



# Asymptomatic SARS-CoV-2 infection: A systematic review and meta-analysis

Pratha Sah<sup>a</sup>, Meagan C. Fitzpatrick<sup>a,b</sup>, Charlotte F. Zimmer<sup>a</sup>, Elaheh Abdollahi<sup>c</sup>, Lyndon Juden-Kelly<sup>c</sup>, Seyed M. Moghadas<sup>c</sup>, Burton H. Singer<sup>d,1</sup>, and Alison P. Galvani<sup>a</sup>

<sup>a</sup>Center for Infectious Disease Modeling and Analysis, Yale School of Public Health, New Haven, CT 06520; <sup>b</sup>Center for Vaccine Development and Global Health, University of Maryland School of Medicine, Baltimore, MD 21201; <sup>c</sup>Agent-Based Modelling Laboratory, York University, Toronto, ON M3J 1P3, Canada; and <sup>d</sup>Emerging Pathogens Institute, University of Florida, Gainesville, FL 32610

Contributed by Burton H. Singer, July 8, 2021 (sent for review May 19, 2021; reviewed by David Fisman and Claudio Jose Struchiner)

**Quantification of asymptomatic infections is fundamental for effective public health responses to the COVID-19 pandemic. Discrepancies regarding the extent of asymptomaticity have arisen from inconsistent terminology as well as conflation of index and secondary cases which biases toward lower asymptomaticity. We searched PubMed, Embase, Web of Science, and World Health Organization Global Research Database on COVID-19 between January 1, 2020 and April 2, 2021 to identify studies that reported silent infections at the time of testing, whether presymptomatic or asymptomatic. Index cases were removed to minimize representational bias that would result in overestimation of symptomaticity. By analyzing over 350 studies, we estimate that the percentage of infections that never developed clinical symptoms, and thus were truly asymptomatic, was 35.1% (95% CI: 30.7 to 39.9%). At the time of testing, 42.8% (95% prediction interval: 5.2 to 91.1%) of cases exhibited no symptoms, a group comprising both asymptomatic and presymptomatic infections. Asymptomaticity was significantly lower among the elderly, at 19.7% (95% CI: 12.7 to 29.4%) compared with children at 46.7% (95% CI: 32.0 to 62.0%). We also found that cases with comorbidities had significantly lower asymptomaticity compared to cases with no underlying medical conditions. Without proactive policies to detect asymptomatic infections, such as rapid contact tracing, prolonged efforts for pandemic control may be needed even in the presence of vaccination.**

asymptomatic fraction | presymptomatic | silent transmission | novel coronavirus | comorbidity

COVID-19 surveillance provides real-time information about the epidemiological trajectory of the pandemic, informing risk assessments and mitigation policies around the world. Given that COVID-19 surveillance systems predominantly rely on symptom-based screening, the prevalence of asymptomatic infection is often not fully captured. Cross-sectional surveys, such as mass testing once an outbreak is identified, do not distinguish the truly asymptomatic from the presymptomatic. Often, the follow-up period after testing is too brief to ascertain whether patients subsequently develop symptoms. The percentage of silent infections identified by such studies is thus context specific, as it depends on the setting, phase of the epidemic, and efficiency of contact tracing. By contrast, the prevalence of truly asymptomatic infections should be stable across similar demographic settings, regardless of epidemiological trajectory and contact tracing.

Compounded by ambiguities about the different clinical manifestations of the disease, which can lead to misinterpretation of clinical and epidemiological studies (1), there have been substantial aberrations in reports and media coverage claiming the asymptomatic percentage to be as low as 4% (2, 3) or as high as 80 to 90% (4, 5). Similarly, the US Centers for Disease Control and Prevention guidelines for COVID-19 pandemic forecasting offer wide bounds for the asymptomatic percentage, ranging from 10 to 70% (6).

Previous meta-analyses of 41 studies (7), 13 studies (8), and 79 studies (9) estimate pooled asymptomaticity ranging from 16 to

20%. Two methodological issues limit the accuracy of these studies. First, pooled asymptomaticity reported in these studies is likely biased downward because they did not account for study designs which have a higher representation of cases experiencing symptoms (10). Second, one of the meta-analyses (7) did not consider biases in reported asymptomaticity that can arise from inadequate longitudinal follow-up. Studies that assess the symptom profile only at the time of testing or do not follow up symptoms for a sufficiently long time period cannot distinguish presymptomatic from asymptomatic infection, overestimating those that are truly asymptomatic.

Accurate estimates of true disease prevalence, including asymptomatic infections, are essential to calculate key clinical parameters, project epidemiological trajectories, and optimize mitigation measures. Clinical evidence indicates that viral loads among asymptomatic and symptomatic infections may be comparable (11–15). Unaware of their risk to others, individuals with silent infections are likely to continue usual behavior patterns. Accounting for silent severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections in the assessment of disease control measures is necessary to interrupt community transmission (16). Although the discrepancy between reported incidence and seroprevalence gives a sense of the extent of asymptomaticity, not

## Significance

**Asymptomatic infections have been widely reported for COVID-19. However, many studies do not distinguish between the presymptomatic stage and truly asymptomatic infections. We conducted a systematic review and meta-analysis of COVID-19 literature reporting laboratory-confirmed infections to determine the burden of asymptomatic infections and removed index cases from our calculations to avoid conflation. By analyzing over 350 papers, we estimated that more than one-third of infections are truly asymptomatic. We found evidence of greater asymptomaticity in children compared with the elderly, and lower asymptomaticity among cases with comorbidities compared to cases with no underlying medical conditions. Greater asymptomaticity at younger ages suggests that heightened vigilance is needed among these individuals, to prevent spillover into the broader community.**

Author contributions: P.S., M.C.F., S.M.M., and A.P.G. designed research; P.S., M.C.F., C.F.Z., E.A., L.J.-K., S.M.M., B.H.S., and A.P.G. performed research; P.S., M.C.F., C.F.Z., E.A., L.J.-K., S.M.M., and A.P.G. analyzed data; and P.S., M.C.F., S.M.M., B.H.S., and A.P.G. wrote the paper.

Reviewers: D.F., University of Toronto; and C.J.S., Fundacao Getulio Vargas.

The authors declare no competing interest.

This open access article is distributed under [Creative Commons Attribution License 4.0 \(CC BY\)](https://creativecommons.org/licenses/by/4.0/).

See [online](#) for related content such as Commentaries.

<sup>1</sup>To whom correspondence may be addressed. Email: [bhsinger@epi.ufl.edu](mailto:bhsinger@epi.ufl.edu).

