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Clinical and epidemiological characteristics of children with COVID-19 in Selangor, Malaysia

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ABSTRACT

Objective: To describe the clinical and epidemiological characteristics of children diagnosed with coronavirus disease 2019 (COVID-19) at Hospital Sungai Buloh, Selangor, Malaysia.

Methods: A retrospective observational study was performed on children aged <12 years diagnosed with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection between January 25 and December 31, 2020. A comparative analysis was undertaken between asymptomatic and symptomatic children, as well as a sub-analysis of their caretakers' COVID-19 status.

Results: A total of 1498 children were included, 48.7% female and 51.3% male. Their mean age was 5.6 years (standard deviation 3.5 years). Overall, 82.3% were detected through contact tracing of positive family members or from the same household. Fifty-seven percent were asymptomatic. The most common symptoms reported were fever, nasal congestion/rhinorrhoea, and cough. Compared to asymptomatic children, those who were symptomatic had higher reported comorbidities, lower total white blood cell (WBC), absolute lymphocyte, and absolute neutrophil counts, raised C-reactive protein (CRP), and raised aspartate transaminase ($P < 0.05$). The median duration of illness was 10 days (interquartile range 3 days). Overall outcomes were good. Only 19 (8.2%) negative caretakers seroconverted prior to discharge.

Conclusions: The majority of the children in the State of Selangor experienced mild COVID-19 illness in 2020, and they did not appear to be key drivers in the transmission of the disease.

Introduction

Since its first appearance in December 2019, the novel coronavirus disease 2019 (COVID-19) has become an international health priority. The infection rate and disease progression appear to differ significantly between adult and paediatric populations. Published data and clinical experience indicate that the paediatric population have milder symptoms, lower rates of infection, lower prevalence of disease, and lower mortality rates (Centers for Disease Control and Prevention, 2021; Gaythorpe et al., 2021).

The population of Malaysia (total 32.6 million people) is young, with 10.5 million aged ≤19 years old ((Department of Statistics Malaysia 2021). In 2020, Malaysia experienced the COVID-19 outbreak in three waves: January 25 to February 15, February 27 to July 8, and October 8 to beyond December 31 (Hashim et al., 2021). The first reported cases involved two paediatric patients who were admitted to Hospital Sungai Buloh (HSgB) on January 25, 2020 (See et al., 2020). As part of the Malaysian containment strategy, all patients with a suspected or confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection were initially admitted. By the third wave, mandatory admission to healthcare facilities was only required for confirmed cases regardless of disease severity. In Malaysia, children are still classified as a high-risk group for COVID-19. As such, the national policies, e.g. school closure, and hospitalization protocols are targeted to protect this group (Ministry of Health 2020).

HSB, located in the northern region of Selangor, was the first hospital in the country designated as a COVID-19 health facility, extending from its original role as the national infectious disease centre. Selangor is the most populous state in Malaysia, with 6.53 million residents over 7951 km^2. It encloses two federal territories, the Federal Territory of Kuala Lumpur with 1.79 million residents over 243 km^2, and the Federal Territory of Putrajaya with 0.1 million residents over 49 km^2 (Department of Statistics Malaysia 2021).

In 2020, there were a total of 113 010 cases nationwide, with 8369 cases identified among children <12 years old. Cases from Selangor and the Federal Territories accounted for the majority of SARS-CoV-2 infections in the country. There were 46 164 cases from Selangor and the Federal Territories alone (CodeBlue, 2021; GitHub 2021).

Abbreviations: Clinical features, Clinical features; Epidemiology, Epidemiology; Paediatric COVID-19, Paediatric COVID-19; SARS-CoV-2, SARS-CoV-2.

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This study describes the epidemiology, clinical characteristics, and outcomes of 1498 children infected with SARS-CoV-2 from Selangor and the Federal Territories of Kuala Lumpur and Putrajaya, who were admitted from January 25 to December 31, 2020.

