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Paediatrics Section

# Comparing the Clinical Spectrum of Paediatric In-patients in pre-COVID-19, during COVID-19 and post-COVID-19 Pandemic Periods in a Tertiary Level Teaching Centre

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## ABSTRACT

**Introduction:** Public awareness of the COVID-19 pandemic has resulted in a reduction in healthcare utilisation for other diseases. Understanding how the COVID-19 pandemic affects hospital admissions and the disease patterns is crucial for proper triaging and planning of health resources in future pandemics.

**Aim:** To compare the clinical spectrum of paediatric inpatients in the post-COVID-19, pre-COVID-19 and during COVID-19 pandemic periods in a tertiary level teaching centre.

**Materials and Methods:** This ambispective study was conducted at the Paediatrics Department of SAT, Government Medical College, Thiruvananthapuram, Kerala, India. The analysis included all cases hospitalised from April 2019 to March 2022, with the data divided into three time periods. The discharge diagnoses of all cases admitted during the study period were coded according to the ICD-10 criteria and included in the analysis. Differences in admissions, disease patterns, and ICU admissions during the three time periods (pre-COVID-19, post-COVID-19, and during COVID-19) were compared using one-way ANOVA and Tukey's post-hoc test.

**Results:** In the present study, ward admissions (p-value <0.001), respiratory infections (p-value 0.031), asthma (p-value 0.009), and chronic systemic diseases (p-value 0.018) decreased in the post-COVID-19 period compared to the pre-COVID-19 period, whereas ICU admissions (p-value 0.010) and Diabetic Ketoacidosis (DKA) (p-value 0.002) increased. When comparing COVID-19 and post-COVID-19 periods, there was an increase in ward admissions (p-value 0.01), respiratory infections (p-value 0.018), and diarrhoea (p-value 0.029), but a decrease in the proportion of ICU admissions (p-value 0.01). There was no significant difference in mortality among the three time periods.

**Conclusion:** There was a significant difference in the clinical spectrum of paediatric inpatients. The significant decrease in admissions of chronic systemic diseases, which require regular follow-up for management changes, raises concerns about the potential impact on patient care.

**Keywords:** Children, Chronic disease, Healthcare services, Hospitalisation, Mortality, Pandemic

## INTRODUCTION

The COVID-19 pandemic has had an enormous impact on society, as public awareness of the pandemic and the imposed lockdown has led to a significant reduction in healthcare utilisation for other diseases worldwide [1]. Lockdowns are public health strategies that not only have a specific effect on COVID-19 transmission but also on all transmissible infectious diseases. This effect may be particularly pronounced in the field of paediatrics [2]. There has been a decrease in other infectious diseases during the pandemic period due to improved hygiene, healthy behavioural practices, school closures, absence of gatherings, and decreased pollution [1,2].

A decrease in the total number of paediatric admissions and visits to the Emergency Department (ED) has been observed worldwide [3,4]. However, it remains unclear whether this reduction is solely due to a decrease in transmissible infections or also due to behavioural changes in healthcare utilisation. If avoidance of care is a significant factor, we would expect a similar reduction in admissions and ED visits for non-infectious diseases compared to visits for transmissible infectious diseases. There have been numerous reported examples of people avoiding seeking treatment out of fear of a hospital environment during the COVID-19 pandemic, which can have potentially disastrous consequences [5-7]. Physicians should be aware of this possibility in the event of future pandemics in their countries.

Children have been less affected by the COVID-19 pandemic, but its repercussions on paediatric illnesses are significant. There may also be a potential increase in the rate of hospitalisation due to the severity of other illnesses as a result of delayed medical care due to parental avoidance of hospitalisation out of fear of contracting COVID-19, economic constraints, and psychosocial factors. There are reports of changes in hospitalisation patterns for childhood illnesses such as asthma, respiratory infections, ED visits, and ICU admissions [8-11], as well as an increased incidence of DKA [12].