This article contains supporting information online at <https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2109229118/-DCSupplemental>.

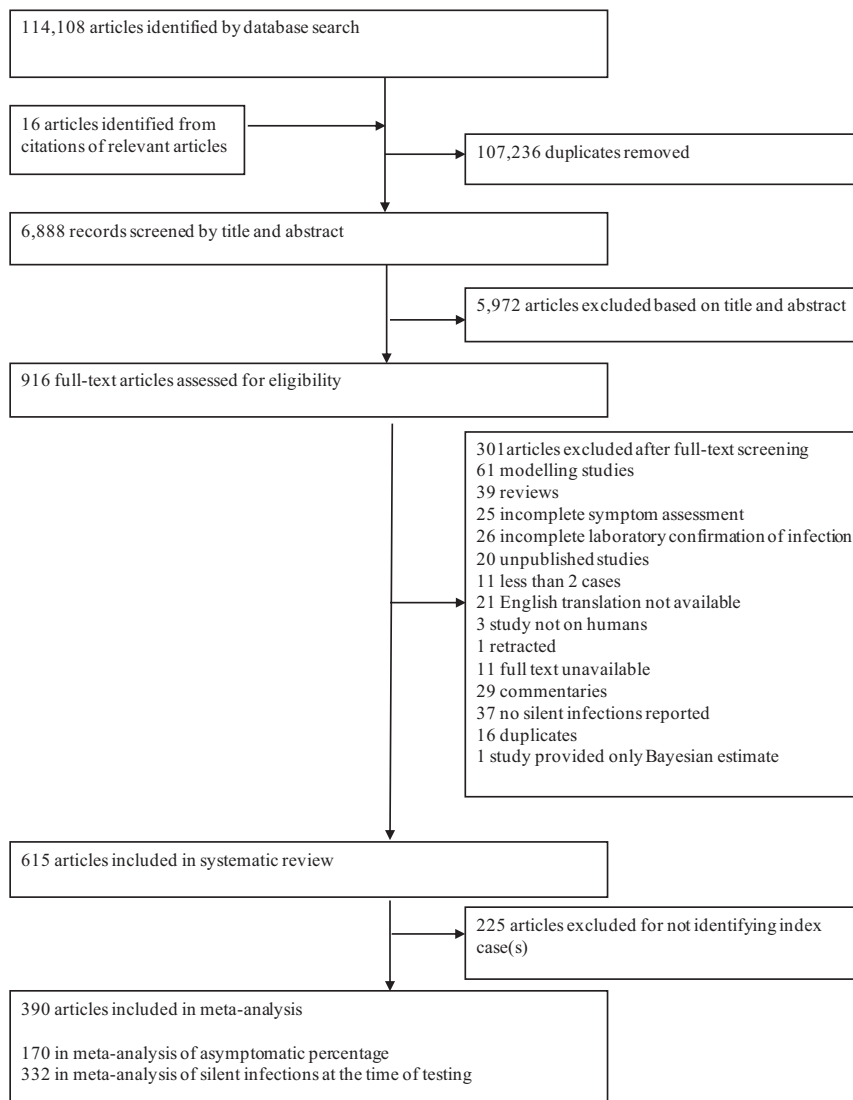
Published August 10, 2021.

all symptomatic cases are reported, and not all asymptomatic cases (for instance, those identified on the basis of exposure) are missed. Consequently, it is not sufficient to simply compare the reported cases to results from seroprevalence studies. We therefore conducted a systematic review and meta-analysis of COVID-19 literature reporting laboratory-confirmed infections to estimate the percentage of SARS-CoV-2 infections that are truly asymptomatic. We also investigated differences in asymptomaticity with respect to age, sex, comorbidity, study design, publication date, duration of symptom follow-up, geographic location, and setting.

### Results

We identified a total of 114,124 abstracts based on our search criteria. After excluding duplicate and irrelevant studies, we used 390 in our meta-analyses (Fig. 1 and *SI Appendix, Table S2*). Most studies were conducted in China ( $n = 104$ , 27%), followed by the United States ( $n = 74$ , 19%), Italy ( $n = 21$ , 5%), and South Korea ( $n = 13$ , 3%). These studies included a total of 104,058 laboratory-confirmed COVID-19 cases, of which 25,050 exhibited no symptoms at the time of testing and 7,220 remained asymptomatic. We identified 170 studies that reported asymptomatic infections (11–13, 17–183), 332

studies that reported silent infections at the time of testing (10–12, 14, 17–20, 23–27, 31, 32, 35–40, 42–44, 46, 47, 49, 50, 52, 53, 56–58, 60–66, 68, 69, 73–75, 77–79, 81, 84, 87, 90–94, 97, 99, 101, 103, 104, 106, 111, 113–116, 118, 119, 121–123, 125, 127, 128, 131, 133, 135, 137, 138, 140, 143, 145, 146, 148–152, 154, 156, 158, 160–163, 166–170, 172–174, 176, 177, 179, 180, 182–405), and 143 that delineated presymptomatic and asymptomatic infections by following-up with those silently infected (11–13, 17–20, 22–29, 31–33, 35–40, 42–44, 46–54, 56–70, 72–75, 77–81, 83, 84, 87, 89–94, 96, 97, 99, 101, 103, 104, 106–109, 111–119, 121–125, 127–129, 131, 133, 135–138, 140, 141, 143, 145–156, 158–164, 166–170, 172–174, 176–183). Among the studies that reported follow-up of clinical symptoms after testing, 11.0% reported at time points at 1 wk to 2 wk, 33.8% reported at 2 wk to 3 wk, and 55.2% reported longer than 3 wk. Among the studies that reported asymptomatic infections, 58.8% reported zero index cases, either because cases were identified through a screening design or because the study only reported the cases that were identified through contact tracing. Of the 41.2% studies that reported data on index cases, these included household members, long-term care residents, members of the community, or travelers returning from COVID-19 hotspots (*SI Appendix, Table S1*).



**Fig. 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram showing the numbers of studies screened and included in the meta-analysis.

A summary of the risk of bias assessment is presented in *SI Appendix, Table S2*. Out of the 170 studies included in the calculation of asymptomaticity, 75 had low risk of bias, 10 had moderate risk of bias, and 85 had serious risk of bias.