Patients and methods

Design

This observational study retrospectively analysed the clinical data of all paediatric patients confirmed with SARS-CoV-2 infection, aged <12 years, admitted to HSgB from January 25 to December 31, 2020. The data were extracted from the electronic hospital information system (E-HIS) and manual records, up to 6 months post-discharge. Data analysed included the following: demographic characteristics, epidemiological data (including possible infection origin, caretaker COVID status on admission and pre-discharge), symptoms, comorbidities, routine vaccination status, specific laboratory investigations, general radiological findings, illness progression, treatment received, and outcomes.

Case definitions

A case was defined as a child confirmed with SARS-CoV-2 infection via reverse-transcriptase PCR (RT-PCR) analysis or rapid antigen test kit (RTK-Ag) of nasopharyngeal and/or oropharyngeal swabs at designated National Public Health laboratories, the Institute of Medical Research, or accredited hospital laboratories. Viral detection using RTK-Ag without confirmatory RT-PCR was accepted in selected situations where there was a strong epidemiological link and reduced laboratory capacity at the time due to a caseload surge. A strong epidemiological link was taken as having multiple family or community members diagnosed with COVID-19 during the same period.

The date of onset (of illness) was defined as the date of earliest symptoms – up to 2 months before admission and until discharge (Han et al., 2021) [Au?5]. If this date was unavailable, then the date the positive swab was taken was set as the date of onset. The duration of illness was calculated from the date of onset to the date of discharge. The standard duration of quarantine (thus admission) varied according to changes in national policy, but was between 10 and 14 days from positive detection.

All symptoms, including those possibly due to underlying comorbidities, or unrelated to COVID-19, or due to co-infection were reported. Illness severity was staged according to Ministry of Health guidelines (Ministry of Health 2020): category 1 (Cat 1): asymptomatic; category 2 (Cat 2): symptomatic without pneumonia; category 3 (Cat 3): symptomatic with pneumonia, without requirement for supplemental oxygen; category 4 (Cat 4): symptomatic with pneumonia, requiring supplemental oxygen; category 5 (Cat 5): critically ill with multi-organ involvement. Illness severity was assigned based on the worst symptoms experienced throughout the illness, including before and during admission. Two children were restaged from Cat 2 to Cat 3, following a retrospective analysis of radiographic images.

Only one caretaker was assigned per person, even though a child may have been accompanied by two or more caretakers. The caretaker of choice, for data collection, was the one positive for COVID-19.

Statistical analysis

Variables with missing data are reported in **Supplementary Material** Tables S1 and S2. Missing data were omitted from the statistical analysis. Continuous variables were described using the mean and standard deviation (SD) if normally distributed and using the median and interquartile range (IQR) if not normally distributed. Categorical variables were described using the frequency (n) and percentage (%). Results of blood investigations were categorized into normal, abnormally high, or abnormally low, using reference values by age (see **Supplementary Material** Table S3). Statistical tests such as the independent t-test, Mann–Whitney U-test, and Chi-square test were performed to assess differences between asymptomatic (Cat 1) and symptomatic (Cat 2–5) children and to perform a targeted analysis comparing caretaker status with their child's epidemiological link; all analyses were performed using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA).

Ethical considerations

The study was registered with the National Medical Research Register (NMRR-20-580-54339) and approved by the Medical Research and Ethics Committee, Ministry of Health, Malaysia.

Results

Baseline characteristics

A total of 1498 children under 12 years of age were admitted to HSB. Their median age was 5.4 years (IQR 2.5–8.5 years) and the male to female ratio was 1.05:1 (Table 1). About 14.8% of children had comorbidities, with bronchial asthma (2.9%), allergies (2.6%), and eczema (2%) being the top three most frequently reported. The vast majority of children (96%) had completed their routine vaccination up to age.

Epidemiological characteristics

Case detection by contract tracing due to a positive family member was the most reported cause of admission (82.3%). Only 50 (3.4%) children were linked to a positive contact at school/childcare. Eight children were index cases without a known epidemiological link and 197 children were screened for other reasons, such as immigration requirement or mass screening due to high community infection.

