Patterns of Virus Exposure and Presumed Household Transmission among Persons with Coronavirus Disease, United States, January–April 2020

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COVID-19 disease was first identified in Wuhan, China, in December 2019 (1). The first reported case in the United States was identified in January 2020 (2); by mid-March, cases had been reported in all 50 states (3). On March 16, 2020, the White House Coronavirus Task Force published guidance for curbing community spread of COVID-19 (4); soon after, states began to enact stay-at-home orders (5). By late May 2020, all 50 states had begun easing restrictions; reported cases reached new peaks in the summer and then winter months of 2020 (6,7). As restrictions further ease with increased availability of vaccine, and as pandemic fatigue may cause persons to adhere less consistently to recommended guidance such as masking and distancing, it may be informative to look back at exposures and within-household transmission during a period when few mitigation measures were in place. We characterized exposures common among persons with the earliest reported confirmed COVID-19 cases in the United States (onset mid-January through early April 2020) and identified factors associated with presumed household transmission.

This activity was reviewed by the Centers for Disease Control and Prevention (CDC) and was conducted consistent with applicable federal law and CDC policy. Forms were approved under the Office of Management and Budget (no. 0920–1011).

Methods

Data Source
The case investigation form (CIF; Appendix 1, https://wwwnc.cdc.gov/EID/article/27/9/20-4577-App1.

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DOI: https://doi.org/10.3201/eid2709.204577

We characterized common exposures reported by a convenience sample of 202 US patients with coronavirus disease during January–April 2020 and identified factors associated with presumed household transmission. The most commonly reported settings of known exposure were households and healthcare facilities; among case-patients who had known contact with a confirmed case-patient compared with those who did not, healthcare occupations were more common. Among case-patients without known contact, use of public transportation was more common. Within the household, presumed transmission was highest from older (>65 years) index case-patients and from children to parents, independent of index case-patient age. These findings may inform guidance for limiting transmission and emphasize the value of testing to identify community-acquired infections.
pdf) is a supplemental questionnaire designed by CDC in January 2020 to collect detailed demographic and epidemiologic information about a convenience sample of US COVID-19 case-patients reported by participating states. This purposive nonprobability sample was selected at the state level from persons identified through care-seeking, surveillance, or contact tracing as having COVID-19; infection with severe acute respiratory coronavirus 2 (SARS-CoV-2) was confirmed by reverse transcription PCR. CDC provided guidance for selection of case-patients across a range of ages and symptom severities (i.e., hospitalized and nonhospitalized), but states individually controlled sampling. The CIF was completed by state or local health department personnel or by CDC staff through case-patient or proxy interviews, along with medical record reviews (when relevant).

Case-patient demographic information included age, sex, race, ethnicity, and occupation. Workplace settings were classified according to 2012 census industry codes (Appendix 2, https://wwwn.cdc.gov/EID/article/27/9/20-4577-App2.pdf). Clinical information included underlying conditions, symptoms, symptom onset date, dates of medical visits, and outcome (death or survival). For hospitalized case-patients, information was requested about whether the patient had been admitted to an intensive care unit, whether oxygen was received, admission and discharge dates, diagnosis, and location. Questions about exposure included whether in the 14 days before illness onset the case-patient had known exposure to a case-patient with laboratory-confirmed COVID-19 (COVID-19 contact) and, if so, the relationship and setting of the exposure. Case-patients were also asked about their exposure risks (activities and possible exposures in the 14 days before illness onset) including travel; friends, acquaintances, co-workers, or family members with fever or respiratory symptoms; close contact with (e.g., caring for, speaking with, or touching) any ill persons; attendance at a mass gathering (e.g., religious event, concert, sports event); public transportation use; attendance or work at a school or daycare; school or daycare attendance by household members; close contact with a contact of a laboratory-confirmed case-patient; close contact with someone with fever, acute respiratory illness, or both who had traveled internationally in the previous 14 days; and time in a healthcare setting as an employee, patient, or visitor.

The CIF also collected data on the case-patient’s household members, defined as anyone who stayed overnight in the same residence as the case-patient during the 14 days before the case-patient’s illness onset until the date of interview. Case-patients were asked for household members’ age, sex, relationship to the case-patient, and whether each person had “experienced fever or respiratory symptoms (e.g., cough, sore throat, etc.) within 14 days before or after the COVID-19 patient’s illness”; if yes, date of illness onset was collected. When the CIF was designed in January 2020, the most commonly reported COVID-19 signs and symptoms were fever and respiratory symptoms, and guidance for mitigation measures within households had not been widely distributed.

**Analysis of Exposures**

We compared exposures between those reporting known close contact with a COVID-19 case-patient in the 14 days before illness onset and those reporting no known contact. Categorical variables were compared by using $\chi^2$ or Fisher exact tests, as appropriate. Continuous variables were compared by using t tests for normally distributed data and Wilcoxon rank sum tests otherwise, $p<0.05$ was considered significant. Analyses were conducted in SAS version 9.4 (https://www.sas.com) and R (https://www.r-project.org).

**Analysis of Presumed Household Transmission**

We separately assessed presumed household transmission by using information about household members provided by the interviewed COVID-19 case-patient (CIF subject). In the absence of SARS-CoV-2 testing data for all household members, we used reported signs and symptoms (i.e., fever or respiratory symptoms) as a proxy for symptomatic COVID-19 infection (i.e., household transmission). We analyzed households of $\geq 2$ members (including the CIF subject) if the CIF subject had experienced $\geq 1$ symptom (to enable identification of the first ill person [index case-patient] in the household), and symptom status was provided for $\geq 1$ other household member. We required that the earliest symptom onset date in the household be $\geq 1$ calendar day before symptom onset in subsequent case-patients (to limit effect of co-exposures outside the home) and that the earliest onset date in the household be $\geq 3$ days (our median serial interval) before the interview (to allow time for symptoms to develop in exposed household members). We considered presumed household transmission to have occurred if $\geq 1$ household member, in addition to the CIF subject, was reported as having fever or respiratory symptoms. The person with the earliest symptom onset date in a household was considered the index case-patient, regardless whether SARS-CoV-2 testing had been performed. Any members of a given household...
not identified as the index case-patient are hereafter referred to as household contacts.

We calculated the overall household attack rate for symptoms as the number of symptomatic household contacts divided by the total number of household contacts with reported symptom status, with Wilson score 95% CI, and the serial interval as the time from symptom onset in the index case-patient to first symptom onset in a household contact. We investigated age and sex of the index case-patients and their contacts, household size, and relationship of the contact to the index case-patient as possible correlates of contact symptom status by using generalized estimating equation logistic regression with households as the cluster and individual symptom status as the outcome; we used an exchangeable correlation matrix and robust SEs. We excluded household contacts missing symptom status from this analysis. We examined models for collinearity and reduced if necessary. We did not include hospitalization status of the index case-patient in models because of collinearity with index case-patient age. We dichotomized contact age (<18 or ≥18 years) to avoid collinearity with familial relationship and index case-patient age.

To explore the validity of using reported symptom status to estimate household symptomatic attack rates, we calculated sensitivity and specificity by using a subset of households for which complete reverse transcription PCR and serologic testing data were available (8). We conducted a sensitivity analysis by reclassifying data according to a range of plausible misclassification rates (Appendix 2).

