Burden of illness in households with SARS-CoV-2 infected children

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Abstract

We investigated the dynamics of illness among household members of SARS-CoV-2 infected children that received medical care (n=32). We identified 144 household contacts (HCs): 58 children and 86 adults. Forty-six percent of HCs developed symptoms consistent with COVID-19 disease. Child-to-adult transmission was suspected in 7 cases.

Keywords: COVID-19, SARS-CoV-2, pediatrics, household transmission

Background

Children comprise of a small proportion of overall COVID-19 cases at 5.2% of laboratory-confirmed infections in the US[1]. However, these data are likely an under-representation of the true pediatric infection burden as initial reports occurred in the setting of school closures and shelter-in-place orders. As the US economy reopens, a dramatic increase of cases has occurred in several states. Recent studies have shown that children may be both as likely to become infected as adults and to infect others, but are less likely to have symptoms, suggesting that they have the potential to be silent facilitators[2,3]. A better understanding of the role children play in the chain of viral transmission is urgently needed.

Studies investigating household transmission have shown children are often secondarily infected by an adult, however, there is a paucity of pediatric-focused studies[4-7]. To address this knowledge gap, we utilized a prospective registry of laboratory-confirmed pediatric COVID-19 cases and conducted contact tracing of household members to characterize the presumed transmission before and after the child's diagnosis.

Methods

We identified children (<18 years old) with laboratory-confirmed SARS-CoV-2 between March 16 and June 14, 2020 who were seen by a healthcare provider at a Children's Healthcare of Atlanta (CHOA) facility. We utilized a prospective registry of patients with a positive nasopharyngeal (NP) swab for SARS-CoV-2 by PCR performed at a CHOA healthcare facility or from an outside healthcare facility prior to transfer to CHOA. Demographic and clinical data were obtained through manual chart abstraction of the electronic medical record. Only children who presented with symptoms concerning for

COVID-19 infection were included. We labeled them as SARS-infected children who sought care (SICs).

Parents or legally authorized representatives (LARs) were contacted in Spanish or English at least 14 days (1 incubation period) following the date of the child's positive COVID-19 test. Up to 3 attempts were made to contact families and verbal consent was obtained prior to study procedures. Parents of enrolled children were then interviewed using a standardized survey to evaluate their child's symptom duration, household contacts (HCs) with symptoms consistent with COVID-19 infection (adult household contact to SIC [AHC] and child household contact to SIC [CHC]), or laboratory-confirmed SARS-CoV-2 diagnosis (Supplemental Table I). Household contacts (HCs) were defined as an adult (≥18 years) or a child (<18 years) who resided in the home with the SIC at the time of diagnosis. We defined symptoms consistent with COVID-19 as fever plus 1 of the following: cough, shortness of breath (SOB), myalgias, loss of taste or smell OR 2 of the following symptoms: cough, myalgias, SOB, and/or loss of taste or smell. The survey also addressed occupational risk factors among adults in the household, smoke exposure in the household, and acceptability of a potential SARS-CoV-2 vaccine. Answers were recorded in a HIPAA secure database. We defined the suspected index case as the first person (child or adult) to report symptoms or test positive for SARS-CoV-2 in the household, documented 14 days prior to, during, or after symptoms of other family members. Descriptive statistics were reported as total numbers, percentages, medians and interquartile ranges as appropriate. This study was approved by the CHOA Institutional Review Board.

Results

We identified 138 SICs at CHOA during the study period and called 58 (42%) families at random order. We were unable to contact 21 subjects due to inability to reach parent/LAR

(n=17) and LAR not able or declined consent for research (n=4). Thirty-eight follow-up parental interviews were conducted (12 in Spanish, 25 in English) and 32 interviews were included in our final analysis. Median contact time from positive test was 37.5 days (IQR 26-43.5). Six interviews were excluded due to asymptomatic patients diagnosed pre-operatively (n=2), age >18 years old (n=2), and interviews with a child in the same family (n=2).

Baseline characteristics are summarized in Table I. The median age of our cohort was 12.7 (IQR 8.3-15.7) years. Fifteen patients were hospitalized while 17 were seen in the Emergency Department (ED) and discharged. Median length of stay for hospitalized patients was 3 (IQR 2-13) days. Overall, 144 HCs were identified among 32 households: 58 (40%) CHCs and 86 (60%) AHCs. The median household size was 4.5 (IQR 4-6.7) individuals, median number of children was 2 (IQR 1-3) and adults was 2 (IQR 2-3). Of the total number of HCs, 67 (46.5%) developed symptoms including 31 (46%) after the SIC's first symptom (11 CHC and 20 AHC) and 36 (54%) before the SIC's first symptom (14 CHC and 22 AHC). The HCs developed symptoms at a median of 4 (IQR 3-10) days after or 4 (IQR 1-11.25) days before the SICs. Of the total number of HCs, at least 29 (20%) had known SARS-CoV-2 testing.