About 88.3% of children had other household members or frequent close contact family members who were also detected to be positive for COVID-19. On average, each child had 2.8 (SD 1.9) positive close contact family/household members.

Illness characteristics

About 56.9% of children were asymptomatic (Cat 1) during their entire illness. A further 41.5% were symptomatic but had no pneumonia (Cat 2). Only 11 (0.8%) patients were diagnosed with COVID-19 pneumonia, three (0.5%) not requiring oxygen support (Cat 3) and four (0.3%) who did (Cat 4). The frequency of symptoms in order from highest to lowest is shown in Table 3. The most common symptoms were fever, nasal congestion/rhinorrhoea, and cough.

Laboratory parameters and imaging findings

Overall, investigations were normal in the majority of children, even amongst symptomatic patients. However, symptomatic children had a higher incidence of low total white blood cell count (8.0% vs 3.6%, $P < 0.025$), low absolute lymphocyte count (7.0% vs 1.0%, $P < 0.001$), and low absolute neutrophil count (19.4% vs 8.6%, $P < 0.001$). High C-reactive protein was more frequent in symptomatic patients (12.5% vs 1.2%, $P < 0.001$) (Table 2).

Investigation of routine liver enzymes (aspartate aminotransferase (AST) and alanine aminotransferase (ALT)) showed normal liver enzyme function in 634 children (88.7% of 715 children with both tests done). There was a higher incidence of raised AST amongst symptomatic children (8.1% vs 3%, $P = 0.004$). However, no children in Cat 4 and only one child in Cat 3 had abnormal liver enzymes (Table 4).

Only 26 children had chest radiography performed (see Table 5 for findings according to illness severity). All asymptomatic children had normal X-rays. Three children had X-rays reported as abnormal with

Table 1
Overall clinical and epidemiological characteristics of the children admitted to Hospital Sungai Buloh in 2020 for COVID-19 (N = 1489)

Sex, *n* (%)	Female	730 (48.7)	Caretaker	Parent	1348 (90 [Au?7])
Age (years)	Mean (SD)	5.57 (3.48)	relationship, *n* (%)	Other family	101 (6.7)
Age group, *n* (%)	Neonate (≤28 days)	9 (0.6)		Other	8 (0.5)
	Infant (1 month to <1 year)	138 (9.2)		Unknown relationship	30 (2 [Au?7])
	Toddler/preschool (1–5 years)	672 (44.9)		No caretaker	11 (0.7)
	School-age (6–11 years)	679 (45.3)	Illness severity, *n*	Category 1	853 (56.9)
Ethnicity, *n* (%)	Malay	1086 (79.9)	(%)	Category 2	622 (41.5)
	Chinese	76 (5.6)		Category 3	7 (0.5)
	Indian	149 (11 [Au?7])		Category 4	4 (0.3)
	Other Malaysian ethnicities	49 (3.5)		Category 5	0 (0)
	Non-Malaysian	138 (9.2)	Investigations		
Comorbidity, *n* (%)	Yes	221 (14.8)	CXR, *n* (%)	Normal	12 (46.1)
Comorbidity present	Bronchial asthma (BA)	44 (2.9)	Total WBC count, *n*	Normal	594 (82 [Au?7])
(breakdown), *n* (%)	Allergies	39 (2.6)	(%)	Abnormal high	87 (12 [Au?7])
	Eczema	30 (2.0)		Abnormal low	43 (5.9)
	Developmental	26 (1.7)	Absolute lymphocyte	Normal	618 (92.2)
	Allergic rhinitis	23 (1.5)	count, *n* (%)	Abnormal high	24 (3.6)
		21 (1.4)		Abnormal low	28 (4.2)
	Neuromedical/neurosurgical				
	General/other/under investigation	14 (0.9)	Absolute neutrophil count, *n* (%)	Normal	542 (81 [Au?7])
	G6PDH deficiency	13 (0.9)		Abnormal high	31 (4.6)
	Cardiovascular system	8 (0.5)		Abnormal low	96 (14.3)
	Prematurity	7 (0.5)	Platelet count, *n* (%)	Normal	646 (89.2)
	Otorhinolaryngology	7 (0.5)		Abnormal high	77 (10.6)
		7 (0.5)		Abnormal low	1 (0.1)
	Orthopaedic/musculoskeletal/ plastic				
	Gastrointestinal	6 (0.4)	CRP, *n* (%)	Normal	652 (92.7)
	Renal	5 (0.3)		Abnormal high	51 (7.3)
	Haematology	5 (0.3)	AST, *n* (%)	Normal	676 (94.3)
	Dermatology	4 (0.3)		Abnormal high	41 (5.7)
	Endocrine	4 (0.3)	ALT, *n* (%)	Normal	649 (90.3)
	Respiratory (other than BA)	3 (0.2)		Abnormal high	70 (9.7)
	Syndromic (chromosomal/genetic)	3 (0.2)	Treatment, *n* (%)	Yes	155 (10.4)
	Oncology	2 (0.1)	Treatment	Symptomatic	130 (83.9)
	Ophthalmology	1 (0.1)	(breakdown), *n* (%)	Antibiotics	26 (16.8)
	Urology	1 (0.1)		Antiviral (treatment of COVID-19)	1 (0.6)
Vaccination, *n* (%)	Up-to-age	1310 (96.3)		Other	28 (18.1)
Epidemiology link, *n* (%)	Family	1217 (82.3)		Pre-existing medication	17 (11 [Au?7])
	School/childcare	50 (3.4)	Duration of illness (days)[a]	Median (IQR)	10 (3 [Au?7])
	Other	203 (13.7)	Outcome	Discharged alive and well	1498 (100)
	Index	8 (0.5)		ICU admission	0 (0)
Positive household contacts, *n* (%)	Yes	1323 (88.3)	Recurrent COVID-19-related health visit, *n* (%)[b]	Yes	8 (0.5)
Number of household contacts	Mean (SD)	2.8 (1.89)	Reason for return	Persistent symptoms	6
				Planned TCA	2