Results

Overview of the Analysis Population

Data were collected from 16 states (Alaska, Arizona, California, Connecticut, Georgia, Hawaii, Illinois, Minnesota, Pennsylvania, Rhode Island, Tennessee, Utah, Virginia, Vermont, Washington, and Wisconsin) with 202 laboratory-confirmed COVID-19 case-patients with symptom onset during January 14–April 4, 2020. Age of COVID-19 case-patients in the sample ranged from <1 to 95 years, almost all were symptomatic (195; 97%), and 1 in 3 was hospitalized for management of COVID-19 symptoms (Appendix 2 Table 3). Of the 202 case-patients, 34 (17%) reported having diabetes mellitus and 48 (24%) reported hypertension.

Exposures

A total of 82 (41%) case-patients reported known contact with a laboratory-confirmed COVID-19 case-patient in the 14 days before symptom onset. The most commonly reported exposure setting was the household (44/82; 54%); within the household setting, the most frequently reported source of COVID-19 exposure was the spouse or partner of the COVID-19 case-patient (16/44; 36%). The second most reported exposure setting was healthcare (20/82; 24%); 14 of the 20 persons exposed in the healthcare setting were healthcare workers, 4 were seeking care for unrelated medical issues, and 2 were visitors.

Among persons reporting no known COVID-19 contact, 20/84 (24%) reported having close contact with an ill person. Persons with no known COVID-19 contact worked in a variety of industries, most commonly healthcare (10/90; 11%); professional/office settings (10/90; 11%); education (9/90; 10%); and accommodation, food, or other services (9/90; 10%) (Table 1). In comparison, 28% (20/72) of persons with known COVID-19 contact reported working in healthcare. Persons with no known COVID-19 contact were significantly less likely than those with known contact to report spending time in a healthcare setting (p = 0.004). However, they were somewhat more likely to report travel (38% vs. 26%) or attendance at a mass gathering (36% vs. 21%) and significantly more likely to report use of public transportation (44% vs. 16%), compared with persons reporting known COVID-19 contact (p = 0.005).

Of the 202 case-patients, 23 (11.3%) reported no known contact with a confirmed case-patient, no travel within 14 days before illness onset, and none of the exposure risks assessed. These persons ranged in age from 21 to 88 years and were significantly older than those reporting ≥1 possible exposure (median age 52 vs. 49 years; p<0.0001). They required hospitalization more frequently than those reporting ≥1 possible exposure (52% [12/23] vs. 30% [54/179]; p = 0.10), and were significantly more likely to report ≥1 underlying medical condition (87% [20/23] vs. 58% [104/179]; p = 0.029). They were much more likely to report having diabetes mellitus (43% [10/23] vs. 14% [24/176]; p = 0.002).

Analysis of Presumed Household Transmission

A total of 69 case-patients provided data on the symptom status of ≥1 household members and were included in our household analysis; in 48 (70%) households, the CIF subject was the first or only symptomatic person in the household (i.e., was identified as the index case-patient; Figure 1). In half (34/69; 49%) of included households, ≥1 household member, in addition to the CIF subject, was symptomatic (i.e., virus transmission was presumed). Included households ranged in size
from 2 to 16 persons (median 4 persons) and comprised a variety of household types (e.g., couples, nuclear families, roommates, multigenerational); household size and members’ ages, sexes, and relationships were interrelated. Presumed transmission was more frequently observed in larger households (78% of households with >5 members vs. 39% of households with <5 members; p = 0.005) (Figure 2). Within households with more members, a larger number of household contacts reported symptoms (Figure 2).

Among 201 household contacts, 193 had data on symptom status, of which 62 (32%; 95% CI 26%–39%) were symptomatic. Sensitivity analysis results showed a similar plausible range of attack rates (21%–39%; Appendix 2 Results and Table 1). The median serial interval was 3 days (range 1–10 days).

Although our sample did not have large numbers of index case-patients at the age extremes, household contacts were more likely to be symptomatic if the index case-patient was <5 (5 households) or ≥65 years of age (9 households) (Figure 3, panel A); trends were similar, but the point estimates were significant only for index case-patients >45 years of age (vs. index case-patients 18–44 years of age) after adjustment for contact age, contact sex, household size, and relationship of the contact to the index case-patient (Table 2). Adult contacts were symptomatic more often than contacts <18 years of age (Figure 3, panel B), but this association was not significant in adjusted analyses (Table 2). The symptom status of household contacts was also associated with their relationship to the index case-patient (Table 2).
the contacts of 9 index case-patients <18 years of age, 11/16 (69%) parents, 6/13 (46%) siblings, and 2/5 (40%) other household contacts later became symptomatic. Among contacts of the 60 adult index case-patients, 12/44 (27%) children (range 2–49 years of age), 12/45 (27%) spouses/partners, 7/16 (44%) parents, and 11/42 (26%) other household contacts became symptomatic. When we restricted the analysis to households in which the CIF subject was the index case-patient, overall trends were similar to those reported above, but small sample sizes precluded adjusted analyses (Appendix 2 Table 2).

Illness severity of the index case-patient could not be assessed in multivariable models because of low sample size and correlation with age. However, among 12 household contacts of 10 index case-patients requiring hospitalization (three 18–44, five 45–64, and two index case-patients ≥65 years of age), only 2 were symptomatic.

Discussion

In this convenience sample of 202 early laboratory-confirmed COVID-19 case-patients, predominantly identified before widespread mitigation measures in the United States, the most commonly reported settings of known exposure were households and healthcare facilities (primarily as a workplace). Within the household, presumed transmission by age of index case-patient followed a U-shaped pattern and was significantly higher among contacts of older (≥65 years of age) index case-patients than among contacts of index case-patients 18–44 years of age. Independent of index case-patient age, parents of index case-patients were significantly more likely than other household members to report development of symptoms consistent with COVID-19.

Previous research has also found healthcare workplaces and households to be commonly reported settings of COVID-19 acquisition in the United States (9,10). In our analysis, the presumed secondary symptomatic attack rate among household members was 32%, somewhat high but consistent with estimates from previous studies, ranging from 10% to 38% (11–16; J.B. Lopez et al., unpub data, https://www.medrxiv.org/content/10.1101/2020.08.19.20177188v1). We found that presumed transmission was highest among contacts of older index case-patients (≥65 years of age), even when controlling for contact age category, relationship, and household size; however, our sample size was insufficient to control for underlying conditions or hospitalization status of the index case-patient or for detailed age category of the household contact, which may have confounded this relationship because evidence suggests that older adults are more susceptible to COVID-19 (17). Although results were not statistically significant in adjusted analyses, we also found that contacts of index case-patients <18 years of age (especially index case-patients <5 years of age) were more likely than contacts of index case-patients 18–44 years of age to be symptomatic. Further, symptoms were significantly more likely to develop in parents of index case-patients than in other household members. This relationship was independent of index case-patient age; however, in 8 households of adult case-patients with parental household members, 6 index case-patients were <30 years of age. Higher secondary transmission to the household contacts of younger versus adult or older COVID-19 case-patients has also been reported in analyses from the United Kingdom, South Korea, and Canada (16; B.J. Lopez et al., unpub. data, https://www.medrxiv.org/content/10.1101/2020.08.19.20177188v1; L.A. Paul, unpub. data, https://www.medrxiv.org/content/10.1101/2021.03.29.21254565v1). These findings may be explained by the fact that SARS-CoV-2–infected children may have similar or higher viral loads than adults (18) and that they may have closer interaction with family members,
especially parents. Parents, compared with other household members, may also play a greater role in caregiving to index case-patients, even for young adults. Conversely, in multigenerational households, adult children may act as caregivers for elderly parents, possibly exposing them before symptom onset.