Potential occupational exposures in AHCs were identified in 14 households including COVID-19 positive co-workers (n=4), occupation as household cleaners (n=2), factory workers (n=2), food industry workers (n=3), store clerks (n=2), or attendance at school/daycare (n=1). No AHCs worked in a healthcare setting. Nineteen of 32 (59%) parents reported they would give their child a vaccine against SARS-CoV-2, 8 reported they would decline immunization, and 5 reported requiring more information. All families except 1 interviewed denied smoke exposure in the home.

We identified 7 SICs that were the first to develop symptoms in the household, making them the suspected index case (Table II). Three SICs were in school or daycare within 14 days of symptoms onset. SIC 1 was febrile for 18 days after initial symptoms and AHC exposure may have occurred beyond 14 days of the SIC's symptom onset. The mother of SIC 4 developed symptoms during patient's hospitalization but was unable to recall how many days after. For SIC 5, the sibling was identified as the first symptomatic household case, followed by 2 siblings and the patient, and then lastly, the mother. SIC 6 was admitted to the hospital for 3 days and parents developed symptoms after patient's discharge. In addition, three SICs did not have other ill household contacts, but did have a known COVID-19 positive or a symptomatic close contact (grandmother, aunt, friend).

Discussion

Because pediatric patients are more likely to be asymptomatic or show mild symptoms, it has been challenging to define their role in SARS-CoV-2 household transmission, which this study aimed to address. Although the majority of cases originated in an adult household member, 7 cases (22%) of presumed child-to-adult transmission were identified in this cohort. In contrast, a recently published study from Switzerland found only 8% of household cases resulted from child-to-adult transmission[8], which may be due to differences in community virus circulation during the study period and strictness in social distancing recommendations. In our study of child-to-adult transmission cases, children were symptomatic for at least 4 days prior to seeking care, the time period when they were most likely to be infectious to other household members[5,9].

There has been varied rates of household transmission reported in other countries. We found that 46.5% of household members of a SIC developed symptoms or had laboratory-confirmed COVID-19 infection. Studies of secondary transmission from China have shown

secondary attack rates between 4.6% to 32.4% among household and close contacts [2,5,10]. Differences in these rates are likely due to multiple factors such as differences in method for identification of secondary cases, household composition, and stringency of isolation measures such as mandatory quarantining of household contacts. One important difference in this cohort was that we presumed secondary cases based mainly on clinical symptoms.

Differences in child and adult transmission rates are likely affected by differences in their social isolation practices. For a majority of our study period, children were not attending school or daycare. The 3 cases of child-to-adult transmission where the child was still enrolled in daycare or school occurred early during the pandemic prior to school closures, stay-at-home orders, and implementation of widespread face mask procedures. In contrast, over half of the households had adults who were essential workers and continued to work during the pandemic, increasing their own risk of exposure and secondary transmission. As circumstances continue to change, child-to-adult transmission rates will need to be closely monitored.

There were several limitations to this study. We had a small cohort of patients at a single hospital system, which were ill enough to seek medical care. In addition, we relied on parental report of symptoms in their child and household members, which may expose our study to recall bias and may miss asymptomatic or minimally symptomatic cases. In the 7 cases of potential child-to-adult transmission, it is possible that the adult and child had the same exposure but a different incubation period or had different exposures. We assumed ill family members also had SARS-CoV-2 infection based on symptoms instead of PCR confirmation. This study occurred during school closures and for 1 month during statewide shelter-in-place orders, which may not reflect transmission in close-contact settings such as in-person school.

Conclusion

We found a higher rate of child-to-adult transmission than previously described. Further ongoing surveillance will be needed to understand child-to-child and child-to-adult transmission if or when schools reopen.

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REFERENCES

1. Stokes EK, Zambrano LD, Anderson KN, et al. Coronavirus Disease 2019 Case Surveillance — United States, January 22–May 30, 2020. MMWR Morb Mortal Wkly Rep 2020;69:759–765. DOI: http://dx.doi.org/10.15585/mmwr.mm6924e2external icon.

2. Bi Q, Wu Y, Mei S, et al. Epidemiology and transmission of COVID-19 in 391 cases and 1286 of their close contacts in Shenzhen, China: a retrospective cohort study [published online ahead of print, 2020 Apr 27]. Lancet Infect Dis. 2020;S1473-3099(20)30287-5. doi:10.1016/S1473-3099(20)30287-5.

