries, neonatal surgeries, and emergency surgeries, and operating on patients with an active or recent COVID-19 infection are likely reasons for the higher postoperative mortality during the pandemic.

COVID-19 pandemic affected different states of India in an asynchronous manner with a few states overwhelmed with loads of cases, while the other states were barely affected, especially during our study period. For instance, Kerala reported lesser COVID-19 cases by August 2020,

while Mumbai and Delhi were ravaged by the pandemic at that time. These differences in COVID-19 are expected to result in differing pattern of admissions,^[20] Southern parts of the country, despite having comparatively better health-care services, suffered from a similar percentage reduction in congenital care hospitalization as did other parts of the country. These findings contrast with what was observed in a large retrospective study of acute myocardial infarction in India during a comparable period.^[6] In that study, Southern parts of India, mainly Kerala reported a lesser magnitude of reduction in admissions for myocardial infarction. Even though there was improvement in the hospitalization rates over the study period, the catchup was more remarkable in myocardial infarction admissions as compared to CHD admissions. In India, the reduction in CHD admission was more related to strictness of lockdown than number of COVID-19 cases, as reported earlier.

As compared to adult cardiology practice in the country and worldwide which reported 30%–50% reduction in acute coronary syndrome admissions,^[1,3,20] congenital cardiac care suffered more. This could be because of limited options for pediatric cardiac care and vulnerable pediatric population with regard to treatment-seeking behavior. Other pediatric specialties such as pediatric oncology services reported a similar downfall in number of new oncology patients and treatment disruptions in existing patients.^[21]

Retrospective nature and lack of individual patient-level data are the major limitations of the study. We could not study the impact of COVID-19 pandemic on various other aspects, including teleconsultations. The study period coincided with the first wave of the pandemic in India. It would be interesting, whether the impact was more during the larger and catastrophic second wave.

The already constrained CHD care infrastructure in resource-limited settings faced a major setback due to the pandemic. Still, most of the centers have performed admirably so that children with CHD are not denied a basic minimum quality of care. It seems that appropriate prioritization has already happened in these unprecedented times. Despite the small workforce for CHD, programs have not collapsed and were able to balance fighting COVID-19 and caring for children. However, these efforts may not be sufficient. Numerous neonates and infants could have lost their lives due to either denied or delayed surgeries. In addition, reduction in the number of procedures is going to create a logarithmic scale pile-up of cases, which could pose major challenges going forward. We need to continue thoughtful triage and prioritize the care for needy children.

There is considerable uncertainty about the course of the pandemic in the coming years. The backlog of unoperated patients with “elective or semi elective” conditions is substantial. Over time some of them could become emergent as their disease progresses. It may be necessary to develop safe strategies to take care of these patients as well as additional nonemergent cases. Some of the burden of outpatient visits can be reduced by task sharing and task shifting using primary care providers, pediatricians,

and physicians assisted remotely through dedicated telemedicine services and other platforms for virtual interaction. Patient education and empowerment through mobile-health technology can eliminate unnecessary hospital visits. This is especially applicable for anticoagulant dose adjustment, fine tuning of arrhythmia management, and heart failure medication dose adjustments.

CONCLUSIONS

The COVID-19 has significantly impacted all aspects related to the delivery of pediatric cardiac services across India. Hospitalizations and cardiac surgeries for children with CHD reduced by two-thirds during the pandemic as compared to prepandemic times, though the reduction was relatively less pronounced in neonatal admissions and conditions that required emergency interventions. The postoperative mortality was higher during the pandemic period, mostly related to performing complex surgeries upon sicker patients on an emergency basis. In an already resource-constrained environment, such a massive reduction in cardiac surgery for CHD could result in persistent pressure on the pediatric care systems over the coming years.

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Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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SUPPLEMENTARY APPENDIX 1: STUDY PRO FORMA: PCSI COVID STUDY

1. Part 1: Hospital Statistics

- All columns give only absolute numbers
- 2019 - include April-July 2019
- 2020 - include April-July 2020.