ALT, alanine aminotransferase; AST, aspartate aminotransferase; CRP, C-reactive protein; CXR, chest X-ray; G6PDH, glucose-6-phosphate dehydrogenase; ICU, intensive care unit; IQR, interquartile range; SD, standard deviation; TCA, [Au?8]; WBC, white blood cell.

[a] Two patients transferred out to Hospital Kuala Lumpur – duration of admission there not included (data not available). One patient – first visit to Hospital Temerloh, recurrent visit is Hospital Sungai Buloh admission (duration of admission inclusive of Hospital Temerloh admission).

[b] One patient – first visit to Hospital Temerloh, recurrent visit is Hospital Sungai Buloh admission.

changes probably due to COVID-19. Ten children had abnormal X-rays with changes not specifically attributed to COVID-19.

Treatments and outcomes

The majority of children recovered from their illness without any treatment. Only 10.4% required treatment, and of these, 83.9% were given symptomatic treatment (e.g., oral rehydration salts, nasal saline drops, metred dose salbutamol inhaler), 16.8% were given antibiotics to cover bacterial infection, and only one child (0.6%) was given an antiviral for only 1 day. The remainder of treatment consisted of pre-existing medications, treatment for fungal rashes, etc. The median duration of illness was 10 days (IQR 3 days).

No children required intensive care unit (ICU) admission and all children were discharged alive and well from the hospital. Children who were newly diagnosed with any comorbidities during admission, e.g. obesity, bronchial asthma, were referred back for follow-up at their respective local healthcare facilities. Only eight children had recurrent

Table 2
Comparison between asymptomatic (category 1) and symptomatic (categories 2–5) children.