Knowledge of changes in disease patterns will prompt high vigilance among primary care and emergency doctors, which will help in preparedness during pandemics and the organisation of healthcare system collaboration. Although an overall reduction in paediatric patients seeking care has been widely reported, stratification of disease-specific groups has been rarely performed [1-3]. Hence, the present study was conducted to compare the clinical spectrum of paediatric inpatients in the post-COVID-19 period with that of the pre-COVID-19 and COVID-19 pandemic periods in a tertiary-level teaching centre.

## MATERIALS AND METHODS

This ambispective study was conducted at the Paediatrics Department of a tertiary care centre, SAT, Government Medical College, Thiruvananthapuram, Kerala. Ethical approval was obtained from the Institutional Ethics Committee (HEC No. 05/46/2020/MCT, dated 24.9.2020). The analysis included all cases hospitalised from April 2019 to March 2022, with the data divided into three time periods. In India, the COVID-19 pandemic was declared, and nationwide lockdown started on March 25, 2020. Therefore, the pre-COVID-19 period was considered from April 2019 to March 2020,

the COVID-19 period from April 2020 to March 2021, and the post-COVID-19 period from April 2021 to March 2022.

**Inclusion criteria:** All children aged between one month to 12 years who were admitted during the study period, irrespective of the disease, were included in the analysis.

**Exclusion criteria:** Cases discharged without a definite diagnosis, such as those discharged against medical advice or absconded, were excluded.

**Data collection:** The authors reviewed the medical records of children and collected details of admission dates and discharge diagnoses from the computerised database system and medical records library. Discharge diagnoses were coded according to the ICD-10 criteria [13]. Admissions were divided into two groups and further subdivided as follows:

| | |
|---|---|
| 1. Critical illnesses admitted in the Paediatric Intensive Care Unit (PICU) | |
| 2. Ward admissions | 1. Respiratory infections |
| | 2. Less serious illnesses not requiring PICU admissions, such as fever, septicaemia, Skin and Soft Tissue Infections (SSTI) |
| | 3. Infections and Infestations, including bacterial (typhoid, diphtheria, pertussis), viral (measles, dengue, Infectious Mononucleosis), Spirochaetal (leptospirosis) |
| | 4. Diarrhoeal diseases |
| | 5. Chronic systemic diseases (Cardiac, Neurologic, Endocrine, Respiratory, Hematologic, Rheumatologic, Nephrology, Immunodeficiency, malignancies, Metabolic and storage diseases) |
| | 6. Miscellaneous group (Poisoning, Drowning, Electrocution) |

## STATISTICAL ANALYSIS

All statistical analyses were performed using Microsoft Excel and SPSS version 26.0. Differences in admissions during the three time periods were compared using one-way ANOVA and Tukey's post-hoc test. Mean difference and 95% confidence intervals were calculated. A p-value of <0.05 was considered statistically significant.

## RESULTS

There were 21,308 admissions in the paediatric department during the entire study period, of which 17,892 (84%) were ward admissions and 3,416 (16%) were ICU admissions. The number of ward admissions was only 2,949 (76%) during the COVID-19 period, compared to 9,718 (87%) during the pre-COVID-19 period and 5,225 (81%) during the post-COVID-19 period. The number of ICU admissions was 886 (23%) during the COVID-19 period, compared to 1,454 (13%) during the pre-COVID-19 period and 1,076 (18%) during the post-COVID-19 period [Table/Fig-1].

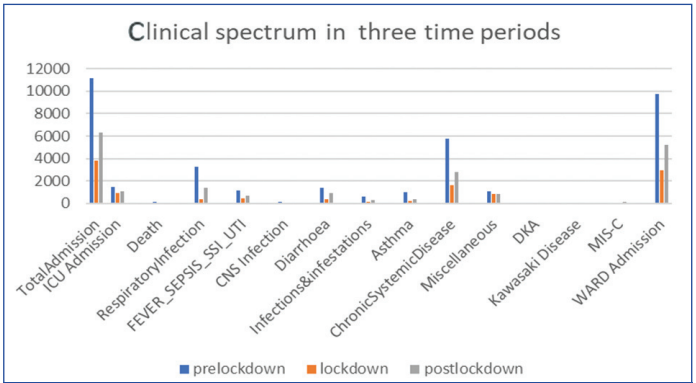
The trend of hospitalisation shows a definite decrease in the number of hospitalised cases for most disease categories during the pandemic period. Even though there was a hike in ward admissions in the post-pandemic period, it was significantly lower than the pre-pandemic period [Table/Fig-2]. The trend of hospitalisation for respiratory and asthma cases is shown separately as they constitute a major portion of paediatric hospital admissions. It was found that hospitalisation for respiratory and asthma diseases was highest in the pre-COVID-19 duration and reduced during COVID-19, and then cases started to increase after the COVID-19 period [Table/Fig-3].