The percentage of cases that were truly asymptomatic among laboratory-confirmed cases was 35.1% (95% CI: 30.7 to 39.9%; Fig. 2). By contrast, a larger percentage of cases exhibited no symptoms at the time of testing (42.8%, 95% prediction interval: 5.2 to 91.1%) due to mischaracterization of presymptomatic cases as asymptomatic. To investigate the degree of mischaracterization, we considered a subset of studies that reported symptoms both at the time of testing and a minimum of 7 d after. Within this subset of studies, 31.8% (95% prediction interval: 5.6 to 78.7%) of cases exhibiting no symptoms at the time of testing progressed to develop symptoms. The percentage of truly asymptomatic cases among these studies was therefore 36.9% (95% CI: 31.8 to 42.4%), similar to that estimated for all studies reporting asymptomatic infections.

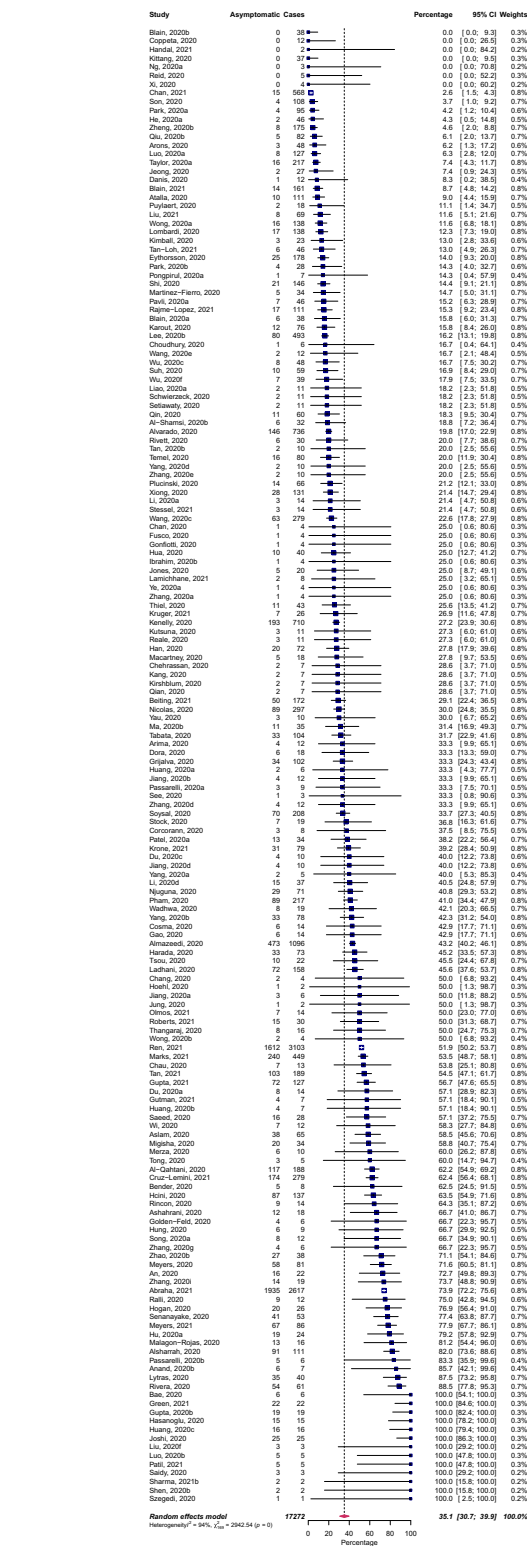
These estimates were obtained after removing index cases from our calculations, correcting bias toward overrepresentation of symptomatic cases that would lead to underestimation of asymptomaticity. Without excluding index cases, estimates of asymptomatic infections using our two complementary approaches would be 27.8% (95% CI: 24.3 to 31.7%) and 29.4 (95% CI: 25.2 to 33.9%). To evaluate the impact of sample selection bias arising from higher participation among those experiencing symptoms, we next restricted our analysis to 25 studies in which complete screening of every individual present at the setting was performed. The pooled asymptomaticity among this smaller subset of studies was 47.3% (95% CI: 34.0 to 61.0%).

We found a statistically significant trend toward a lower asymptomatic percentage with increasing age ( $P < 0.01$ ; Table 1). In pairwise comparisons, the asymptomatic percentage was significantly lower for the elderly, at 19.7% (95% CI: 12.7 to 29.4%) compared with 46.7% (95% CI: 32.0 to 62.0%) for children ( $P < 0.01$ ). Asymptomaticity also varied across study settings ( $P = 0.03$ ; Table 1). In particular, studies on long-term care facilities reported lower asymptomaticity compared with studies on healthcare facilities ( $P = 0.04$ ) and household transmission ( $P = 0.04$ ). We found no association between asymptomatic percentage and geographic location, study design, follow-up duration, or publication date (Table 1). We found that asymptomaticity in males was similar to that in females (log incidence rate ratio [IRR] 0.09, 95% CI  $-0.07$  to 0.25,  $P = 0.27$ ; *SI Appendix, Fig. S1*). Cases with comorbidities had lower asymptomaticity compared to cases with no underlying medical conditions (log IRR  $-0.43$ , 95% CI  $-0.82$  to  $-0.04$ ,  $P = 0.03$ ; *SI Appendix, Fig. S2*).

Egger's test for asymptomatic percentage was significant ( $P = 0.04$ ; *SI Appendix, Fig. S3*), providing evidence of potential small-study effects. We therefore conducted a sensitivity analysis by excluding studies with relatively small sample sizes (less than 10 infections). The pooled estimate in the restricted meta-analysis (33.1%; 95% CI: 28.0 to 38.5%) was similar to our original estimate, suggesting that our estimates are robust to publication bias.

**Discussion**

The SARS-CoV-2 pandemic infected more than 80 million people within a year and is still spreading rapidly despite widespread control efforts. The elements of the global response are similar to those deployed during the SARS-CoV-1 outbreak: detecting new cases through symptom-based surveillance, subsequent testing, and isolation of confirmed cases. In 2002, these measures achieved containment within 8 mo and fewer than 8,500 cases worldwide. Given that the aerosol and surface stability of the two viruses are similar (406), a crucial difference between the two outbreaks could be the role of silent infections in propagating transmission chains. Multiple clinical studies have indicated that viral loads in asymptomatic and symptomatic



**Fig. 2.** Pooled percentage of laboratory-confirmed COVID-19 cases which did not report follow-up of silent infections or failed to identify index cases were excluded from the analysis.

infections of COVID-19 may be similar (11–14, 354). Furthermore, the presymptomatic phase of SARS-CoV-2 is highly infectious (53), and transmission from those in this phase may be responsible for more than 50% of incidence (16). This is a

**Table 1. Pooled estimates for percentages of all positive cases which remain asymptomatic stratified by age, gender, publication date, symptom follow-up duration, study design, and study setting**