A substantial proportion (60%) of case-patients in our sample did not report contact with a laboratory-confirmed COVID-19 case-patient in the 14 days before illness onset. Among case-patients without known COVID-19 contact, travel and public activities were more common, although only public transportation use was significantly higher when this group was compared with case-patients with known COVID-19 contact. Public transportation has not been identified as a major source of SARS-CoV-2 transmission (19–21), although transmission on buses, trains, and commercial flights has been reported (19,22–26). However, in our analysis, public transportation use might also have been more common among essential workers, those living in densely populated areas, or those with a history of travel—factors that could also increase opportunity for exposure to SARS-CoV-2 (27). Case-patients reporting no known source of infection, travel, or any other exposure risk factor tended to be older and to have more underlying medical conditions—particularly diabetes mellitus. Persons with concurrent conditions may be not only more susceptible to severe outcomes from COVID-19 (28,29) but also more susceptible to infection, as suggested by other analyses of SARS-CoV-2 (8,30) and Middle East respiratory syndrome coronavirus (31); however, more investigation is warranted.

The first limitation of our study was that the COVID-19 case-patients for whom the CIF was completed are a convenience sample of case-patients reported by 16 states during January–April 2020. Given restricted testing practices in the United States during January–March 2020, these case-patients are not representative of all US COVID-19 case-patients in terms of demographics, clinical characteristics, or exposures. Furthermore, common exposures have varied in time and geography over the course of the epidemic, and it is not possible to exclude the possibility that persons without known COVID-19 exposure had contact with an asymptomatic friend, co-worker, or
family member. Our observed secondary attack rates (symptomatic persons) may also have been affected by the timing of the investigation because public awareness regarding measures to mitigate within-household transmission (e.g., isolation and mask-wearing within the home) was probably lower in the early stages of the US epidemic. Information was not collected on the specifics of known COVID-19 exposure, such as mask wearing or social distancing in the home or other exposure settings, because these were not common practices during survey design. The use of a convenience sample may have also affected findings regarding presumed household transmission, such as if selection were biased toward inclusion of more severe cases or larger investigations.

A second limitation is that SARS-CoV-2 infection in most household members was not laboratory-confirmed, so household members with other causes of illness could have been misclassified as COVID-19 case-patients and those with asymptomatic SARS-CoV-2 infections misclassified as non-case-patients. The possibility of misclassification of children may have been higher, given that young children frequently experience respiratory symptoms (32) and are less likely to show symptoms of SARS-CoV-2 infection (33–35). However, overall patterns were similar when analysis was restricted to laboratory-confirmed index case-patients, and the point estimate for odds of presumed symptomatic infection among contacts of index case-patients <5 years of age versus contacts of those 18–44 years of age was similar when contacts of unconfirmed index case-patients <5 years of age were excluded. In addition, 4 of 5 households with index case-patients <5 years of age reported that >1 household member attended school or daycare in the 14 days before illness onset in the CIF subject, suggesting a possible outside source of infection. Of note, similar methods are frequently used for studies of influenza (36), and our observed overall symptomatic attack rate and serial interval are consistent with previous knowledge of SARS-CoV-2 transmission (37,38). It is also possible that symptoms developed in some household members after the date of interview. To limit this possibility, we excluded households in which the interview took place <3 days (median serial interval in our data) after the CIF subject’s symptom onset. Similarly, some presumed secondary case-patients may have actually been index case-patients or were co-exposed to the index case-patient; we tested exclusion of contacts with a 1-day lag in symptom onset and found similar trends, although the sample size precluded adjusted models. Previous research showing longer incubation periods for older patients suggests that households with older index patients would be less affected by such misclassification (39,40).

### Table 2. Factors associated with symptom status of 172 household contacts of 64 symptomatic index case-patients in households with presumed COVID-19 transmission, United States, January–April 2020*

| Factor | Unique households | No. with symptoms/no. total contacts (%) | aOR (95% CI)† | p value‡ |
|--------|------------------|----------------------------------------|---------------|---------|
| Contact sex | F | 50 | 28/85 (32.9) | Referent | 0.73 |
| | M | 46 | 29/87 (33.3) | 0.90 (0.49–1.64) | |
| Contact age, y | <18 | 25 | 13/50 (26.0) | Referent | 0.73 |
| | >18 | 63 | 44/115 (38.3) | 1.15 (0.53–2.47) | |
| Household size, persons | <5 | 48 | 23/92 (25.0) | Referent | 0.006 |
| | >5 | 16 | 34/80 (42.5) | 3.56 (1.45–8.74) | |
| Index case-patient age, y | <5 | 5 | 11/19 (57.9) | 3.69 (0.65–20.95) | 0.035 |
| | 5–17 | 4 | 6/13 (46.2) | 2.09 (0.39–11.05) | |
| | 18–44 | 26 | 15/82 (18.3) | Referent | |
| | 45–64 | 21 | 20/49 (40.8) | 4.61 (1.45–14.66) | |
| | >65 | 8 | 5/9 (55.6) | 15.43 (2.28–104.17) | |
| Relationship of contact to index case-patient | Spouse | 43 | 11/44 (25.0) | Referent | 0.070 |
| | Child | 21 | 11/39 (28.2) | 1.78 (0.58–5.45) | |
| | Parent | 17 | 18/31 (58.1) | 4.55 (1.22–17.00) | |
| | Other§ | 23 | 17/58 (29.3) | 1.47 (0.42–5.11) | |

*A total of 21 contacts from 5 households (i.e., 5 index case-patients) are excluded because of missing data: only relationship data for 7, only sex data for 2, only index case-patient’s age for 1; only contact’s age for 5, relationship and contact age for 6. Households with presumed transmission indicates households of laboratory-confirmed COVID-19 case-patients where >1 household member exhibited symptoms; index case-patient indicates household member with first reported onset of symptoms (regardless of laboratory confirmation); household contact indicates household member of the index case-patient. aOR, adjusted odds ratio (adjusted for all variables in the table); COVID-19, coronavirus disease.

†Calculated using robust SEs.

‡Generalized Wald test.

§Includes siblings, grandparents, grandchildren, friends, and any household relationship or contact other than spouse, child, or parent.
Last, our sample size was limited by state capacity for participation and data completeness. We did not have sufficient sample size to control for all possible confounders, such as index case-patient signs/symptoms, clinical characteristics, or detailed contact age category, so residual confounding is possible. The lower sample size also limited the precision of our estimates.

Our findings underline the exposure risk associated with work in a healthcare setting and within the household, as previously documented (9,10). However, most case-patients in the analysis did not have known contact with a laboratory-confirmed COVID-19 case-patient, reflecting unrecognized transmission and highlighting the need for widespread testing in addition to community mitigation measures such as masking, hand hygiene, physical distancing, and limiting nonessential travel, as well as vaccination (41–43). When going out in public, persons should take preventive actions and consider the risks associated with public activities by taking into account local orders, their ability to maintain physical distance during the activity, and whether they or their household members are at risk for severe illness from COVID-19 (41). Everyday preventive actions also protect at-risk household members. In this analysis, presumed household transmission was common, especially from the oldest index case-patients and from children to their parents. These findings are especially relevant to the context of in-person schooling because children exposed at schools or daycare centers may introduce COVID-19 into the home. Special care must be taken to mitigate exposure risks outside the home and to protect household members at high risk for severe COVID-19, such as older persons and those with concurrent conditions. Persons with COVID-19 should follow recommendations to reduce the risk for within-household transmission, such as staying in a separate room, wearing a mask among others, practicing hand and cough hygiene, and frequently cleaning high-touch surfaces (44).