3. Park, YJ., Choa, YJ, Park, O. et. al. Contact tracing during coronavirus disease outbreak, South Korea, 2020. Emerg Infect Dis. 2020 Oct [*date cited*]. https://doi.org/10.3201/eid2610.201315

4. Jiang XL, Zhang XL, Zhao XN, et al. Transmission potential of asymptomatic and paucisymptomatic SARS-CoV-2 infections: a three-family cluster study in China. J Infect Dis. 2020; 221(12): 1948-1952. jiaa206. doi:10.1093/infdis/jiaa206.

5. Cheng HY, Jian SW, Liu DP, et al. Contact Tracing Assessment of COVID-19 Transmission Dynamics in Taiwan and Risk at Different Exposure Periods Before and After Symptom Onset. [published online ahead of print, 2020 May 1]. JAMA Intern Med. 2020;e202020. doi:10.1001/jamainternmed.2020.2020.

6. Garazzino S, Montagnani C, Dona D, et al. Multicentre Italian study of SARS-CoV-2 infection in children and adolescents, preliminary data as at 10 April 2020. Euro Surveill 2020; 25(18): 2000600. doi:10.2807/1560-7917.ES.2020.25.18.2000600.

7. Li W, Zhang B, Lu J, et al. The characteristics of household transmission of COVID-19. [published online ahead of print, 2020 Apr 17]. Clin Infect Dis. 2020;ciaa450. doi:10.1093/cid/ciaa450.

8. Posfay-Barbe, K., Wagner, N., Gauthey, M., et. al. COVID-19 in children and the dynamics of infection in families. [published online ahead of print, 2020 May 26]. Pediatrics. 2020;e20201576. doi:10.1542/peds.2020-1576.

9. Wei WE, Li Z, Chiew CJ, Yong SE, Toh MP, Lee VJ. Presymptomatic Transmission of SARS-CoV-2 — Singapore, January 23–March 16, 2020. MMWR Morb Mortal Wkly Rep 2020;69:411–415. DOI: http://dx.doi.org/10.15585/mmwr.mm6914e1.

10. Wu J, Huang Y, Tu C, et al. Household Transmission of SARS-CoV-2, Zhuhai, China, 2020 [published online ahead of print, 2020 May 11]. Clin Infect Dis. 2020;ciaa557. doi:10.1093/cid/ciaa557.

Table I: Baseline characteristics of 32 included pediatrics COVID-19 cases who had secondary parental survey.

	Number	%
Sex (n=32)		
Male	17	53.13
Female	15	46.88
Age (years)		
<1	1	3.13
1-4	6	18.75
5-9	7	21.88
10-14	8	25.00
15-17	10	31.25
Race/Ethnicity		
White/Caucasian only	8	25.00
Hispanic/Latino	15	46.88
African American/Black	8	25.00
Other	1	3.13
Underlying conditions		
None	12	37.50
Cardiac	0	0.00
Asthma	11	34.38
Hematological	2	6.25
Malignancy	4	12.50
Obesity	14	43.75
Days of symptoms prior to seeking care		
0-1	5	15.63

2-5	10	31.25
>5	15	46.88
Not reported	2	6.25
Hospitalization		
Inpatient	15	46.88
Outpatient	17	53.13

SIC as suspected index case	Age (years)	Underlying conditions	Length of Hospitalization (days)	# Other Children in home	# Adults in home	Potential Exposures	HC with symptoms PRIOR to SIC	HC with symptoms AFTER SIC	Adult symptoms onset after child (days)	# Secondary cases/ #Susceptible household contacts
1[a]	0.58	None	0	1	2	Daycare	0	1 (adult)	+18	1 of 3 (33%)
2	2	None	0	1	4	Unknown	1 (child)	2 (adult)	+4	3 of 5 (60%)
3	2	None	0	1	2	Close contact	0	2 (adults)	+3, +10	2 of 3 (67%)
4[b]	12	None	24	1	2	School	0	1 (adult)	Unknown	1 of 3 (33%)
5	13	Asthma	0	2	5	Unknown	3 (children)	1 (adult)	+3	4 of 7 (57%)
6[c]	14	Asthma/Obesity	3	2	2	Unknown	0	2 (adults)	+>3days	2 of 4 (50%)
7	17	Asthma	4	2	3	School	0	1 (adult)	+6	1 of 5 (20%)
									% HCs with sxs:	**45.7%**

[a] Patient was febrile for 18 days following first day of symptoms.
[b] Parent developed symptoms while staying in the room with patient but unknown how many days after patient's symptoms onset.
[c] Parents did not develop symptoms until after patient was discharged, but days after was not reported.
SIC: SARS-CoV-2 positive child who sought care at our hospital, HC: household contact, +: days after SICs first symptom