There was a decrease in respiratory infections during the COVID-19 period, and the rise in the post-COVID-19 period was lower than the pre-COVID-19 period. The timeline of COVID-19 infection and Multisystem Inflammatory Syndrome in Children (MISC) shows a peak of MISC cases after each COVID-19 peak [Table/Fig-4]. This is important from an epidemiological point of view as it indicates MISC as a post-COVID-19 phenomenon.

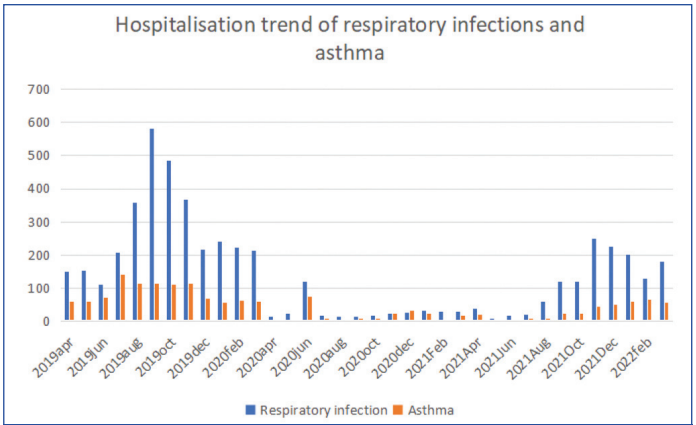
Comparison of admissions among the three periods showed that ward admissions (p-value <0.010), respiratory infections (p-value=0.031), asthma (p-value=0.009), and chronic systemic diseases (p-value=0.018) were decreased in the post-COVID-19

| Admissions | Pre-COVID-19 n (%) | COVID-19 n (%) | Post-COVID-19 n (%) |
|---|---|---|---|
| *Total admissions | 11,172 (100) | 3835 (100) | 6301 (100) |
| Ward admissions | 9718 (87) | 2949 (76) | 5225 (81) |
| ICU admissions | 1454 (13) | 886 (23) | 1076 (18) |
| Death | 149 (1.3) | 44 (1.1) | 78 (1.3) |
| COVID-19 death | 0 (0) | 3 (0.1) | 8 (0.1) |
| Respiratory infection | 3304 (28) | 344 (10.4) | 1358 (18) |
| Fever/sepsis/SSI/UTI | 1173 (10) | 414 (10) | 655 (10) |
| CNS Infection | 146 (1.3) | 60 (1.5) | 55 (0.9) |
| Diarrhoea | 1427 (13) | 350 (9) | 947 (15) |
| Infections and infestations | 632 (5.7) | 173 (4.5) | 268 (4.2) |
| Bronchial asthma | 1013 (9) | 188 (4) | 343 (4.5) |
| †Chronic systemic disease | 5756 (51) | 1646 (43) | 2777 (43) |
| ‡Miscellaneous | 1051 (9) | 823 (22) | 809 (14) |
| Diabetic ketoacidosis | 28 (0.3) | 34 (0.9) | 46 (0.9) |
| Kawasaki disease | 42 (0.4) | 25 (0.7) | 17 (0.2) |
| MISC | 0 (0) | 60 (1.6) | 131 (2.6) |
| COVID-19 infection | 2 (.02) | 684 (22) | 627 (15) |