Acknowledgments

We thank the Alaska Department of Health and Social Services’ Sections of Epidemiology and Public Health Nursing, Kimberly Yousey-Hinides, Danyel Olson, Hazal Kayalioğlu, Nicole Torigian, Hawaii Department of Health COVID Investigation and Surveillance Response Team, Austin Bell, Kalyla Bilski, Emma Contestabile, Claire Henrichsen, Katherine Schleiss, Samantha Siebman, Emily Holodick, Lisa Nguyen, Kristen Ehresmann, Anna Kocharian, Lin Zhao, Sharon Balter, Rebecca Fisher, Chelsea Foo, Prabhu Gounder, Jeffrey D. Gunzenhauser, Meredith Haddix, M. Claire Jarashow, Talar Kamali, Moon Kim, Jan King, Dawn Terashita, Elizabeth Traub, Roshan Reporter, Patricia Mottu-Monteon, Anthony Aguiar, Anna Kocharian, Lin Zhao, Richard Crawford, CDC Rhode Island Field Team, CDC Santa Clara County Field Team, CDC Utah Field Team, Holly Biggs, Matt Biggerstaff, Fiona Havers, Amber Haynes, Adriana Lopez, Brian Rha, Katherine Roguski, Mayuko Takamiya, and local and tribal public health agencies.

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Address for correspondence: Rachel M. Burke, Centers for Disease Control and Prevention, 1600 Clifton Rd NE, Mailstop H24-5, Atlanta, GA 30329-4027, USA; email: rburke@cdc.gov

EID Podcast Oral HPV Infection in Children, Finland

Human papillomavirus (HPV) is usually thought of as a sexually transmitted infection. However, HPV also can spread through other forms of contact. New research indicates that it might even be common for mothers to transmit the virus to their children before, during, and after birth.

In this EID podcast, Dr. Stina Syrjänen, a professor and chairman emerita at the University of Turku and chief physician in the Department of Pathology at Turku University Hospital in Finland, describes her findings on nonsexual transmission of HPV among young children and families.

Visit our website to listen: https://go.usa.gov/xHKGj
Patterns of Virus Exposure and Presumed Household Transmission among Persons with Coronavirus Disease, United States, January–April 2020

Appendix 1

COVID-19 Case Investigation Form

Reporting jurisdiction: ______________ Case state/local ID: ______________

Reporting health department: ______________ CDC 2019-nCoV ID: ______________

Contact ID a: ______________ NNDSS loc. rec. ID/Case ID b: ______________

a. Only complete if case-patient is a known contact of prior source case-patient. Assign Contact ID using CDC 2019-nCoV ID and sequential contact ID, e.g., Confirmed case CA102034567 has contacts CA102034567 -01 and CA102034567 -02. b. For NNDSS reporters, use GenV2 or NETSS patient identifier.
Interviewer information

Name of interviewer: Last ______________________________
First______________________________________
Affiliation/Organization: ____________________________________________
Telephone ______________________________ Email
_______________________________________________

Date of interview: ________________(MM/DD/YYYY) Date of medical chart abstraction:
_________________ (MM/DD/YYYY)

Data sources used for this form?

□ Case-patient interview       □ Other interview, specify relationship to
case:___________________________ □ Medical Chart Abstraction

Case-patient’s primary language: ____________________ Was this form administered via a
translator? □ Yes □ No □ Unknown

Case-patient demographic information

1. Report date to CDC (MM/DD/YYYY): ____/_____/_______
2. Under what process was the case first identified? (check all that apply): □ PUI/sought care
   for acute illness □ Contact tracing of case patient □ Surveillance system, please
   specify:___________________________ □ EpiX notification of travelers; if checked, DGMQID_______________ □ Unknown
   □ Other, specify:_________________
3. Date of birth (MM/DD/YYYY): ____/_____/_______
4. Age:    ____________         Age units:  □ Years  □ Months  □ Days
5. Sex:    □ Male  □ Female  □ Other  □ Unknown
6. Ethnicity: □ Hispanic/Latino □ Non-Hispanic/Latino □ Not specified
7. Race (check all that apply):  □ White  □ Asian  □ American Indian/Alaska Native
   □ Black
   □ Native Hawaiian/Other Pacific Islander   □ Unknown   □ Other, specify:

8. County of Residence:_________________________ State of Residence:________
9. Country of Residence: □ United States □ Other, specify________________________
10. Occupation:__________________________________________

   If student, what grade level? __________________________________________
   If child, does s/he attend day care? □ Yes □ No □ Unknown

Travel history

11. In the 14 days prior to illness onset, were you traveling away from your home
internationally? □ Yes □ No □ Unknown
12. In the 14 days prior to illness onset, were you traveling away from your home within the United States?
- [ ] Yes
- [ ] No
- [ ] Unknown

13. Where did you travel 14 days prior to illness onset (list ALL locations, including overnight transits and layovers)?

| Trip  | Departure Date (MM/DD/YYYY) | Departure city, state/province/country | Arrival Date (MM/DD/YYYY) | Arrival city, state/province/country |
|-------|-----------------------------|---------------------------------------|---------------------------|--------------------------------------|
| 1     |                             |                                       |                           |                                      |
| 2     |                             |                                       |                           |                                      |
| 3     |                             |                                       |                           |                                      |
| 4     |                             |                                       |                           |                                      |
| 5     |                             |                                       |                           |                                      |

**Exposure history**

14. In the 14 DAYS prior to illness, did you have close contact with another lab-confirmed COVID-19 case-patient?
- [ ] Yes
- [ ] No
- [ ] Unknown

Date Range: Start Date (MM/DD/YYYY) ____________
End Date (MM/DD/YYYY) ____________

15. Relationship to COVID-19 source case (select all that apply):
- [ ] Spouse/Partner
- [ ] Child
- [ ] Parent
- [ ] Other Family
- [ ] Friend
- [ ] HCW
- [ ] Co-worker
- [ ] Classmate
- [ ] Roommate
- [ ] Contact only – no relationship
- [ ] Other

(specify): ___________________

16. Exposure setting to the COVID-19 source case (select all that apply):
- [ ] Household
- [ ] Work
- [ ] Daycare
- [ ] School/University
- [ ] Transit
- [ ] Rideshare
- [ ] Hotel
- [ ] Cruise Ship
- [ ] Healthcare

- [ ] Other (specify): ___________________

17. In the 14 DAYS prior to illness onset, did you:

| Exposure                                                                 | Answer       | Date Range |
|-------------------------------------------------------------------------|--------------|------------|
| … have any household members, friends, acquaintances, or co-workers who had fever or respiratory symptoms (e.g. cough, sore throat etc.)? | [ ] Yes [ ] No [ ] Unknown |            |
| … have close contact (e.g. caring for, speaking with, or touching) with any ill persons? | [ ] Yes [ ] No [ ] Unknown |            |
| Exposure                                                                 | Y/N/Unk                          | Facility type (Select all that apply)                                                                 | Date(s) exposure occurred |
|-------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------|---------------------------|
| Work in healthcare setting:                                            | ☐ Y ☐ N ☐ Unk                    | ☐ Hospital ☐ Urgent Care ☐ Doctor’s office/clinic ☐ Dialysis unit/center ☐ Long Term Care Facility ☐ Other (specify) |                           |
|                                                                         | If yes, what was your role:      | ☐ Physician ☐ Nurse ☐ Administration staff ☐ Housekeeping ☐ Patient transport ☐ Other, specify         |                           |
| Volunteer in healthcare setting                                        | ☐ Y ☐ N ☐ Unk                    | ☐ Hospital ☐ Urgent Care ☐ Doctor’s office/clinic ☐ Dialysis unit/center ☐ Long Term Care Facility ☐ Other (specify) |                           |
| Have direct patient contact                                            | ☐ Y ☐ N ☐ Unk                    | ☐ Hospital ☐ Urgent Care ☐ Doctor’s office/clinic ☐ Dialysis unit/center ☐ Long Term Care Facility ☐ Other (specify) |                           |
Visit healthcare setting as a patient (not just for this illness)  
- Y
- N
- Unk

