SARS-CoV-2 Transmission in an Urban Community: The Role of Children and Household Contacts

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Abstract

This is a single center US retrospective study of infection patterns among household sick contacts of children with confirmed Severe Acute Respiratory Syndrome – Coronavirus 2 (SARS-CoV-2) infection in an urban setting. A household sick contact (HHSC) was identified in fewer than half (42%) of patients and no child-to-adult transmission was identified.

KEY WORDS: COVID-19; Coronavirus infections; Pandemic; Pediatrics; Social Determinants of Health
Introduction

Since the first reported cases of Severe Acute Respiratory Syndrome-Coronavirus 2 (SARS-CoV-2) in November 2019, the incidence in children has remained low and the majority of children are either asymptomatic or have mild illness.\(^1\) This has generated significant interest in the role of pediatric patients in transmission of SARS-CoV-2 infection. When cases of SARS-CoV-2 infection began to rise in the United States, closure of schools and childcare facilities was among the earliest containment strategies enacted by state governments. Communities continue to use infection rates and transmission patterns as the basis for planning safe strategies for return to normal social and industrial functioning and school reopening. For this reason, studying the transmission of the disease among children and families is an area of intense public health interest.

Studies thus far have demonstrated that transmission of SARS-CoV-2 largely occurs within family clusters and adult household contacts have most frequently been identified as the primary source of exposure for SARS-CoV-2 infection in children.\(^2,3\) Additionally, review of data from elementary schools in Australia and Ireland show minimal transmission among young children attending school during the pandemic.\(^4,5\) A US study examining household transmission patterns similarly found that children are most often secondarily infected by adults but interestingly identified higher rates of child-to-adult transmission compared to studies conducted outside the United States.\(^6\) This highlights important differences that may exist in transmission patterns in the United States. It is imperative to explore these differences further as they may have important social and economic implications.

Transmission in urban communities within the United States is of particular interest. Review of reported US data reveals that racial and ethnic minority populations have been disproportionately affected by coronavirus disease (COVID-19) with higher mortality rates.\(^7\) According to US census data, 78% of the population in Detroit, Michigan identifies as African American or black. Detroit has the highest percentage of poverty of any major U.S. city (38%) and residents are less likely to have access to reliable employment, education, housing, and access to food and healthcare.\(^8\) The adverse effects of school closures and quarantine may be more pronounced where these conditions exist.\(^9\)
understanding the epidemiology of the disease in these communities is critical. For this reason, we sought to describe transmission patterns of SARS-CoV-2 infection among households in a pediatric population in Detroit, Michigan.

Methods

We identified all pediatric patients who tested positive for SARS-CoV-2 via nasopharyngeal swab using a PCR assay or serum antibody testing at The Children’s Hospital of Michigan (a tertiary care center in Detroit, MI) between March 12 - June 15, 2020. This study was approved by the Wayne State University Institutional Review Board and verbal informed consent was obtained from the patient’s parent/legal guardian. A retrospective chart review was conducted on all patients and the presence or absence of a sick contact was identified in either the emergency department note or the admission history and physical. Every chart reviewed either identified the presence of a sick contact including if they were tested for SARS-CoV-2, or clearly stated that there were no known sick contacts. A household sick contact (HHSC) was defined as someone who lives with the child that either tested positive for SARS-CoV-2 or had symptoms suggestive of COVID-19 including fever, cough, congestion, sore throat, and diarrhea. From the electronic medical record, we abstracted patient demographics, presenting symptoms, presence of household sick contacts. Illness severity was classified based on published criteria by Dong, et al. as follows:

- Asymptomatic: No clinical signs or symptoms, chest imaging if performed was negative
- Mild: Symptoms of acute upper respiratory tract infection including fever, cough, myalgia, sore throat, runny nose or sneezing or gastrointestinal symptoms such as vomiting, diarrhea, abdominal pain with normal physical exam
- Moderate: Pneumonia without hypoxemia
• Severe: Respiratory or gastrointestinal symptoms with dyspnea, central cyanosis or hypoxemia with oxygen saturation of <92% in room air
• Critical: Acute respiratory syndrome, respiratory failure, shock, encephalopathy, myocardial injury or heart failure, coagulation dysfunction acute kidney injury.