	<i>n</i>	Estimate (%)	CI (95%)	<i>P</i> value (test of overall effect)
Age class				<b>&lt;0.01</b>
Children (0 y to 18 y)	18	46.7	32.0 to 62.0	
Adults (19 y to 59 y)	17	32.1	22.2 to 43.9	
Elderly (≥60 y)	17	19.7	12.7 to 29.4	
Study design				0.10
Population screening	102	38.2	32.0 to 44.8	
Others	68	30.7	24.8 to 37.4	
Publication date				0.18
January–April 2020	27	34.8	23.6 to 47.9	
May–August 2020	69	29.5	24.2 to 35.4	
September–December 2020	50	41.1	31.4 to 51.4	
January–April 2021	24	38.4	25.6 to 53.1	
Symptom follow-up duration				0.07
7 d to 21 d	73	40.6	32.9 to 48.6	
21+ d	90	32.1	27.0 to 37.7	
Setting				<b>0.03</b>
Community	39	34.0	25.3 to 43.8	
Healthcare facility	81	38.5	31.6 to 45.9	
Household	18	42.5	30.9 to 54.9	
Long-term care facility	15	17.8	9.7 to 30.3	
Others	17	38.4	23.5 to 55.9	
Geographic location				0.78
China	50	33.6	26.1 to 42.0	
United States	28	33.3	22.6 to 46.1	
Others	92	36.8	30.4 to 43.6	

Stratifications with statistically significant subgroup differences ( $P < 0.05$ ) are in bold.

striking difference from SARS-CoV-1 in which the infectiousness peaked at 12 d to 14 d after symptom onset (407). Although silent infections of SARS-CoV-1 were reported, no known transmission occurred from silently infected or even mildly symptomatic SARS cases.

Since the emergence of COVID-19, there has been much speculation about the silent transmission of the disease. Cross-sectional studies testing exposed individuals who do not exhibit symptoms often conflate asymptomatic infections with those in the presymptomatic phase, leading to substantial overestimation of asymptomatic infection. Longitudinal studies without sufficient follow-up similarly lead to overestimation of asymptomaticity (408). Additionally, inconsistent use of terminology has led to confusion, particularly when distinguishing infections which are silent at the time of testing from those which are truly asymptomatic (4, 5). A previous meta-analysis, for example, incorrectly includes infections in the presymptomatic phase to calculate pooled estimate of asymptomatic percentage (409). By contrast, several studies conducted early in the pandemic reported few asymptomatic infections, primarily due to restrictive testing criteria which focused on testing of severe cases that required hospitalization (410, 411). Inaccuracy in either direction is detrimental for public health. Overestimation of asymptomaticity engenders a perception that SARS-CoV-2 is less virulent, whereas underestimation skews key epidemiological parameters such as infection fatality rate and hospitalization rate upward, leading to suboptimal policy decisions.

To robustly estimate the asymptomatic percentage from studies with varying degrees of methodological vigor, we conducted two separate meta-analyses. In the first analysis, we estimated the asymptomatic percentage as 35.1% (95% CI: 30.7 to 39.9%), by including all studies with a duration of follow-up sufficient to identify asymptomatic infections. In the second analysis, we only included studies that both delineated silent infections at the time

of testing and conducted follow-up to distinguish the presymptomatic stage from asymptomatic infections. With this analysis, we estimated the asymptomatic percentage as 36.9% (95% CI: 31.8 to 42.4%). Our estimates have overlapping CIs, which suggests that our pooled analysis is robust to methodological differences in symptom assessment. Our estimates are higher than the 15.6% (95% CI: 10.1 to 23.0%), 17% (95% CI: 14 to 20%), and 20% (95% CI: 17 to 25%) reported by three previous meta-analyses using 41 studies (7), 13 studies (8), and 79 studies (9). In large part, this difference arises because we excluded index cases from our calculation, correcting a bias that leads to underestimation of asymptomaticity. Our estimates of asymptomatic percentage without excluding index cases were 27.8% and 29.4%, for our two approaches. The lower bounds of 24% and 25%, for the two analyses overlaps with the range of the previous largest meta-analysis. Compared with other respiratory infections, the lower bound of our analyses is higher than the 13 to 19% estimated for influenza (412, 413), and the 13% for SARS-CoV-1 (414).

We found that 42.8% (95% prediction interval: 5.2 to 91.1%) of infections were silent at the time of testing. These cases have been incorrectly referred to as asymptomatic in previous studies (4, 5, 189, 239). This rate is context specific, as it is likely influenced by the association between symptomaticity and the time window when an infection is detectable or tested by RT-PCR. Additionally, the proportion of silent infections at the time of testing is highly sensitive to the efficiency of contact tracing. If most contacts are identified and tested swiftly, then nearly all infections will be silent at the time of testing. By contrast, if contact tracing is slow and incomplete, then a larger fraction of individuals will have developed symptoms by the time they are approached for testing, and a smaller proportion of those tested will be symptom-free. Reports of silent infections at the time of testing are also likely impacted by epidemic trajectory largely due to the predominance of recent infections in samples taken during



the growth phase, in contrast with a higher proportion of older infections in samples taken during the declining phase. Unbiased measures of asymptomaticity, on the other hand, should be consistent across similar demographic settings, regardless of contact tracing and epidemic trajectory.

Several gaps remain in our understanding of asymptomatic carriage of COVID-19. Particularly, it is unclear why certain infections remain asymptomatic while the majority develop clinical symptoms. Our results indicate that children have greater asymptomaticity compared to the elderly. We also found that cases with comorbidities have lower asymptomaticity compared with cases with no underlying medical conditions. Additionally, studies on long-term care facilities reported lower asymptomaticity compared to other study settings. Given that the risk of severe illness is high among the elderly, the age association identified by our study implies that absence of symptoms may correlate with the tendency of developing milder symptoms. Case severity in SARS-CoV-2 patients has been linked to a cytokine storm which occurs more frequently in elderly patients (415, 416). Genetic (417), environmental risk factors, sex-linked differences (418), and cross-reactive immunity (419) might also contribute, although no studies have unequivocally demonstrated their association with either symptom status or severity.

Higher representation of asymptomatic SARS-CoV-2 infections among younger people has grave implications for control policies in daycares, schools, and universities. Settings with close, extensive contact among large groups of younger individuals are particularly susceptible to superspreader events of COVID-19 which may go undetected if surveillance focuses on symptomatic cases. This close congregation of relatively large groups similarly explains why influenza, mumps, and measles often spread more rapidly in schools and college campuses than in the broader community (420–422). As schools and universities convene in the midst of the COVID-19 pandemic, campus outbreaks are increasingly reported (423). Although COVID-19 severity is lower among young people, campus transmission with a large undetected component could more easily bridge to the rest of the population, fueling local and regional resurgence.