Visit healthcare setting for any reason other than as a patient  
- Y
- N
- Unk

Contact with a known COVID-19 case-patient in a healthcare setting  
- Y
- N
- Unk

| Table | Hospital unit/center | Dialysis unit/center | Long Term Care Facility | Other (specify) |
|-------|----------------------|----------------------|-------------------------|----------------|
| Y     |                      |                      |                         |                |
| N     |                      |                      |                         |                |
| Unk   |                      |                      |                         |                |

19. Do you reside in an institutional or group setting (e.g. long-term care facility/nursing home, boarding school, college dormitory, etc.)?  
- Yes
- No
- Unknown

20. How many people in total resided in your household (HH) from the 14 days prior to illness through the date of this interview (excluding you)? ________.

A household member is anyone with at least one overnight stay during the 14 days prior to patient’s illness onset to the date of this interview. If patient belongs to multiple HH, group HH members by identifying the 1st HH as A, the 2nd HH as B, etc.

| HH (if case-patient belongs to >1 HH) | Relation to patient | Sex | Age (specify unit as years, months, or days) | Did household member have fever or respiratory symptoms (e.g. cough, sore throat, etc.) in the 14 days prior to patient’s illness onset, during the patient’s illness, or 14 days after patient’s illness? | Date of illness onset of household member (MM/DD/YYY) |
|--------------------------------------|---------------------|-----|---------------------------------------------|-------------------------------------------------|--------------------------|
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
| A                                    |                    |     |                                            |                                                  |                          |
Symptoms
21. If symptomatic, onset date of first symptom (MM/DD/YYYY): ____/_____/_______  Unknown  Asymptomatic
22. If experienced symptoms, are you  Still symptomatic  Unknown symptom status  Symptoms resolved
   If symptoms resolved, date of symptom resolution (MM/DD/YYYY): ____/_____/_______  Unknown date
23. During this illness, did you experience any of the following symptoms?

| Symptom | Symptom |
|---------|---------|
| Fever ≥100.4F (38C) | Cough (new onset or worsening of chronic cough) |
| Highest temp ______ °F | Dry |
| Date of onset (MM/DD/YYYY) | Productive |
| Duration of fever ≥100.4F (38C) (days) | Bloody sputum (hemoptysis) |
| Subjective fever (felt feverish) | Shortness of breath (dyspnea) |
| Chills | Wheezing |
| Fatigue | Chest Pain |
| Muscle aches (myalgia) | Abdominal pain |
| Rash | Vomiting |
| Headache | Nausea |
| Eye redness (conjunctivitis) | Diarrhea (≥3 loose/looser than normal stools/24hr period) |
| Runny nose (rhinorrhea) | Poor Feeding/Poor appetite |
| Sore throat | Seizures |
| Other, specify: | Other, specify: |

Past medical history
24. Do you have any pre-existing medical conditions?  Unknown

| Chronic Lung Disease | Asthma/reactive airway disease | Emphysema/COPD |
|----------------------|-------------------------------|---------------|
| Other chronic lung disease | Active tuberculosis | |
| Condition                                      | Yes | No | Unknown |
|-----------------------------------------------|-----|----|---------|
| Diabetes Mellitus                             |     |    |         |
| Cardiovascular disease                        |     |    |         |
| Hypertension                                  |     |    |         |
| Coronary artery disease                       |     |    |         |
| Heart failure/Congestive heart failure        |     |    |         |
| Cerebrovascular accident/Stroke               |     |    |         |
| Congenital heart disease                      |     |    |         |
| Other                                         |     |    |         |
| Renal disease                                 |     |    |         |
| Chronic kidney disease/insufficiency          |     |    |         |
| End-stage renal disease                       |     |    |         |
| Dialysis                                      |     |    |         |
| Other                                         |     |    |         |
| Liver disease                                 |     |    |         |
| Alcoholic hepatitis                           |     |    |         |
| Chronic liver disease                         |     |    |         |
| Cirrhosis/End stage liver disease             |     |    |         |
| Hepatitis B, chronic                          |     |    |         |
| Hepatitis C, chronic                          |     |    |         |
| Non-alcoholic fatty liver disease (NAFLD)/NASH|     |    |         |
| Other                                         |     |    |         |
| Immunocompromised Condition                   |     |    |         |
| HIV infection                                 |     |    |         |
| AIDS or CD4 count <200                        |     |    |         |
| Solid organ transplant                        |     |    |         |
| Stem cell transplant (e.g., bone marrow       |     |    |         |
| Cancer: current/in treatment or diagnosed in last 12 months |     |    |         |
| Other                                         |     |    |         |
| Immunosuppressive therapy                     |     |    |         |

If YES, specify: ____________________________
For what condition:  

| Neurologic/neurodevelopmental disorder | Yes | No | Unknown | If YES, specify: |
|----------------------------------------|-----|----|---------|-----------------|
| Other chronic diseases                 | Yes | No | Unknown | If YES, specify: |

25. Current height: ________ (inches) OR ________ (cm)
26. Current weight: ________ (pounds) OR ________ (kg)
27. If female, are you currently pregnant?  □ Yes  Weeks pregnant at illness onset__________ □ No □ Unknown
28. If female, are you postpartum (≤6 weeks postpartum)?  □ Yes □ No □ Unknown
29. If female, are you breastfeeding?  □ Yes □ No □ Unknown
30. If child, is he/she being breastfed?  □ Yes □ No □ Unknown

Social history
31. Do you currently smoke cigarettes?  □ Yes □ No □ Unknown  
   If yes, how many packs of cigarettes per day? ______ For how many years? ______
32. Have you ever smoked cigarettes?  □ Yes □ No □ Unknown  
   If yes, how many packs of cigarettes per day? ______ For how many years? ______  
   How long since you last smoked a cigarette? ____ (m) ___ (y)
33. Do you currently use e-cigarettes/vape-pen?  □ Yes □ No □ Unknown
34. In the past year, how often did you have a drink containing alcohol?  
   □ Never  □ Monthly or less  □ 2-4 times a month  □ 2-3 times per week  □ 4 or more times per week

Course of Illness
35. Do you feel back to normal?  □ Yes □ No □ Not applicable (patient deceased) □ Not applicable (patient asymptomatic) □ Unknown  
   If yes, when did you feel back to normal? ______/_____/_______ (MM/DD/YYYY)
36. Did you miss work or school for this illness?  □ Yes □ No □ Unknown  
   If yes, how many days during illness? __________
37. Did you receive any medical care for the illness?  □ Yes □ No □ Unknown
38. If yes, where and which dates did you seek care after this illness started (check all that apply)? [Please add extra visit dates in comments box]
   □ Doctor’s office  Date 1: ______/_____/_______ (MM/DD/YYYY)  Date 2:  
   □ Emergency room  Date 1: ______/_____/_______ (MM/DD/YYYY)  Date 2:  
   □ Retail store/pharmacy  Date 1: ______/_____/_______ (MM/DD/YYYY)  Date 2:  

Page 8 of 14
39. Was the patient hospitalized?  □ Yes  □ No  □ Unknown  If YES, please fill out hospitalization section below  If no, skip to Question #53