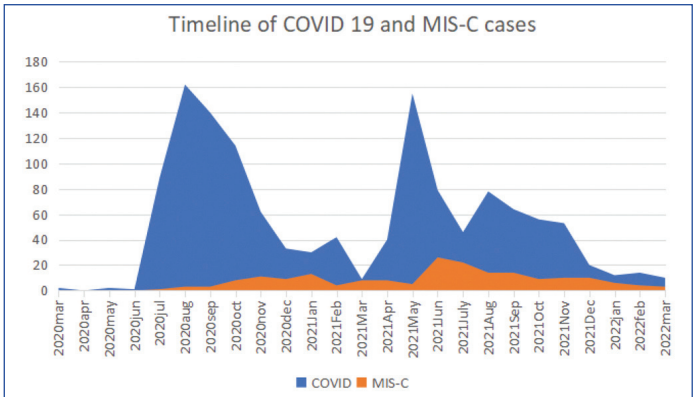
**[Table/Fig-1]:** Number (Percentage) of admissions in paediatric department during pre-COVID-19, COVID-19, and post-COVID-19 pandemic periods.
*Some discharge diagnosis has multiple diagnosis, So added up value is different
†Cardiac, Neurologic, Endocrine. Respiratory, Haematologic, Rheumatologic, Nephrology, Immunodeficiency, Malignancies, Metabolic and storage diseases
‡Poisoning, Drowning, Electrocution; MISC: Multisystem inflammatory syndrome in children




**[Table/Fig-2]:** Trend of paediatric hospitalisation in pre-COVID-19, post-COVID-19 and during COVID-19 periods.
*Chronic systemic disease- Cardiac, Neurologic, Endocrine. Respiratory, Haematologic, Rheumatologic, Nephrology, Immunodeficiency, Malignancies, Metabolic and storage diseases
†Miscellaneous-Poisoning, Drowning, Electrocution




**[Table/Fig-3]:** Hospitalisation trend of respiratory infections and asthma during pre-COVID-19, post-COVID-19 and during COVID-19 periods.




**[Table/Fig-4]:** MISC and COVID-19 timeline.

period compared to the pre-COVID-19 period, whereas ICU admissions (p-value=0.010) and DKA (p-value=0.002) were increased. Comparing COVID-19 and post-COVID-19, there was an increase in ward admissions (p-value=0.01), respiratory infections (p-value=0.018), and diarrhoea (p-value=0.029), but a decrease in ICU admissions (p-value=0.01). There was no significant difference in mortality among the three time periods [Table/Fig-5].