Our meta-analyses are subject to limitations, many related to the unprecedented pace of clinical research since the emergence of COVID-19. First, we found considerable heterogeneity in the percentage of asymptomatic infections. Subgroup analysis revealed that studies with longer follow-up reported lower asymptomaticity. Second, all reports of asymptomatic cases are confounded by the subjective and shifting definition of symptoms. For instance, the list of clinical manifestations associated with COVID-19 has expanded since the initial definitions (424). These changing definitions impact the classification of infections as asymptomatic or silent, and the more limited suite of symptoms initially considered indications of COVID-19 could bias early studies toward higher percentages in these categories. Nonetheless, we found no statistically significant differences in asymptomatic percentage when we stratified studies based on publication date. Third, in the studies included in our meta-analysis, it is possible that early mild symptoms occurring before a positive PCR test might go unrecorded, biasing the studies toward higher asymptomaticity. Fourth, although we corrected for the bias introduced by inclusion of predominantly symptomatic index cases, our estimates are still likely affected by sample selection bias, as participation is expected to be highest among those experiencing symptoms (10). Additionally, factors such as socioeconomic position, occupation, ethnicity, place of residence, internet and technological access, and scientific and medical interest could have contributed to nonrandom enrollment (425). To evaluate the effect of these biases, we calculated the pooled asymptomatic percentage using 25 studies that reported screening of all individuals in the study setting. Asymptomaticity among this smaller subset of studies was 47.3% (95% CI: 34.0 to 61.0%), with CIs that overlap with our primary analysis but the point estimate is

higher than the base case CI. We therefore cannot rule out nonrandom sampling as a source of bias for estimation of the asymptomatic percentage.

In our meta-analysis, we excluded 225 studies that did not identify index cases. Additionally, 223 studies reported silent infections at the time of testing but were excluded from analysis of asymptomaticity for not reporting symptom assessment during follow-up for at least 7 d or for not specifying the duration of follow-up. Large-scale longitudinal surveys should prioritize the inclusion of these data to facilitate accurate estimation of the asymptomatic percentage. At minimum, such studies should report the number of index cases among their study participants, the clinical symptom status of individuals at the time of testing, the duration of symptom follow-up, and symptom status during the follow-up. Ideally, studies would additionally provide a full symptom profile both at time of testing and by the end of follow-up, to facilitate reclassification as case definitions are updated.

Estimating the extent of COVID-19 asymptomaticity is critical for calculating key epidemiological characteristics, quantifying the true prevalence of infection, and developing appropriate mitigation efforts. This meta-analysis also establishes a baseline for asymptomaticity, prior to widespread vaccination coverage. Amid concerns that vaccines may be less protective against infection than disease, widespread vaccination coverage may soon lead to a rise in the percentage of infections that present asymptotically. The high prevalence of silent infections even at baseline, coupled with their transmission potential, necessitates accelerated contact tracing, testing, and isolation of infectious individuals, as symptom-based surveillance alone is inadequate for control.

## Methods

**Definition of Silent, Asymptomatic, and Presymptomatic Infection.** We defined silent infections as laboratory-confirmed COVID-19 cases that did not exhibit any clinical symptoms, including fever, upper respiratory symptoms, pneumonia, fatigue, headache, myalgia, dehydration, or gastrointestinal dysfunction, at the time of testing. Asymptomatic infections include those that continued to exhibit no clinical symptoms during at least 7 d of follow-up after testing. Presymptomatic cases were those that developed clinical symptoms subsequent to initial testing. The presymptomatic stage begins with the start of infectiousness and ends with the onset of symptoms (426).

**Search Strategy and Selection Criteria.** We conducted a systematic review to identify studies reporting laboratory-confirmed COVID-19 cases without symptoms at the time of testing. Our search was inclusive of all studies that provided data regarding cases that were asymptomatic, presymptomatic, or both. We finalized systematic search criteria on May 1, 2020, and study collection was initiated by searching PubMed, EMBASE, Web of Science, and the World Health Organization Global Research Database on COVID-19 (427) weekly from inception through April 2, 2021, with no language restrictions. Our search terms included “SARS-CoV-2,” “novel coronavirus,” “coronavirus 2019,” “COVID-19,” “COVID 2019” AND “asymptomatic,” “no symptoms,” “presymptomatic,” “paucisymptomatic,” “sub-clinical,” “silent transmission,” “silent infection,” “without any symptoms,” and “without symptoms” (*SI Appendix, Table S1*). All studies of any design that included these terms, were published after January 1, 2020, and described the symptom status of COVID-19 cases were considered in the screening step. No changes were made to the search criteria after the study initiation on May 1, 2020. The study protocol is available in the Open Science Framework online public database, registration DOI: 10.17605/OSF.IO/ZCJ62.

All articles were double-screened (by P.S. and C.F.Z.) based on the title and abstract. Studies were excluded if they were 1) duplicate publications, 2) editorials, reviews, discussions, or opinion pieces, 3) ambiguous about the presence of silent infection, 4) modeling studies without primary data, 5) based on fewer than two cases, 6) not conducted in humans, or 7) retracted. All identified full-text articles were reviewed by P.S. and C.F.Z. For each full-text article, we manually searched references for additional relevant studies. Studies included in our meta-analysis either reported laboratory confirmations of COVID-19 at a single time point, providing a snapshot of disease prevalence in the study subjects, or reported longitudinal data over a period of follow-up.

Risk of bias was assessed independently by two authors, and consensus was achieved through discussion. We adapted the ROBINS-I checklist (428) to include seven items: 1) enrollment of all patients satisfying the criteria for

inclusion, 2) enrollment of cases regardless of symptom status, 3) confirmation of cases using RT-PCR, 4) symptoms monitored by clinicians rather than self-reporting, 5) symptom assessment at the end of the follow-up period, 6) symptom follow-up duration of at least 7 d, and 7) loss to follow-up less than 5%.