Purpose:  □ Clinical indication  □ No clinical indication (e.g., isolation for public health)

Hospitalization
40. Hospital name: ____________________________________________________  Hospital phone: _____________________________

41. If yes, Admission date 1 ___/___/___ (MM/DD/YYYY)  , discharge date 1 ___/___/____ (MM/DD/YYYY)  □ Patient still hospitalized

42. To where was the patient discharged?
□ Home  □ Transferred to another hospital  □ Nursing facility/rehab  □ Hospice
□ Other __________  □ Unknown

43. If hospitalized more than once, please enter the second hospitalization’s admission and discharge dates:
Hospital name: ____________________________________________________  Hospital phone: _____________________________
Admission date 2 ___/___/___ (MM/DD/YYYY)  , discharge date 2 ___/___/____ (MM/DD/YYYY)  □ Patient still hospitalized

44. To where was the patient discharged?
□ Home  □ Transferred to another hospital  □ Nursing facility/rehab  □ Hospice
□ Other __________  □ Unknown

45. First recorded vital signs: Temp_________ (Unit: □ °F / □ oC)  Blood pressure:
________ (systolic) / ________ (diastolic)
Heart rate: _________  Resp rate:___________
O2 Sat: _______________ (Type of support required when O2 saturation was measured:
□ Room Air  □ Nasal Cannula  □ Face Mask  □ CPAP or BIPAP  □ High Flow Nasal Cannula
□ Invasive mechanical ventilation
□ Other, specify: □ Unknown
Fraction of Inspired Oxygen/Flow __________%  □ Liters/minute (LPM)  □ Unknown
□ NA
46. First recorded laboratory values for:

|                | Date (MM/DD/YYYY) | Value | Unit         |
|----------------|-------------------|-------|--------------|
| White blood cell (WBC) count |                   |       | Cells x 10^9/L | x 1000/μL |
| Absolute neutrophil count |                   |       | Cells x 10^9/L | x 1000/μL |
| Absolute lymphocyte count |                   |       | Cells x 10^9/L | x 1000/μL |
| Platelets (Plt) |                   |       | Cells x 10^9/L | x 1000/μL |
| Aspartate transaminase (AST) |             |       | U/L | IU/L | Other: | |
| Alanine aminotransferase (ALT) |               |       | U/L | IU/L | Other: | |
| Lactate dehydrogenase (LDH) |                 |       | U/L | IU/L | Other: | |

47. Was the patient admitted to an intensive care unit (ICU)?
   - Yes
   - No
   - Unknown
   ICU admission date 1 __________/________/________ (MM/DD/YYYY)
   ICU discharge date 1 __________/________/________ (MM/DD/YYYY)
   ICU admission date 2 __________/________/________ (MM/DD/YYYY)
   ICU discharge date 2 __________/________/________ (MM/DD/YYYY)

48. During hospitalization, did the patient receive...

|                         | Start Date (MM/DD/YYYY) | Last Date (MM/DD/YYYY) | Total Days |
|-------------------------|-------------------------|------------------------|------------|
| Supplemental Oxygen?    |                         |                        |            |
| BiPap or CPAP use?      |                         |                        |            |
| High flow nasal cannula?|                         |                        |            |
| Invasive mechanical ventilation? |              |                        |            |
| ECMO?                   |                         |                        |            |

49. Did the patient receive a discharge diagnosis of pneumonia (refer to clinical discharge summary)?
   - Yes
   - No
   - Unknown
50. Did the patient receive a discharge diagnosis of acute respiratory distress syndrome (ARDS) (refer to clinical discharge summary)?
☐ Yes  ☐ No  ☐ Unknown

51. Clinical Discharge Diagnoses and ICD10 Discharge Codes

| Clinical Discharge Diagnoses | ICD-10-CM Code |
|-----------------------------|----------------|
| 1.                          |                |
| 2.                          |                |
| 3.                          |                |
| 4.                          |                |
| 5.                          |                |
| 6.                          |                |
| 7.                          |                |
| 8.                          |                |
| 9.                          |                |
| 10.                         |                |

52. Did the patient receive any antiviral medications during hospitalization for this illness:

| Medication | Dose | Frequency | Start Date (MM/DD/YYYY) | Last Date (MM/DD/YYYY) | Total Days |
|------------|------|-----------|--------------------------|------------------------|------------|
| Remdesivir | ☐ PO | ☐ IV | ☐ IM | | | |
| Other:_________ | ☐ PO | ☐ IV | ☐ IM | | | |
| Other:_________ | ☐ PO | ☐ IV | ☐ IM | | | |

53. Was a chest x-ray taken?  ☐ Yes  ☐ No  ☐ Unknown
54. Were any of these chest x-rays abnormal?  ☐ Yes  ☐ No  ☐ Unknown

Date of first abnormal chest x-ray: _____/_____/_______ (MM/DD/YYYY)

55. For first abnormal chest x-ray, please check all that apply:  Report not available: ☐

- Air space density
- Cannot rule out pneumonia
- ARDS (acute respiratory distress syndrome)
- Other

- Air space opacity
- Consolidation
- Lung infiltrate
- Pleural Effusion

- Bronchopneumonia/pneumonia
- Cavitation
- Interstitial infiltrate
- Empyema

56. Was a chest CT/MRI taken?  ☐ Yes  ☐ No  ☐ Unknown
57. Were any of these chest CT/MRIs abnormal?  □ Yes  □ No  □ Unknown  
   Date of first abnormal CT/MRI: ______ / ______ / ______ (MM/DD/YYYY)  

58. For first abnormal chest CT/MRI, please check all that apply: Report not available:  

| Diagnosis                                                      | Yes | No | Unknown |
|---------------------------------------------------------------|-----|----|---------|
| Air space density                                             |     |    |         |
| ARDS (acute respiratory distress syndrome)                    |     |    |         |
| Empyema                                                       |     |    |         |
| Enlarge epiglottis                                            |     |    |         |
| Air space opacity/opacification                                |     |    |         |
| Lung infiltrate                                               |     |    |         |
| Pneumothorax                                                  |     |    |         |
| Tracheal narrowing                                            |     |    |         |
| Bronchopneumonia/pneumonia                                   |     |    |         |
| Interstitial infiltrate                                       |     |    |         |
| Pneumomediastinum                                            |     |    |         |
| Ground glass opacities                                       |     |    |         |
| Consolidation                                                 |     |    |         |
| Lobar infiltrate                                              |     |    |         |
| Widened mediastinum                                           |     |    |         |
| Other                                                         |     |    |         |
| Cavitation                                                    |     |    |         |
| Pleural effusion                                              |     |    |         |

Lab Results

59. SARS-CoV-2 Testing (Please report further test results in comments)  

| Date of sample collection (MM/DD/YYYY) | Sample Type | Result       |
|----------------------------------------|-------------|--------------|
|                                        | □ NP □ OP □ Sputum | □ Pos □ Neg □ Inconclusive |
|                                        | □ Other, specify: |                      |
|                                        | □ NP □ OP □ Sputum | □ Pos □ Neg □ Inconclusive |
|                                        | □ Other, specify: |                      |
|                                        | □ NP □ OP □ Sputum | □ Pos □ Neg □ Inconclusive |
|                                        | □ Other, specify: |                      |
|                                        | □ NP □ OP □ Sputum | □ Pos □ Neg □ Inconclusive |
|                                        | □ Other, specify: |                      |