A. OPD load

	2019	2020	Remarks
April			
May			
June			
July			
Total			

OPD load

	2019					2020				
	Neonate	Infants	1-10	11-18	GUCH >18	Neonate	Infants	1-10	11-18	GUCH >18
April										
May										
June										
July										

b. Pediatric cardiology/CTVS hospital admissions

	2019			2020			Remarks
	New	Old	Total	New	Old	Total	
April							
May							
June							
July							

Pediatric cardiology/CTVS hospital admissions

	Neonate		Infants		GUCH	
	2019	2020	2019	2020	2019	2020
April						
May						
June						
July						
Total						

Outcomes "In unoperated" patients

	In-hospital mortality		No of patients on ventilator	
	2019	2020	2019	2020
April				
May				
June				
July				
Total				

b. Number of cardiac surgeries performed

	2019			2020		
	Emergency*	Elective	In hospital deaths**	Emergency*	Elective	In hospital deaths**
Total numbers						
April						
May						
June						
July						
Neonatal surgeries						
April						
May						
June						
July						
Infantile surgeries						
April						
May						
June						
July						
GUCH surgeries						
April						
May						
June						
July						

*Definition of emergency: Any transcatheter or surgical intervention in patients presenting with spells, refractory heart failure, shock, or needing ventilatory care, **In-hospital death: Using the STS congenital database taskforce definition of postoperative mortality, "any death, regardless of cause, occurring (1) within 30 days after surgery in or out of the hospital and (2) after 30 days during the same hospitalization subsequent to the operation"

Types of surgery	2019	2020	Remarks
ASO			
TAPVC repair			
CoA repair			
PA band			
Aortopulmonary shunts			
VSD closure			
ASD closure			
PDA ligation			
Total correction			
Rastelli			
BD Glenn			
Fontan			
Valve surgeries			
Epicardial pacing			
Others			

b. Interventions

	2019				2020			
	Diagnostic	Emergency	Elective	Major complications*	Diagnostic	Emergency	Elective	Major complications*
Total numbers								
April								
May								
June								
July								
Neonatal								
April								
May								
June								
July								
Infants								
April								
May								
June								
July								
GUCH								
April								
May								
June								
July								

*Major complication: Any transcatheter intervention resulting in new-onset severe spells, refractory heart failure, cardiogenic shock, requirement of postprocedure ventilation, blood transfusion due to blood loss during the procedure, cardiac or local site complications

Types of interventions	2019	2020	Remarks
BAS			
AVBD			
PVBD			
CoA balloon			
PTMC			
Other balloon dilatations			
VSD device			
ASD device			
PDA device			
Other devices			
Coil for APC			
Pacemakers			
ICD/CRT			
RVOT stenting			
PDA stenting			
CoA stenting			
PA stenting			
Other stenting			
Others			

b. Teleconsultations

	2019			2020			Remarks
	New	Old	Total	New	Old	Total	
April							
May							
June							
July							

Teleconsultations

	2019			2020			Remarks
	Neonate	Infants	GUCH	Neonate	Infants	GUCH	
April							
May							
June							
July							

Advice on teleconsultation	2019	2020
Emergency visit		
Advised to visit hospital		
Advised to contact local doctor		
No active intervention		
Medicines changed		
Noncardiac issues addressed		
Others		

Table S1: Number of surgeries in each risk adjustment for congenital heart surgery category during the study period

Category	2019 (n=4586), n (%)	2020 (n=1238), n (%)
1	1056 (23.0)	232 (18.7)
2	2384 (52.0)	626 (50.6)
3	786 (17.1)	260 (21.0)
4	50 (1.1)	8 (0.7)
5	0	0
6	0	0
Excluded (others)	310 (6.8)	112 (9.0)

$P < 0.0001$ for overall comparison between both the years, $P < 0.001$ for comparison of category 1 versus all others between both the years, $P < 0.006$ for comparison of category 3 and 4 versus all others between both the years. RACHS: Risk adjustment for congenital heart surgery