| Category | Time periods | Mean difference (95% CI) | p-value |
|---|---|---|---|
| Ward admissions | Pre COVID-19- COVID-19 | 10.55 (6.42-14.67) | **<0.001** |
| | Pre COVID-19- post-COVID-19 | 5.27 (1.15-9.39) | **0.010** |
| | COVID-19- post-COVID-19 | -5.27 (-9.4-1.15) | **0.010** |
| ICU admissions | Pre COVID-19- COVID-19 | -10.54 (-14.67-6.42) | **<0.001** |
| | Pre COVID-19- post-COVID-19 | -5.27 (-9.39-1.15) | **0.010** |
| | COVID-19- post-COVID-19 | 5.27 (1.15-9.4) | **0.010** |
| Death | Pre COVID-19- COVID-19 | 0.06 (-0.48-0.61) | 0.952 |
| | Pre COVID-19- post-COVID-19 | 0.007 (-0.53-0.55) | 0.999 |
| | COVID-19- post-COVID-19 | -0.059 (-0.6-0.48) | 0.962 |
| Respiratory infection | Pre COVID-19- COVID-19 | 20.04 (11.19-28.9) | **<0.001** |
| | Pre COVID-19- post-COVID-19 | 9.63 (0.78-18.5) | **0.031** |
| | COVID-19- post-COVID-19 | -10.40 (-19.26--1.55) | **0.018** |
| Fever/sepsis/ Skin and soft tissue infection/UTI | Pre COVID-19- COVID-19 | 0.053 (-2.81-2.92) | 0.999 |
| | Pre-COVID-19- post-COVID-19 | -0.21 (-3.08-2.65) | 0.982 |
| | COVID-19- post-COVID-19 | -0.26 (-3.13-2.6) | 0.972 |
| CNS infection | Pre-COVID-19- COVID-19 | -0.16 (-0.67-0.34) | 0.702 |
| | Pre-COVID-19- post-COVID-19 | 0.48 (-0.02-0.99) | 0.059 |
| | COVID-19- post-COVID-19 | 0.65 (0.15-1.15) | **0.009** |
| Diarrhoea | Pre-COVID-19- COVID-19 | 4.97 (-0.88-10.82) | 0.109 |
| | Pre-COVID-19- post-COVID-19 | -1.44 (-7.3-4.41) | 0.818 |
| | COVID-19- post-COVID-19 | -6.41 (-12.27--0.56) | **0.029** |
| Bronchial asthma | Pre-COVID-19- COVID-19 | 4.67 (1.28-8.06) | **0.005** |
| | Pre-COVID-19- post-COVID-19 | 4.39 (1-7.78) | **0.009** |
| | COVID-19- post-COVID-19 | -0.27 (-3.67-3.11) | 0.978 |
| *Chronic systemic disease | Pre-COVID-19- COVID-19 | 7.39 (0.86-13.93) | **0.024** |
| | Pre-COVID-19- post-COVID-19 | 7.69 (1.16-14.24) | **0.018** |
| | COVID-19- post-COVID-19 | 0.30 (-6.23-6.84) | 0.993 |
| Diabetic ketoacidosis | Pre-COVID-19- COVID-19 | -0.63 (-1.06--0.22) | **0.002** |
| | Pre-COVID-19- post-COVID-19 | -0.63 (-1.06--0.22) | **0.002** |
| | COVID-19- post-COVID-19 | -0.001 (-0.42-0.42) | 1.000 |

**[Table/Fig-5]:** Comparison of admissions in paediatric department during pre-COVID-19, and post-COVID-19 periods.
*Cardiac, Neurologic, Endocrine. Respiratory, Haematologic, Rheumatologic, Nephrology, Immunodeficiency, Malignancies, Metabolic and storage diseases; One-way ANOVA and Tukey's post-hoc test

## DISCUSSION

There is a significant difference in the trend of disease patterns among hospitalised children in the post-COVID-19 period compared to the pre-COVID-19 and COVID-19 pandemic periods. Knowledge of changing trends helps in triaging and optimum allocation of scarce resources, especially in crisis situations like a pandemic [14-18]. Changes in healthcare-seeking behavior, referral and admission criteria, and resource availability of staff and hospital beds might have affected the hospitalisation pattern. There is a scarcity of data comparing the post-COVID-19 period with the pre-COVID-19 and COVID-19 periods, and most available data compare the pre-COVID-19 and COVID-19 periods. Significant reduction in paediatric ward admissions during the COVID-19 and post-COVID-19 periods has been seen in previous studies [9,16,19]. Goel V et al., reported a lower daily admission rate in the COVID-19 era [18]. The tertiary care hospital was a COVID treatment centre in the public sector, which continued to provide services for other illnesses as well. So, parental avoidance of hospitalisation due to fear of contracting COVID-19, especially for non-serious illnesses, could have contributed to this.

Ward admissions and acute respiratory infections decreased during the COVID-19 period and increased during the post-COVID-19 period, but it was still lower than the pre-COVID-19 period. A decrease in infectious diseases, including acute respiratory infections, during the post-COVID-19 period has been previously reported [19]. The number of bronchial asthma cases decreased during the COVID-19 period and did not significantly increase during the post-COVID-19 period. For asthma, the indoor stay during the pandemic may have led to less transmission of respiratory pathogens and allergens [14,15,20]. A large time series analysis in France also reported a 70% reduction in the common cold and otitis media [21]. Previous studies have found that emergency visits for asthma decreased by 76-84% [20,22-25]. It has been reported that easing strict lockdown restrictions did not lead to a substantial rebound in asthma cases [25]. It is possible that the healthy behavioural changes and care at home by parents continued into the post-COVID-19 period, which could have decreased acute asthma exacerbations [24].