		Asymptomatic (n = 853)	Symptomatic (n = 633)	P-value			Asymptomatic (n = 853)	Symptomatic (n = 633)	P-value
Sex, n (%)	Female	430 (50.4)	298 (47.1)	0.204	Vaccination, n (%)	Up-to-age	744 (96 [Au?7])	566 (96.8)	0.466
Age (years)	Mean (SD)	5.78 (3.37)	5.31 (3.61)	0.011	Epidemiology link, n (%)	Family	680 (96 [Au?7])	536 (96.1)	0.991
Age	Neonate (≤28 days)	5 (0.6)	4 (0.6)	<0.001		School/childcare	28 (4 [Au?7])	22 (3.9)	
group,	Infant (1 month to <1 year)	55 (6.4)	82 (13 [Au?7])		Positive household contacts,	Yes	737 (90 [Au?7])	582 (92.5)	0.093
n					n (%)				
(%)	Toddler/preschool (1–5 years)	384 (45 [Au?7])	280 (44.2)		Number of contacts	Mean (SD)	2.82 (1.986)	2.77 (1.766)	0.504
	School-age (6–11 years)	409 (47.9)	267 (42.2)		Investigations				
Ethnicity,	Malay	587 (68.8)	498 (78.7)	<0.001	CXR, n (%)	Normal	3 (100)	9 (39.1)	0.047
n	Chinese	51 (6 [Au?7])	25 (3.9)		Total WBC count, n (%)	Normal	277 (82.7)	317 (81.5)	0.025
(%)	Indian	99 (11.6)	50 (7.9)			Abnormal high	46 (13.7)	41 (10.5)	
	Other Malaysian ethnicities	24 (2.8)	25 (3.9)			Abnormal low	12 (3.6)	31 (8 [Au?7])	
	Non-Malaysian	92 (10.8)	35 (5.5)		Absolute lymphocyte count,	Normal	296 (94.3)	322 (90.4)	<0.001
Comorbidity, n (%)	Present	103 (12.9)	118 (19.1)	0.001	n (%)	Abnormal high	15 (4.8)	9 (2.5)	
Comorbidity	Bronchial asthma (BA)	19 (2.4)	25 (4.0)	0.073		Abnormal low	3 (1 [Au?7])	25 (7 [Au?7])	
present	Allergies	15 (1.9)	24 (3.9)	0.022	Absolute neutrophil count, n	Normal	271 (86.3)	271 (76.3)	<0.001
(break-	Eczema	11 (1.4)	19 (3.1)	0.028	(%)	Abnormal high	16 (5.1)	15 (4.2)	
down),	Developmental	19 (2.4)	7 (1.1)	0.083		Abnormal low	27 (8.6)	69 (19.4)	
n	Allergic rhinitis	10 (1.3)	13 (2.1)	0.209	Platelet count, n (%)	Normal	290 (86.6)	356 (91.5)	0.051
(%)	Neuromedical/ neurosurgical	15 (1.9)	6 (1)	0.161		Abnormal high	45 (13.4)	32 (8.2)	
	General/other/under investigation	5 (0.6)	9 (1.5)	0.117		Abnormal low	0 (0)	1 (0.3)	
	G6PDH deficiency	5 (0.6)	8 (1.3)	0.191	CRP, n (%)	Normal	322 (98.8)	330 (87.5)	<0.001
	Cardiovascular	3 (0.4)	5 (0.8)	0.28		Abnormal high	4 (1.2)	47 (12.5)	
	Prematurity	4 (0.5)	3 (0.5)	0.967	AST, n (%)	Normal	322 (97 [Au?7])	354 (91.9)	0.004
	Otorhinolaryngology	3 (0.4)	4 (0.6)	0.47		Abnormal high	10 (3 [Au?7])	31 (8.1)	
	Orthopaedic/ musculoskeletal/plastic	3 (0.4)	4 (0.6)	0.47	ALT, n (%)	Normal	306 (91.9)	343 (88.9)	0.171
	Gastrointestinal	0 (0)	6 (1 [Au?7])	0.005		Abnormal high	27 (8.1)	43 (11.1)	
	Haematology	3 (0.4)	2 (0.3)	0.87					
	Dermatology	2 (0.2)	2 (0.3)	0.797					
	Endocrine	3 (0.4)	1 (0.2)	0.452					
	Respiratory (other than BA)	1 (0.1)	2 (0.3)	0.42					
	Syndromic (chromosomal/genetic)	1 (0.1)	2 (0.3)	0.42					
	Oncology	1 (0.1)	1 (0.2)	0.856					
	Ophthalmology	0 (0)	1 (0.2)	0.255					
	Urology	0 (0)	1 (0.2)	0.255					

ALT, alanine aminotransferase; AST, aspartate aminotransferase; CRP, C-reactive protein; CXR, chest X-ray; G6PDH, glucose-6-phosphate dehydrogenase; SD, standard deviation; WBC, white blood cell.