A follow-up phone call survey was conducted and patients were interviewed six weeks after hospital discharge to identify subsequent sick contacts and determine the timing of sick contacts in relation to the study patient’s symptoms.

Results

SARS-CoV-2 testing was performed in 1264 children, of whom 71 (5.1%) tested positive. Patient demographics, presenting symptoms, and severity of illness are shown in Table 1. When race was reported, 85% of our patient sample identified as African American. When ethnicity was reported, nine percent identified as Hispanic. Though the majority (55%) of children were either asymptomatic or had mild disease, 83% were hospitalized and nearly one quarter (severe 6% and critical 17%) had significant illness.

Among the 71 children, only 30 (42%) identified a HHSC prior to the onset of the study patient’s symptoms. Of the 30 households with sick contacts present, 25 households had a contact that tested positive for SARS-CoV-2 (83%), the remaining five households had HHSCs that were identified based on symptoms alone. In follow-up phone calls where sixty one percent of families were reached, there was no reported illness in any household contact up to six weeks after the child became ill. In all cases where a HHSC was identified, there was no evidence of child-to-adult transmission, and only one case of child-to-child transmission from 3 and 6-year-old siblings to a 47-day old infant. A parent (23/30; 76%) was the most common index HHSC. Characteristics of HHSCs are detailed in Table 2.

Discussion
This study adds to a growing body of published literature \textsuperscript{[2-6]} regarding pediatric SARS-CoV-2 infection patterns within household units. Among children with identified HHSCs, we found no evidence of child-to-adult transmission. This is consistent with other studies that suggest that children are not the primary vectors for SARS-CoV-2 infection as was initially suspected; rather children are most commonly infected by adult sick contacts.\textsuperscript{[2, 3, 10]}

Interestingly, less than one-half of children who tested positive for SARS-CoV-2 in our institution had a sick contact within the household. This is in contrast to studies from Switzerland and China in which a HHSC was identified in the majority of children studied, concluding that children are mainly infected inside familial clusters.\textsuperscript{[2, 11]} Our results more closely reflect the findings of Mannheim, et al. from Chicago, an urban location similar to our study setting who reported that only 63\% of children reported a HHSC.\textsuperscript{[10]}

The reasons for these differences in transmission between settings are not clear. The results reported out of Switzerland and China in comparison to those in urban US cities may be due to differences in disease prevalence or the response to the pandemic in the regions studied. Alternatively, the results may suggest that children in our population were more likely to have become ill as a result of spread from the community rather than a sick contact within the home. This may be the result of greater difficulty in adhering to strict quarantine and social distancing mandates within our urban population where the social determinants of health play a major role.\textsuperscript{9} A household contact study done in China by Li, et al. demonstrated no secondary transmission to household contacts when the index patient with COVID-19 is properly quarantined.\textsuperscript{[12]} In a population where adherence to physical distancing and quarantine protocols may be difficult, it is harder to predict disease exposure and therefore may be more difficult to prevent spread. For this reason, understanding the unique factors that impact individual communities will be essential for planning as the pandemic evolves.

There are several limitations to this study. The sample size studied is small. In addition, the reliance on the memory of the individual being queried on the follow-up phone call could have resulted in recall bias and one-third of families could not be reached for follow-up. Finally, the household
contacts could have been asymptomatic and this could have resulted in underreporting of transmission within household units. Classification of HHSC as positive based on symptoms alone rather than testing could have inflated the number of households with sick contacts although this accounted for only a minority of HHSC in our study.

Considering the results of our study that show that children in our urban population less frequently became ill from sick contacts within their households, it is important to acknowledge the factors within our population that may contribute to community spread among children. Pandemic response planning, containment strategies, as well as the decision to resume in-person education and extracurricular activities for children should take into account the context of local factors relevant to individual communities as well as the prevalence of SARS-CoV-2. Further large-scale studies and contact tracing initiatives are necessary to understand the role of children in the transmission of SARS CoV-2 infection in different community settings and continued ongoing surveillance is necessary as schools and childcare centers reopen.
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Table 1. Demographics and Clinical Characteristics of Study children