A study on child mortality reported that there was no excess mortality during the COVID-19 period, as seen in the present study [26]. However, a study by Goel V et al., reported an increase in mortality during the lockdown period [18]. In the present study, although the proportion of PICU admissions increased, the mortality remained the same.

The increased proportion of ICU admissions during the COVID-19 and post-COVID-19 periods in our study is similar to a study by Goldman RD et al., but contradictory to a study by Pines JM et al., [27,28]. This increase in ICU admissions could be due to disease progression resulting from delays in seeking medical care, economic and psychosocial factors preventing hospital visits, and diversion of healthcare resources towards COVID-19 patients [15,29,30]. The reduction in infectious contacts due to hygiene measures imposed by the pandemic may have led to a decreased immune training and increased susceptibility to severe infections in children [31,32].

Admissions due to chronic systemic diseases remained decreased during the COVID-19 and post-COVID-19 periods, with a further decrease in the post-COVID-19 period compared to the pre-COVID-19 period. During the lockdown, people may have started using healthcare facilities in their nearby areas and accessing non-contact healthcare utilisation facilities provided by the government [25,26]. Disruptions in routine care for people with chronic conditions and a decrease in follow-up visits for paediatric chronic cases have been reported during the pandemic [15]. This is an important issue to be taken care of because many of them would have serious illnesses that need regular monitoring and necessary adjustments in treatment. Parents of children with chronic illnesses should continue to access medical care and must not delay seeking it. Mathematical modeling projects a 3.6% increase in child mortality due to the COVID-19 pandemic's effects on low and middle-income countries [33].

Our study, similar to previous studies [12,29,34], observed a significant increase in Diabetic Ketoacidosis (DKA) compared to the pre-COVID-19 period. Reduced access to primary care services and parental anxiety during the pandemic may have contributed to this increase. There is speculation that COVID-19 infection may trigger the development of ketoacidosis by directly damaging pancreatic beta cells, based on observations that other coronaviruses bind to ACE2 receptors expressed by these cells [29,34-35].

Contrary to previous reports [11], the miscellaneous group, which includes poisoning and electrocution, showed a significant increase during the COVID-19 period. One study by Goyal V [18] also reported an increase in poisoning. This could be due to school closures and children being unsupervised at home. Caregivers need to be made aware of safety precautions for children at home. The timeline of COVID-19 and MISC in the presnt study suggested a post-COVID phenomenon. The temporal, geographic, and epidemiological features of MISC strongly support this [36].

Stratifying disease diagnoses into categories provides a better overview of the specific effects of the pandemic on parents' and children's propensity to seek hospital care. This can serve as a basis for future studies to focus on the acuity of clinical presentations and the proportion of delayed diagnoses or treatments. The results of the current study emphasised the need for ongoing surveillance of hospital admission patterns to provide information to policymakers in planning future pandemic healthcare strategies.

### Limitation(s)

As the present study only includes aggregate analysis of referred cases admitted to a single tertiary care referral centre, further studies are required to obtain a more comprehensive picture.

## CONCLUSION(S)

The spectrum of childhood diseases and healthcare utilisation show drastic variations due to the COVID-19 pandemic and disruptions to essential health services in the post-COVID-19 period compared to the pre-COVID-19 and COVID-19 periods. The rise of MISC cases after each peak of COVID-19 indicates it as a post-COVID-19 phenomenon, and it is important to investigate its long-term effects. Respiratory infections and asthma cases, which constitute a major portion of paediatric admissions, show a significant reduction in the post-COVID-19 period compared to the pre-COVID-19 period. This reduction may be due to the healthy behavioural changes adopted during the lockdown period continuing afterward. While some conditions may have become less common, others indicate unmet needs in paediatric care, especially for chronic systemic diseases. Awareness of these changes in paediatric disease and admission patterns helps anticipate the necessary adjustments in resource allocation for future pandemics.

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