**Data Analysis.** We conducted a meta-analysis using the studies identified through our systematic review to determine the prevalence of those truly asymptomatic among infected individuals. To delineate true asymptomaticity from the combination of asymptomatic and presymptomatic infections, we pursued two complementary analyses: 1) a single-step analysis based on reports of those who were asymptomatic at the end of a follow-up period and 2) a two-step analysis first evaluating the percentage of infections without symptoms at the time of testing and then assessing asymptomaticity by subtracting those that progressed to develop symptoms. In the single-step analysis, we calculated asymptomaticity as the percentage of confirmed COVID-19 cases that continued to exhibit no clinical symptoms for at least 7 d after testing, whether or not symptom status was reported specifically at the time of testing. In the two-step analysis, we focused on a subset of studies that distinguished asymptomatic cases from those that were presymptomatic by reporting symptoms at time of testing as well as conducting follow-up of symptoms for at least 7 d after testing. In both analyses, we removed index case(s) from the denominator of our calculations to minimize representational bias that would result in overestimation of symptomaticity. As a sensitivity analysis, we repeated our calculations including index cases. For studies that did not follow a population screening design, we assumed that single infections without an epidemiological link were necessarily detected due to their symptoms. Therefore, we subset the calculations to include only those infections which were part of a cluster.

To calculate pooled estimates, study outcomes were logit transformed, each study was assigned a weight using the inverse variance method (429), the DerSimonian–Laird estimator was applied to evaluate between-study variance (430), and the Clopper–Pearson method was used to determine CIs (431). Given heterogeneity in asymptomatic percentages estimated across studies, we used a random-effects meta-analysis model, applying the Hartung and Knapp (432) method to adjust test statistics and CIs for the random effect. We evaluated small-study effects visually with a contour-enhanced funnel plot and statistically with Egger’s test (433). As a sensitivity analysis, we excluded studies with a small sample size (<10 infections), and we considered whether their removal impacted the pooling of results.

We conducted subgroup analysis stratified by age class, study design (population screening or not), publication date, duration of symptom follow-up, geographic location, and setting (community, healthcare facility, household, long-term care facilities, and other which encompassed schools, ships, conference, call centers, labor and delivery units, homeless shelters, and detention facilities). For subgroup analysis involving age class, we selected studies where all confirmed cases were either children (0 y to 18 y), adults (19 y to 59 y) or the elderly ( $\geq 60$  y). We evaluated sex-based differences in asymptomaticity by selecting only those studies that stratified asymptomatic cases with respect to sex. For each of these studies we calculated the IRR, which was the ratio of the asymptomatic percentage in males relative to that in females. A similar analysis was performed to evaluate the asymptomaticity in cases with comorbidity relative to those without.

We next evaluated the impact of sample selection bias arising from higher participation among those experiencing symptoms in studies with voluntary participation. In this analysis, we calculated the pooled asymptomaticity after restricting to a smaller subset of studies that performed screening of every individual at the study setting. To avoid age-dependent bias in asymptomaticity, we removed studies where all participants belonged to a single age class (children, adults, or the elderly). Out of the 25 studies selected, 7 studies performed screening of all close household contacts (64, 80, 83, 103, 117, 131), 3 screened all flight passengers (28, 84, 91), and 2 screened all members of a tourist/pilgrim group (94, 129). Others were based on screening of healthcare workers (25, 110), inpatients admitted for non-COVID-19 reasons (19, 50, 59, 72, 108, 113), rigorously community screening (82, 166), travelers (18, 180), and those associated with a detention facility (92).

The meta-analysis and subgroup analyses were conducted using the `metaprop` function from the R package `meta`. Meta-analyses of sex-based and comorbidity-based differences in asymptomaticity were performed using the `rma` function from the R package `metafor`.

**Data Availability.** All study data are included in the article and *SI Appendix*.

**ACKNOWLEDGMENTS.** A.P.G. acknowledges funding from NSF Expeditions Grant 1918784, NIH Grant 1R01AI151176-01, NSF Grant RAPID-2027755, and the Notsew Orm Sands Foundation. S.M.M. was supported by the Canadian Institutes of Health Research [OV4 – 170643, COVID-19 Rapid Research] and Natural Sciences and Engineering Research Council of Canada Emerging Infectious Diseases Modelling Initiative (NSERC EIDM), Mathematics for Public Health (MfPH) grant.