| Characteristics          | No. (%) | Value (n=71) |
|--------------------------|---------|--------------|
| Age in years             |         |              |
| Median (IQR<sup>a</sup>) | 6       | (0.8-13)     |
| <1 year                  | 19      | (27)         |
| 1 - 4 years              | 12      | (17)         |
| 5 - 9 years              | 16      | (23)         |
| 10 - 14 years            | 14      | (20)         |
| 15 - 17 years            | 10      | (14)         |
| Gender                   |         |              |
| Female                   | 41      | (58)         |
| Race<sup>b</sup>         |         |              |
| African American         | 45      | (85)         |
| Ethnicity<sup>c</sup>    |         |              |
| Hispanic                 | 9       | (21)         |
| Non-Hispanic             | 33      | (79)         |
| Signs and Symptoms       |         |              |
| Fever                    | 46      | (65)         |
| Cough                    | 25      | (35)         |
| Sore Throat              | 9       | (13)         |
| DIB/Wheeze               | 13      | (18)         |
| Chest Pain               | 6       | (8)          |
| Vomiting                 | 22      | (31)         |
| Diarrhea                 | 18      | (25)         |
| Hypoxia                  | 6       | (8)          |
| Severity of Illness      |         |              |
| Asymptomatic             | 15      | (21)         |
| Mild                     | 24      | (34)         |
| Moderate                 | 16      | (23)         |
| Severe                   | 4       | (6)          |
| Critical                 | 12      | (17)         |
| Hospitalized             | 59      | (83)         |

Percentages may not equal 100 due to rounding
<sup>a</sup> Abbreviation: Inter-Quartile range (IQR)
<sup>b</sup> Race reported on 53/71 patients, percentage reflects denominator of 53
<sup>c</sup> Ethnicity reported on 42/71 patients, percentage reflects denominator of 42
Table 2. Data Regarding Household Sick Contact (HHSC)

|                                | No. (%) |
|--------------------------------|---------|
| Children with at least one HHSC| 30/71 (42) |
| Relationship of Child to Index HHSC (n=30) |         |
| Parent                         | 23 (76) |
| Sibling*                       | 2 (7)   |
| Grandparent                    | 6 (20)  |
| Onset of Illness of Child relative to HHSC (n=30) |         |
| After but unspecified          | 7 (23)  |
| Less than 1 week After         | 3 (10)  |
| 1-2 weeks After                | 8 (27)  |
| 2-4 weeks After                | 9 (30)  |
| >4 weeks After                 | 3 (10)  |

*One sibling was an adult sibling that transmitted to a pediatric patient.*
Questions pertaining to the parents or sick household contacts:

1. Was anyone else living with the child also sick? Yes/No
2. Were they tested for COVID? Yes/No
   a. COVID positive or negative
3. Were they diagnosed with any other viral illness
   a. Influenza Yes/No
   b. Other: _____
4. Age of the relative: Age in Years______
5. Gender: M/ F
6. Race: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, and White
7. Ethnicity: Hispanic/Non Hispanic
8. What is their relationship to the child?
   Mother/Father/Grandparent/Aunt/Uncle/Cousin/Family Friend
9. When did they develop symptoms? Date______
10. What symptoms did they have...
    a. Fever Yes/No
    b. Cough Yes/No
    c. Congestion Yes/No
    d. Diarrhea Yes/No
    e. Hematuria Yes/No
    f. Were they diagnosed with pneumonia? Yes/No
    g. Were they diagnosed with Pulmonary Embolism? Yes/No
    h. Were they diagnosed with a DVT? Yes/No
    i. Were they diagnosed with hypoxia (low oxygen level): Yes/No
11. Were they hospitalized? Yes/No
    a. Were they admitted to an ICU? Yes/No
12. Pre existing medical conditions:
    a. Asthma
    b. COPD
    c. Chronic kidney disease
    d. Sickle cell disease
    e. Cancer
    f. Immunosuppressive medications
    g. Hypertension
    h. Diabetes (Type 1 or Type 2)
    i. Heart disease
    j. Stroke
13. Smoking history:
    a. Never smoked: Yes/No
    b. Former smoker: Yes/No
    c. Current smoker: Yes/No
14. When did symptoms resolved? Date______