Table 3
Reported symptoms of children (categories 2–5, $n = 633$) admitted to Hospital Sungai Buloh in 2020 for COVID-19.

Symptoms, *n* (%)	
Fever	397 (62.7)
Nasal congestion/rhinorrhoea	224 (35.4)
Cough	203 (32.1)
Diarrhoea	72 (11.4)
Rash	48 (7.6)
Vomiting	37 (5.8)
Sore throat	30 (4.7)
Dyspnoea	8 (1.3)
Other symptoms, *n* (%)	
Neurology	37 (5.8)
Poor oral intake/loss of appetite	16 (2.5)
Abdominal pain/discomfort	2 (1.6)
Less active/lethargy	8 (1.3)
Musculoskeletal	6 (0.9)
Oral ulcer	5 (0.8)
Chest discomfort/pain	4 (0.6)
Eye pathology	4 (0.6)
Irritability	4 (0.6)
ENT-related	3 (0.5)
Pruritus	3 (0.5)
Reduced urine output	3 (0.5)
Constipation	3 (0.5)
Nausea	2 (0.3)
Bloody stool	2 (0.3)
Lymphadenopathy	1 (0.2)
Toothache	1 (0.2)
Biochemical	1 (0.2)
Jaundice	1 (0.2)
Dry cracked lips	1 (0.2)
Hand swelling	1 (0.2)

visits to HSgB for COVID-19-related issues. For one child, the admission to HSgB was the second admission during his illness. Five children presented to the emergency department with mild symptoms and were discharged with treatment and extension of home quarantine. The time to recurrent presentation for symptomatic patients ($n = 6$) ranged from 2 to 78 days. Two children were seen at the HSgB paediatric specialist clinic to follow up on biochemical abnormalities but were otherwise clinically well.

Comorbidities as a risk factor

There were more children with comorbidities in the symptomatic group than in the asymptomatic group (19.1% vs 12.9%, $P = 0.001$); in particular, those with self-reported allergies (3.9% vs 1.9%, $P = 0.022$), eczema (3.1% vs 1.4%, $P = 0.028$), or a gastrointestinal pathology (1% vs 0, $P = 0.005$).

Child to adult, or adult to child transmission

Children were most frequently cared for by their parent (90.0%) and only 11 children (0.7%) had no caretaker in the ward (Table 1). There were a total of 1101 caretakers for the 1498 children. The majority of caretakers (819 people, 77.9%) tested positive for COVID-19 on admission (Table 7).

As mentioned earlier, children were most frequently detected through case screening within a family cluster. A concurrent household contact was present in 97.6% of this group of children. In contrast, only 28% of children with school/childcare-linked epidemiology had concurrent household contacts ($P < 0.001$) (Table 6). Children identified from school/childcare contact were more likely to be accompanied by a negative carer (78.6% vs 15.3%, $P < 0.001$) and none of these negative carers seroconverted ($P < 0.001$) (Table 7).

Table 5
Basic radiographic characteristics by illness severity

	Normal	Abnormal: Probable COVID-19	Abnormal: Non-specific
Category 1	3	NA	-
Category 2	8	NA	4
Category 3	-	3[a]	4
Category 4	1	-	3

NA, [Au?10].
[a] Two patients classified as category 2 during admission, re-categorized retrospectively.

Missing data

Two main factors contributed to missing data in this study. These were different record handling when patient volume surged and non-standardized clerking. With regards to investigations, standard blood investigations (full blood count, liver function tests ± renal profile, CRP) were sent for all positive patients until December 1, 2020. Subsequently, blood investigations were only performed on a case-by-case basis, at the attending clinician's discretion. Chest X-rays were not performed routinely from the start of the pandemic.