60. Was patient tested for other viral respiratory pathogens during their illness?  □ Yes (report results below)  □ No  □ Unknown  

| Pathogen | Positive | Negative | Not Tested/Unknown | Collection Date (MM/DD/YYYY) | Specimen Type |
|----------|----------|----------|--------------------|-----------------------------|---------------|
| Flu A/H1 | □        | □        | □                  | / / /                     |               |
| Flu A/H3 | □        | □        | □                  | / / /                     |               |
| Flu B    | □        | □        | □                  | / / /                     |               |
| Flu (no type) | □    | □        | □                  | / / /                     |               |
| Virus/Microorganism                          | Yes | No | Unknown | Date MM/DD/YYYY |
|--------------------------------------------|-----|----|---------|-----------------|
| Respiratory syncytial virus/RSV            |     |    |         |                 |
| Adenovirus                                 |     |    |         |                 |
| Parainfluenza virus 1                      |     |    |         |                 |
| Parainfluenza virus 2                      |     |    |         |                 |
| Parainfluenza virus 3                      |     |    |         |                 |
| Parainfluenza virus 4                      |     |    |         |                 |
| Respiratory syncytial virus/RSV            |     |    |         |                 |
| Human metapneumovirus                      |     |    |         |                 |
| Rhinovirus/enterovirus                     |     |    |         |                 |
| Human coronavirus 229E                     |     |    |         |                 |
| Human coronavirus HKU1                     |     |    |         |                 |
| Human coronavirus NL63                     |     |    |         |                 |
| Human coronavirus OC43                     |     |    |         |                 |

61. Were any bacterial culture tests performed during their illness?  □ Yes  □ No  □ Unknown
   If yes, was there a positive culture for a bacterial pathogen?  □ Yes  □ No  □ Unknown
   If yes, specify pathogen: __________________________________________________
   If yes, specify date of culture (MM/DD/YYYY): ____________
   If yes, site where pathogen identified:  □ Blood  □ Sputum  □ Bronchoalveolar lavage (BAL)  □ Endotracheal aspirate  □ Pleural fluid
   □ Cerebrospinal fluid (CSF)  □ Other, specify: ______________
   If more than one bacterial culture test was performed, please record in additional comments.

Outcome
62. Did the patient die as a result of this illness?
   □ Yes, Date: _____/_____/_____(MM/DD/YYYY)  □ No  □ Unknown
   Where did the death occur:  □ Home  □ Hospital  □ ER  □ Hospice  □ Other, specify__________________________
   (If the following information is not currently available, please send an update later using death certificate or death note in hospital record.)
   Contribution of COVID-19 to death  □ Underlying/primary  □ Contributing/secondary  □ No contribution to death  □ Unknown
   Was autopsy performed?  □ Yes  □ No  □ Unknown
Primary Cause of death (death certificate/coroner)

Any additional comments or notes?

This is the end of the case investigation form. Thank you very much for your time. If you have any questions please feel free to contact the CDC at 770-488-7100 or eocreport@cdc.gov
Patterns of Virus Exposure and Presumed Household Transmission among Persons with Coronavirus Disease, United States, January–April 2020

Appendix 2

Supplemental Methods

Workplace Setting Classification

The CIF asked participants to classify their “occupation.” This free text was then processed by the National Institute for Occupational Safety and Health (NIOSH) using the NIOSH Industry and Occupation Computerized Coding System (NIOCCS) to produce 2012 Census Industry Codes. Workplace settings were categorized according to 2012 Census Industry Codes, because the CIF did not ask about occupation and industry separately. The following groups were created: accommodation, food, and other services (census industry codes 8660 – 8690 or 8770 – 9290; does not include public administration); construction (census industry code 0770); education (free text of “student” among persons ≥18 years [and census industry code 9890], or census industry codes 7860 – 7890); healthcare (reported occupation as a healthcare worker or census industry codes 7970 – 8270); manufacturing (census industry codes 1070 – 3990); professional or office setting (census industry codes 6470 – 6780 or 6870 – 7190 or 7270 – 7490); transportation, warehousing, and utilities (census industry codes 0570 – 0690 or 6070 – 6390); wholesale or retail trade (census industry codes 4070 – 4590 or 4670 – 5790); insufficient information (census industry code 9990 or unable to classify industry); not currently in workforce (retired, homemaker, unemployed, child <18 years of age); other (census industry codes not previously mentioned).

Sensitivity Analysis

A subset of 18 households included in our analysis participated in a household transmission study in Utah (1). Laboratory-confirmed COVID-19 case-patients were identified
by public health surveillance, and their households were enrolled within 10 days of sample collection from that initial case-patient. Nasopharyngeal (NP) and serum samples were collected from all household members at enrollment and after a 14-day follow-up period and were tested for SARS-CoV-2 by RT-PCR (NP samples) and enzyme immunoassay (serum samples). Reported household member symptom status was compared to test results (counting any RT-PCR or serology positive as a confirmed COVID-19 case patient) to calculate the sensitivity and specificity of the CIF question regarding household contact symptom status (“Did household member have fever or respiratory symptoms (e.g. cough, sore throat, etc.) in the 14 days prior to patient’s illness onset, during the patient’s illness, or 14 days after patient’s illness?”). Misclassification-adjusted attack rates were calculated for a range of the estimated sensitivity (Se) and specificity (Sp), plus or minus 10%, in increments of 5%, using the formula (2):

\[
\text{Adjusted Attack Rate} = \frac{\text{Symptomatic contacts} - \text{Total contacts} \times (1 - \text{Sp})}{\text{Se} - (1 - \text{Sp})} ÷ \text{Total contacts}
\]

**Supplemental Results**

In the subset of households for whom testing data was available on all household members (3), 13 of 18 test-positives were identified as symptomatic (sensitivity = 72%) and 50 of 59 test-negatives were identified as asymptomatic (specificity = 85%). The misclassification-adjusted household attack rate was 30.0% (unadjusted AR = 32.1%). The adjusted attack rates for a range of sensitivity and specificity values are shown in Appendix Table 1. The most plausible values are considered to be those estimated for Sp and Se within 5% of the calculated values and are highlighted in grey. Sample-size limitations precluded age-specific sensitivity analyses.

**Reference**

1. Lewis NM, Chu VT, Ye D, Conners EE, Gharpure R, Laws RL, et al. Household transmission of SARS-CoV-2 in the United States. Clin Infect Dis. 2020;ciaa1166. PubMed

[https://doi.org/10.1093/cid/ciaa1166](https://doi.org/10.1093/cid/ciaa1166)
2. Lash TLFM, Fink AK. Applying quantitative bias analysis to epidemiologic data: Springer; 2009.

3. Centers for Disease Control and Prevention. COVID data tracker [cited 2021 Apr 21].
   https://covid.cdc.gov/covid-data-tracker/#datatracker-home.