- Hao et al., Reconstruction of the full transmission dynamics of COVID-19 in Wuhan. *Nature* **584**, 420–424 (2020).
- Dong et al., Epidemiology of COVID-19 Among Children in China. *Pediatrics* **145**, e20200702 (2020).
- Heneghan, J. Brassey, T. Jefferson, COVID-19: What proportion are asymptomatic? <https://www.cebm.net/covid-19/covid-19-what-proportion-are-asymptomatic/>. Accessed 29 May 2020.
- Day, Covid-19: Four fifths of cases are asymptomatic, China figures indicate. *BMJ* **369**, m1375 (2020).
- Mayor, Covid-19: Nine in 10 pregnant women with infection when admitted for delivery are asymptomatic, small study finds. *BMJ* **369**, m1485 (2020).
- Centers for Disease Control and Prevention, COVID-19 Pandemic Planning Scenarios. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios-archived/planning-scenarios-2020-05-20.pdf>. Accessed 18 August 2020.
- He, Y., Guo, R., Mao, J., Zhang, Proportion of asymptomatic coronavirus disease 2019 (COVID-19): A systematic review and meta-analysis. *J. Med. Virol.* **93**, 820–830 (2021).
- O. Byambasuren et al., Estimating the extent of asymptomatic COVID-19 and its potential for community transmission: Systematic review and meta-analysis. *J. Assoc. Med. Microbiol. Infect. Dis. Can.*, **5**, 223–234 (2020).
- D. Buitrago-Garcia et al., Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: A living systematic review and meta-analysis. *PLoS Med.* **17**, e1003346 (2020).
- D. F. Gudbjartsson et al., Spread of SARS-CoV-2 in the Icelandic population. *N. Engl. J. Med.* **382**, 2302–2315 (2020).
- A. Kimball et al., Asymptomatic and presymptomatic SARS-CoV-2 infections in residents of a long-term care skilled nursing facility - King County, Washington, March 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 377–381 (2020).
- M. M. Arons et al., Presymptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. *N. Engl. J. Med.* **382**, 2081–2090 (2020).
- S. Hoehl et al., Evidence of SARS-CoV-2 infection in returning travelers from Wuhan, China. *N. Engl. J. Med.* **382**, 1278–1280 (2020).
- Q. M. L. Thi et al., Severe acute respiratory syndrome coronavirus 2 shedding by travelers, Vietnam, 2020. *Emerging Infect. Dis. J.* **26**, 1624–1626 (2020).
- R. Zhou et al., Viral dynamics in asymptomatic patients with COVID-19. *Int. J. Infect. Dis.* **96**, 288–290 (2020).
- S. M. Moghadas et al., The implications of silent transmission for the control of COVID-19 outbreaks. *Proc. Natl. Acad. Sci. U.S.A.* **117**, 17513–17515 (2020).
- S. Almazzeedi et al., Characteristics, risk factors and outcomes among the first consecutive 1096 patients diagnosed with COVID-19 in Kuwait. *EClinicalMedicine* **24**, 100448 (2020).
- M. Al-Qatani et al., The prevalence of asymptomatic and symptomatic COVID-19 in a cohort of quarantined subjects. *Int. J. Infect. Dis.* **102**, 285–288 (2021).
- H. O. Al-Shamsi, E. A. Coomes, K. Aldhaheri, S. Alrawi, Serial screening for COVID-19 in asymptomatic patients receiving anticancer therapy in the United Arab Emirates. *JAMA Oncol.* **7**, 129–131 (2021).
- D. Alsharrah et al., Clinical characteristics of pediatric SARS-CoV-2 infection and coronavirus disease 2019 (COVID-19) in Kuwait. *J. Med. Virol.* **93**, 3246–3250 (2021).
- G. R. Alvarado et al., Symptom characterization and outcomes of sailors in isolation after a COVID-19 outbreak on a US aircraft carrier. *JAMA Netw. Open* **3**, e2020981 (2020).
- P. An, P. Song, Y. Wang, B. Liu, Asymptomatic patients with novel coronavirus disease (COVID-19). *Balkan Med. J.* **37**, 229–230 (2020).
- P. Anand et al., Clinical profile, viral load, management and outcome of neonates born to COVID 19 positive mothers: A tertiary care centre experience from India. *Eur. J. Pediatr.* **180**, 547–559 (2021).
- Y. Arima et al., Severe acute respiratory syndrome coronavirus 2 infection among returnees to Japan from Wuhan, China, 2020. *Emerg. Infect. Dis.* **26**, 1596–1600 (2020).
- M. S. Alshahrani et al., Prevalence of the SARS-CoV-2 infection among post-quarantine healthcare workers. *J. Multidiscip. Healthc.* **13**, 1927–1936 (2020).
- A. Aslam et al., SARS CoV-2 surveillance and exposure in the perioperative setting with universal testing and personal protective equipment (PPE) policies. *Clin. Infect. Dis.*, **10.1093/cid/ciaa1607** (2020).
- E. Atalla et al., Clinical presentation, course, and risk factors associated with mortality in a severe outbreak of COVID-19 in Rhode Island, USA, April-June 2020. *Pathogens* **10**, 8 (2020).
- S. H. Bae et al., Asymptomatic transmission of SARS-CoV-2 on evacuation flight. *Emerg. Infect. Dis.* **26**, 2705–2708 (2020).
- W. R. Bender, A. Hirshberg, P. Coutifaris, A. L. Acker, S. K. Srinivas, Universal testing for severe acute respiratory syndrome coronavirus 2 in 2 Philadelphia hospitals: Carrier prevalence and symptom development over 2 weeks. *Am. J. Obstet. Gynecol. MFM* **2**, 100226 (2020).