Discussion

Disease characteristics

The study data are consistent with international reports of the reduced severity of COVID-19 in children (Alsharrah et al., 2020; Arslan et al., 2021; Hoang et al., 2020; Ng et al., 2021; Parcha et al., 2021; (The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. Vital Surveillances 2020)The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team, 2020; Xu et al., 2020), with the overwhelming proportion only being detected through contact tracing, predominantly of a family contact. The most common symptoms, when manifested, were fever, nasal congestion/rhinorrhoea, and cough. Similar to observations reported by the International Paediatric Association (Klein et al., 2020), children less than 1 year old and with comorbidities were more likely to be symptomatic. The prevalence of comorbidities in the present study population was 15%, compared to 25% in adults (Sim et al., 2020). Atopic disease was the most common

Table 4
Liver enzyme derangement by illness severity.

Child with abnormal liver enzymes ($n = 81$)	Abnormal ALT only[a]	Abnormal AST only[b]	Abnormal ALT and AST
Total	41 (50.6%)	11 (13.6%)	29 (35.8%)
Category 1	18 (22.2%)	1 (0.01%)	9 (0.1%)
Category 2	22 (27.2%)	10 (12.3%)	20 (24.7%)
Category 3	1 (0.01%)	-	-
Category 4	-	-	-

ALT, alanine aminotransferase; AST, aspartate aminotransferase.
[a] Four children (three category 2, one category 1) no AST taken, ALT normal.[b]One child (category 2) no ALT taken, AST high; one child (category 2) no ALT taken, AST normal.

Table 6
Comparison between children detected through family versus school/childcare epidemiological link

		Family (n = 1206)	School/childcare (n = 50)	P-value
Positive household contacts, n (%)	Yes	1177 (97.6)	14 (28)	<0.001
Average number of household contacts	Mean (SD)	3.08 (1.78)	0.44 (0.812)	<0.001

SD, standard deviation.

Table 7
Clinical characteristics of caretakers in relation to epidemiological factors

Caretaker distribution, n (%)	Total	Family	School/childcare	Other	Unknown epidemiological link
	n = 1101	863 (78.4)	45 (4.1)	164 (14.9)	29 (2.6)
Caretaker COVID-19 status, n (%)	Total(n = 1046)	Family(n = 852)	School / Child-care (n = 42)	Other(n = 152)	p value
Positive status on admission	815 (77.9)	722 (84.7)	9 (21.4)	84 (55.3)	<0.001
Negative status on admission	231 (22.1)	130 (15.3)	33 (78.6)	68 (44.7)	
Caretaker COVID-19 status, n (%)	Total(n = 1023)	Family(n = 843)	School/childcare(n = 39)	Other(n = 141)	P-value
Positive (admission to discharge)	819 (74.4)	722 (85.6)	9 (23.1)	84 (59.6)	<0.001
Negative (admission) to positive (discharge)	19 (1.7)	14 (1.7)	0 (0)	3 (2.1)	
Negative (admission to discharge)	193 (17.5)	107 (12.7)	30 (76.9)	191 (18.7)	

reported comorbidity. The presence of symptoms or comorbidities did not affect the overall outcome. Most children did not require any treatment during the course of their illness, none required ICU admission, all recovered fully prior to discharge, and only a handful were seen at HSgB after 6 months.

There were some significant differences in laboratory values between asymptomatic and symptomatic children. For instance, low total WBC, absolute lymphocyte, and absolute neutrophil counts, and raised AST. However, as all of the children recovered fully with minimal intervention, we maintain that routine blood sampling is not recommended.

With the low number of recurrent visits to the hospital post-discharge, it is presumed that there were no serious complications, e.g. multisystem inflammatory syndrome in children (MIS-C), amongst this study population. However, this needs confirmation with data from surrounding healthcare facilities where children may have been seen without referral to ourselves.