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**Appendix Table 1.** Misclassification-adjusted household attack rates for varying levels of sensitivity and specificity of household case identification

| Specificity | Sensitivity |
|-------------|-------------|
|             | 62%         | 67%         | 72%         | 77%         | 82%         |
| 75%         | 19.3%       | 17.0%       | 15.2%       | 13.7%       | 12.5%       |
| 80%         | 28.9%       | 25.8%       | 23.3%       | 21.3%       | 19.6%       |
| 85%         | 36.4%       | 32.9%       | 30.0%       | 27.6%       | 25.6%       |
| 90%         | 42.5%       | 38.8%       | 35.7%       | 33.0%       | 30.7%       |
| 95%         | 47.6%       | 43.7%       | 40.5%       | 37.7%       | 35.2%       |

**Appendix Table 2.** Factors associated with symptom status of 112 household contacts of 44 laboratory-confirmed index COVID-19 case patients–United States, January – April 2020*

| Factor                  | Unique households | N with symptoms / Total contacts (%) | Crude OR | 95% CI† | p-value‡ |
|-------------------------|-------------------|-------------------------------------|----------|---------|---------|
| Contact Sex             |                   |                                     |          |         |         |
| Female                  | 37                | 11 / 57 (19.3%)                    | 1.00     | -       | -       |
| Male                    | 29                | 7 / 55 (12.7%)                     | 0.57     | (0.24, 1.35) | 0.20    |
| Contact Age             |                   |                                     |          |         |         |
| <18 years               | 17                | 6 / 37 (16.2%)                     | 1.00     | -       | -       |
| 18+ years               | 43                | 12 / 69 (17.4%)                    | 0.92     | (0.31, 2.79) | 0.89    |
| Household Size          |                   |                                     |          |         |         |
| <5 people               | 36                | 9 / 70 (12.9%)                     | 1.00     | -       | -       |
| 5+ people               | 8                 | 9 / 42 (21.4%)                     | 2.44     | (0.63, 9.47) | 0.20    |
| Index Age               |                   |                                     |          |         |         |
| <5 years                | 2                 | 2 / 7 (28.6%)                      |          |         |         |
| 5 - 17 years            | 2                 | 0 / 5 (0.0%)                       |          |         |         |
| 18 - 44 years           | 20                | 8 / 65 (12.3%)                     |          |         |         |
| 45 - 64 years           | 15                | 7 / 30 (23.3%)                     |          |         |         |
| 65+ years               | 5                 | 1 / 5 (20.0%)                      |          |         |         |
| Relationship of Contact to Index Case | |                                    |          |         |         |
| Spouse                  | 34                | 4 / 35 (11.4%)                     | 1.00     | -       | 0.20    |
| Child                   | 16                | 7 / 30 (23.3%)                     | 2.68     | (0.74, 9.72) | 0.20    |
| Parent                  | 9                 | 5 / 17 (29.4%)                     | 2.83     | (0.51, 15.76) | 0.20    |
| Other                   | 13                | 2 / 30 (6.7%)                      | 0.73     | (0.13, 4.05) |         |

*60 contacts from 20 households (i.e., 20 index cases) with complete data are excluded because the index case was not the subject of the CIF (i.e., was not necessarily laboratory-confirmed as SARS-CoV-2–positive). An additional 4 contacts from 1 household (i.e., 1 index case) are excluded because the index case was not the subject of the CIF and data were missing. An additional 17 contacts from 4 households (i.e., 4 index cases) are excluded due to missing data; 2 persons missing sex, 10 missing contact age category, 11 missing relationship. Definitions: Index case – household member with first reported onset of symptoms. Household contact – household member of the index case.

Abbreviations: OR – odds ratio. CI – confidence interval. CIF – Case Investigation Form.

†Calculated using robust standard errors.
‡Generalized Wald test.
### Appendix Table 3. Characteristics of 202 COVID-19 case-patients with submitted case investigation forms, United States, January 14 – April 4, 2020

| Characteristic                  | N (%) |
|--------------------------------|-------|
| **Reporting Month**            |       |
| January – February, 2020       | 23 (11.4) |
| March, 2020                    | 106 (52.5) |
| April, 2020                    | 73 (36.1) |
| **Demographics**               |       |
| Sex                            |       |
| Female                         | 90 (44.6) |
| Male                           | 106 (52.5) |
| Unknown                        | 6 (3.0) |
| Age (years)                    |       |
| 0–4                            | 5 (2.5) |
| 5–17                           | 10 (5.0) |
| 18–44                          | 71 (35.1) |
| 45–64                          | 66 (32.7) |
| 65–74                          | 26 (12.9) |
| 75–84                          | 12 (5.9) |
| 85+                            | 5 (2.5) |
| Unknown                        | 7 (3.5) |
| Race                           |       |
| American Indian / Alaska Native| 1 (0.5) |
| Asian                          | 37 (18.3) |
| Black                          | 12 (5.9) |
| Multiracial                    | 2 (1.0) |
| Native Hawaiian / Other Pacific Islander | 4 (2.0) |
| White                          | 97 (48.0) |
| Other*                         | 4 (2.0) |
| Unknown                        | 45 (22.3) |
| Ethnicity                      |       |
| Hispanic / Latino              | 23 (11.4) |
| Not Hispanic / Latino          | 130 (64.4) |
| Unknown                        | 49 (24.3) |
| **Behavioral History**         |       |
| Smoking history                |       |
| Current                        | 4 (2.0) |
| Former                         | 31 (15.3) |
| Never                          | 121 (59.9) |
| Unknown                        | 46 (22.8) |
| Alcohol consumption            |       |
| Never                          | 62 (30.7) |
| Monthly or less                | 25 (12.4) |
| At least 2x per month          | 38 (18.8) |
| Unknown                        | 77 (38.1) |
| **Underlying conditions**      |       |
| Diabetes mellitus              |       |
| No                             | 147 (72.8) |
| Yes                            | 34 (16.8) |
| Unknown                        | 21 (10.4) |
| Obesity (BMI ≥30)              |       |
| No                             | 60 (29.7) |
| Yes                            | 35 (17.3) |
| Unknown                        | 107 (53.0) |
| Hypertension                   |       |
| No                             | 130 (64.4) |
| Yes                            | 48 (23.8) |
| Unknown                        | 24 (11.9) |
| Chronic respiratory condition  |       |
| No                             | 152 (75.2) |
| Yes                            | 30 (14.9) |
| Unknown                        | 20 (9.9) |
| Renal disease                  |       |
| No                             | 167 (82.7) |
| Yes                            | 14 (6.9) |
| Unknown                        | 21 (10.4) |
| Immunosuppressive condition    |       |
| No                             | 172 (85.1) |
| Yes                            | 8 (4.0) |
| Unknown                        | 22 (10.9) |
| Characteristic                                           | N (%)  |
|---------------------------------------------------------|--------|
| **Clinical summary**                                    |        |
| Symptom status                                          |        |
| No                                                      | 6 (3.0)|
| Yes                                                     | 195 (96.5)|
| Unknown                                                 | 1 (0.5)|
| Outcome                                                 |        |
| Deceased                                                | 6 (3.0)|
| Survived                                                | 158 (78.2)|
| Unknown                                                 | 38 (18.8)|
| Hospitalization status                                  |        |
| Not hospitalized                                        | 115 (56.9)|
| Hospitalized for clinical management of COVID-19 symptoms| 66 (32.7)|
| Hospitalized, unknown or other purpose (e.g., isolation) | 13 (6.4)|
| Hospitalization unknown                                 | 8 (4.0)|
| **Information about hospitalization†**                  |        |
| Discharge                                               |        |
| Deceased                                                | 5 (7.6)|
| Home                                                    | 23 (34.8)|
| Other                                                   | 2 (3.0)|
| Unknown                                                 | 36 (54.5)|
| Admitted to the Intensive Care Unit                     |        |
| No                                                      | 26 (39.4)|
| Yes                                                     | 34 (51.5)|
| Unknown                                                 | 6 (9.1)|
| Mechanical ventilation                                  |        |
| No                                                      | 43 (65.2)|
| Yes                                                     | 15 (22.7)|
| Unknown                                                 | 8 (12.1)|

*All persons who indicated that none of the following racial categories applied to them: American Indian / Alaska Native, Asian, Black, Multiracial, Native Hawaiian / Other Pacific Islander, White.

†For case-patients hospitalized for clinical management of COVID-19 symptoms, N = 66.