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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission dynamics and social contact patterns

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ABSTRACT

Background

Understanding the community burden and transmission dynamics of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can assist to make informed decisions for prevention policies.

Methods

From August through October 2018, before the SARS-CoV-2 pandemic, we performed a cross-sectional contact survey nested in a prospective household cohort in an urban (Jouberton, North West Province) and a rural community (Agincourt, Mpumalanga Province) in South Africa to measure contact rates in 535 study participants. Participants were interviewed to collect details on all contact events (within and outside of the household).

During the SARS-CoV-2 pandemic we enrolled 1211 individuals from 232 randomly selected households in the same urban and rural community, and followed the cohort prospectively for 16 months (July 2020 through November 2021), collecting blood every two months to test for SARS-CoV-2 antibodies. Using these longitudinal SARS-CoV-2 seroprevalence estimates and comparing these with reported laboratory-confirmed cases, hospitalizations and deaths, we investigated the community burden and severity of SARS-CoV-2.

We also performed a case-ascertained household transmission study of symptomatic SARS-CoV-2 index cases living with HIV (LWH) and not LWH (NLWH) in two urban communities (Jouberton, North West Province and Soweto, Gauteng Province) from October 2020 through September 2021. We enrolled 131 SARS-CoV-2 index cases at primary healthcare clinics. The index cases and their 457 household contacts were followed up for six weeks with thrice weekly visits to collect nasal swabs for SARS-CoV-2 testing on reverse transcription real-time polymerase chain reaction (rRT-PCR), irrespective of symptoms. We assessed household cumulative infection risk (HCIR), duration of virus detection and the interval between index and contact symptom onset (serial interval). By collecting high-resolution household contact patterns in these households using wearable sensors, we assessed the association between contact patterns and SARS-CoV-2 household transmission.

Results

During the contact survey, we observed an overall contact rate of 14 (95% confidence interval (CI), 13-15) contacts per day, with higher contact rates in children aged 14-18 years (22, 95%CI 8-35) compared to children <7 years (15, 95%CI 12-17). We found higher contact rates in the rural site (21, 95%CI 14-28) compared to the urban site (12, 95%CI 11-13).

When comparing the household cohort seroprevalence estimates to district SARS-CoV-2 laboratory-confirmed infections, we saw that only 5% of SARS-CoV-2 infections were reported to surveillance. Three percent of infections resulted in hospitalization and 0.7% in death. People LWH were not more likely to be seropositive for SARS-CoV-2 (odds ratio [OR] 1.0, 95%CI 0.7–1.5), although the sample size for people LWH was small (159/1131 LWH).

During the case-ascertained household transmission study for SARS-CoV-2, we estimated a HCIR of 59% (220/373) in susceptible household members, with similar rates in households with an index LWH and NLWH (60% LWH vs 58% NLWH). We observed a higher risk of transmission from index cases aged 35–59 years (adjusted OR [aOR] 3.4, 95%CI 1.5–7.8) and ≥60 years (aOR 3.1, 95% CI 1.0–10.1) compared with those aged 18–34 years, and index cases with a high SARS-CoV-2 viral load (using cycle threshold values (C_t) <25 as a proxy, aOR 5.3, 95%CI 1.6–17.6). HCIR was also higher in contacts aged 13–17 years (aOR 7.1, 95%CI 1.5–33.9) and 18–34 years (aOR 4.4, 95% CI 1.0–18.4) compared with <5 years. Through the deployment of wearable sensors, we were able to measure high-resolution within-household contact patterns in the same households. We did not find an association between duration (aOR 1.0 95%CI 1.0-1.0) and frequency (aOR 1.0 95%CI 1.0-1.0) of close-proximity contact with SARS-CoV-2 index cases and household members and transmission.

Conclusion

We found high contact rates in school-going children, and higher contact rates in the rural community compared to the urban community. These contact rates add to the limited literature on measured contact patterns in South Africa. The burden of SARS-CoV-2 is underestimated in national surveillance, highlighting the importance of serological surveys to determine the true burden. Under-ascertainment of cases can hinder containment efforts through isolation and contact tracing. Based on seroprevalence estimates in our study, people LWH did not have higher SARS-CoV-2 community attack rates.

In the household transmission study, we observed a high HCIR in households with symptomatic index cases, and that index cases LWH did not infect more household members compared to people NLWH. We found a correlation between age and SARS-CoV-2 transmission and acquisition, as well as between age and contact rates.

Although we did not observe an association between household contact patterns and SARS-CoV-2 transmission, we generated SARS-CoV-2 transmission parameters and community and household contact data that can be used to parametrize infectious disease models for both SARS-CoV-2 and other pathogens to assist with forecasting and intervention assessments. The availability of robust data is important in the face of a pandemic where intervention strategies have to be adapted continuously.