Transmission

Children, with their developing immune systems, have more frequent respiratory infections compared to adults. Toddlers and school children have on average eight respiratory infections a year, compared to two to three in adults (Thomas, 2021). There is ongoing concern regarding the infectivity of children and their potential as the asymptomatic reservoir for the transmission of SARS-CoV-2 (CodeBlue, 2021; Han et al., 2021; Lu et al., 2020).

The current study supports the hypothesis that children may not be a potent source of SARS-CoV-2 infection, although there are obvious limitations in the localized nature of the population and lack of detailed analysis of related factors. Only 50 children were detected through school/childcare contact, although school/childcare facilities were closed for a significant portion of the year in Malaysia (Buonsenso et al., 2021). These children were more likely to be accompanied by a negative caretaker. Furthermore, only about 8% of all negative caretakers seroconverted after accompanying their positive child during their admission.

Ng et al. (2021) showed that despite a rise in cases coinciding with school reopening, this rise was simultaneously preceded by an increase in adult cases. This suggests a general reopening of community activities as contributing to the rise in cases, rather than school per se. In Sweden ((Ludvigsson et al., 2021)Ludvigsson et al., 2020) and Norway (Brandal et al., 2021) where schools were allowed to stay open during their outbreaks, there was minimal child-to-child and child-to-adult transmission of SARS-CoV-2.

School closure is a containment strategy to target child-to-child and child-to-adult transmission. However, the evidence suggests that transmission through school or childcare is not the main driver for this disease.

Socio-economic and health impacts

Children have been largely spared from direct SARS-CoV-2 infection [Au?6]. Nevertheless, children may suffer from the long-term consequences of the impact of COVID-19 on driving their families into poverty, interruption in learning, and overall effect on health and safety, through a reduction in income and in social and health services (United Nations, 2020).

As with any childhood illness, family and community involvement is crucial to their recovery. In this study, 1101 carers were admitted together with 1498 children. Although the majority of the carers were admitted in their own right, at least 20% of them (negative caretakers) were admitted solely as caretakers. The pandemic has resulted in double-income households becoming single-income households, or single- to nil-income households. This effect extends beyond a child's admission to hospital, due to school/childcare services closure.

Article 28 of the United Nations Convention on the Rights of the Child (1989)(United Nations. Convention on the rights of the child 1989) upholds a child's right to education. In recognition of this right, primary schooling is mandatory in Malaysia ((Education Act 1996 1996)). Schools provide the environment for both formal and informal education, provide safeguarding and supervision to enable working parents to earn a living, and in some communities, schools are a main source of access to nutritious food, safe water, and healthcare services (Armitage & Nellums, 2020). Strategies undertaken to mitigate the loss of school hours, such as online learning, may serve to replace formal education but are inadequate to address the loss of other equally important school functions. While school closure has been one of the methods employed to reduce the spread of COVID-19, a continuing review with scientific evidence of the benefits and harms is necessary.

Conclusions

COVID-19 was a mild disease in children in Selangor in the year 2020. However, even as this report is being finalized, variants of concern are ravaging our communities, with children being increasingly affected. Therefore, we remain cautious on the applicability of the study findings going forward and urge our fellow practitioners to be vigilant regarding the acute disease and possible complications in previously asymptomatic children (e.g. MIS-C).

The health of our children is not the only parameter by which we should analyse the impact of COVID-19. Overall child welfare includes

consideration of missed schooling, socializing, and learning opportunities, missed routine vaccination, psychological impact, and alteration of family dynamics. One of the limitations of this study was its inability to analyse the impact of these pyscho-socio-economic factors, which warrant future further investigation.

Nonetheless, we believe that the study findings will contribute to the global pool of knowledge. Our understanding of COVID-19 in children and adults must grow in tandem so that we may better combat this disease and its ill effects on our health and lives.

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Ethical approval

The study was registered with the National Medical Research Register (NMRR-20-580-54339) and approved by the Medical Research and Ethics Committee, Ministry of Health, Malaysia (KKM/NIHSEC/P20-706).

Conflict of interest

We declare no conflict of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijregi.2021.11.012.

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