30. H. Blain *et al.*, Efficacy of a test-retest strategy in residents and health care personnel of a nursing home facing a COVID-19 outbreak. *J. Am. Med. Dir. Assoc.* **21**, 933–936 (2020).
31. H. Blain *et al.*, Atypical clinical presentation of COVID-19 infection in residents of a long-term care facility. *Eur. Geriatr. Med.* **11**, 1085–1088 (2020).
32. J. F.-W. Chan *et al.*, A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: A study of a family cluster. *Lancet* **395**, 514–523 (2020).
33. L. Chang, L. Zhao, H. Gong, L. Wang, L. Wang, Severe acute respiratory syndrome coronavirus 2 RNA detected in blood donations. *Emerg. Infect. Dis.* **26**, 1631–1633 (2020).
34. N. Van Vinh Chau *et al.*, The natural history and transmission potential of asymptomatic SARS-CoV-2 infection. *bioRxiv* [Preprint] (2020). <https://doi.org/10.1101/2020.04.27.20082347>.
35. M. Chehrassan *et al.*, Management of spine trauma in COVID-19 pandemic: A preliminary report. *Arch. Bone Jt. Surg.* **8**, 270–276 (2020).
36. L. Coppeta *et al.*, Contact screening for healthcare workers exposed to patients with COVID-19. *Int. J. Environ. Res. Public Health* **17**, 9082 (2020).
37. M. A. Corcoran *et al.*, Prolonged persistence of PCR-detectable virus during an outbreak of SARS-CoV-2 in an inpatient geriatric psychiatry unit in King County, Washington. *Am. J. Infect. Control* **49**, 293–298 (2021).
38. S. Cosma *et al.*, The “scar” of a pandemic: Cumulative incidence of COVID-19 during the first trimester of pregnancy. *J. Med. Virol.* **93**, 537–540 (2021).
39. K. Danis *et al.*, Cluster of coronavirus disease 2019 (COVID-19) in the French Alps, February 2020. *Clin. Infect. Dis.* **71**, 825–832 (2020).
40. A. V. Dora *et al.*, Universal and serial laboratory testing for SARS-CoV-2 at a long-term care skilled nursing facility for Veterans - Los Angeles, California, 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 651–655 (2020).
41. W. Du *et al.*, Clinical characteristics of COVID-19 in children compared with adults in Shandong Province, China. *Infection* **48**, 445–452 (2020).
42. W. Du *et al.*, Persistence of SARS-CoV-2 virus RNA in feces: A case series of children. *J. Infect. Public Health* **13**, 926–931 (2020).
43. E. Eythorsson *et al.*, Clinical spectrum of coronavirus disease 2019 in Iceland: Population based cohort study. *BMJ* **371**, m4529 (2020).
44. F. M. Fusco *et al.*, COVID-19 among healthcare workers in a specialist infectious diseases setting in Naples, Southern Italy: Results of a cross-sectional surveillance study. *J. Hosp. Infect.* **105**, 596–600 (2020).
45. Y. Gao *et al.*, A cluster of the corona virus disease 2019 caused by incubation period transmission in Wuxi, China. *J. Infect.* **80**, 666–670 (2020).
46. A. Gonfiotti *et al.*, Clinical courses and outcomes of five patients with primary lung cancer surgically treated while affected by severe acute respiratory syndrome coronavirus 2. *Eur. J. Cardiothorac. Surg.* **58**, 598–604 (2020).
47. C. G. Grijalva *et al.*, Transmission of SARS-CoV-2 infections in households - Tennessee and Wisconsin, April-September 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 1631–1634 (2020).
48. N. Gupta *et al.*, Transmission of SARS-CoV-2 infection by children: A study of contacts of index paediatric cases in India. *J. Trop. Pediatr.* **67**, fmaa081 (2021).
49. M. S. Han *et al.*, Clinical characteristics and viral RNA detection in children with coronavirus disease 2019 in the Republic of Korea. *JAMA Pediatr.* **175**, 73–80 (2021).
50. S. Harada, *et al.*, Control of a nosocomial outbreak of COVID-19 in a university hospital. *Open Forum Infect. Dis.* **7**, ofaa512 (2020).
51. I. Hasanoglu *et al.*, Higher viral loads in asymptomatic COVID-19 patients might be the invisible part of the iceberg. *Infection* **49**, 117–126 (2021).
52. N. Hcini *et al.*, Maternal, fetal and neonatal outcomes of large series of SARS-CoV-2 positive pregnancies in peripartum period: A single-center prospective comparative study. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **257**, 11–18 (2021).
53. X. He *et al.*, Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nat. Med.* **26**, 672–675 (2020).
54. C. A. Hogan *et al.*, Large-scale testing of asymptomatic healthcare personnel for severe acute respiratory syndrome coronavirus 2. *Emerg. Infect. Dis.* **27**, 250–254 (2021).
55. Z. Hu *et al.*, Clinical characteristics of 24 asymptomatic infections with COVID-19 screened among close contacts in Nanjing, China. *Sci. China Life Sci.* **63**, 706–711 (2020).
56. C.-Z. Hua *et al.*, Epidemiological features and viral shedding in children with SARS-CoV-2 infection. *J. Med. Virol.* **92**, 2804–2812 (2020).
57. L. Huang *et al.*, Initial CT imaging characters of an imported family cluster of COVID-19. *Clin. Imaging* **65**, 78–81 (2020).
58. K. Huang *et al.*, A retrospective analysis of the epidemiology, clinical manifestations, and imaging characteristics of familial cluster-onset COVID-19. *Ann. Transl. Med.* **8**, 747 (2020).
59. Q. Huang *et al.*, Asymptomatic COVID-19 infection in patients with cancer at a cancer-specialized hospital in Wuhan, China - Preliminary results. *Eur. Rev. Med. Pharmacol. Sci.* **24**, 9760–9764 (2020).
60. I. F.-N. Hung *et al.*, SARS-CoV-2 shedding and seroconversion among passengers quarantined after disembarking a cruise ship: A case series. *Lancet Infect. Dis.* **20**, 1051–1060 (2020).
61. O. R. Ibrahim *et al.*, COVID-19 in children: A case series from Nigeria. *Pan Afr. Med. J.* **35**, 53 (2020).
62. T. H. Jeong *et al.*, Real asymptomatic SARS-CoV-2 infection might be rare: Importance of careful interviews and follow-up. *J. Korean Med. Sci.* **35**, e333 (2020).
63. X.-L. Jiang *et al.*, Transmission potential of asymptomatic and paucisymptomatic severe acute respiratory syndrome coronavirus 2 infections: A 3-family cluster study in China. *J. Infect. Dis.* **221**, 1948–1952 (2020).
64. Y. Jiang *et al.*, Characteristics of a family cluster of Severe Acute Respiratory Syndrome Coronavirus 2 in Henan, China. *J. Infect.* **81**, e46–e48 (2020).
65. H. Jiang *et al.*, Clinical features, laboratory findings and persistence of virus in 10 children with coronavirus disease 2019 (COVID-19). *Biomed. J.* **44**, 94–100 (2021).
66. N. K. Jones *et al.*, Effective control of SARS-CoV-2 transmission between healthcare workers during a period of diminished community prevalence of COVID-19. *eLife* **9**, e59391 (2020).
67. R. K. Joshi, R. K. Ray, S. Adhya, V. P. S. Chauhan, S. Pani, Spread of COVID-19 by asymptomatic cases: Evidence from military quarantine facilities. *BMJ Mil. Health* **167**, 217–218 (2021).
68. J. Jung *et al.*, Investigation of a nosocomial outbreak of coronavirus disease 2019 in a paediatric ward in South Korea: Successful control by early detection and extensive contact tracing with testing. *Clin. Microbiol. Infect.* **26**, 1574–1575 (2020).
69. Y. Kang *et al.*, A retrospective view of pediatric cases infected with SARS-CoV-2 of a middle-sized city in mainland China. *Medicine (Baltimore)* **99**, e23797 (2020).
70. L. Karout *et al.*, COVID-19 prevalence, risk perceptions, and preventive behavior in asymptomatic Latino population: A cross-sectional study. *Cureus* **12**, e10707 (2020).
71. S. P. Kennelly *et al.*, Asymptomatic carriage rates and case fatality of SARS-CoV-2 infection in residents and staff in Irish nursing homes. *Age Ageing* **50**, 49–54 (2021).
72. S. C. Kirshblum *et al.*, Screening testing for SARS-CoV-2 upon admission to rehabilitation hospitals in a high COVID-19 prevalence community. *PM R.* **12**, 1009–1014 (2020).
73. B. R. Kittang *et al.*, Outbreak of COVID-19 at three nursing homes in Bergen. *Tidsskr. Nor. Laegeforen.*, 10.4045/tidsskr.20.0405 (2020).
74. S. Kutsuna, *et al.*, SARS-CoV-2 screening test for Japanese returnees from Wuhan, China, January 2020. *Open Forum Infect. Dis.* **7**, ofaa243(2020).
75. S. N. Ladhani *et al.*, Investigation of SARS-CoV-2 outbreaks in six care homes in London, April 2020. *EClinicalMedicine* **26**, 100533 (2020).
76. J. Y. Lee *et al.*, Epidemiological and clinical characteristics of coronavirus disease 2019 in Daegu, South Korea. *Int. J. Infect. Dis.* **98**, 462–466 (2020).
77. W. Li *et al.*, Virus shedding dynamics in asymptomatic and mildly symptomatic patients infected with SARS-CoV-2. *Clin. Microbiol. Infect.* **26**, 1556.e1–1556.e6 (2020).
78. J. Li *et al.*, Comparative analysis of symptomatic and asymptomatic SARS-CoV-2 infection in children. *Ann. Acad. Med. Singap.* **49**, 530–537 (2020).
79. J. Liao *et al.*, Epidemiological and clinical characteristics of COVID-19 in adolescents and young adults. *Innovation (N Y)* **1**, 100001 (2020).
80. Z. Liu *et al.*, Investigation of a family cluster outbreak of COVID-19 indicates the necessity of CT screening for asymptomatic family members in close contact with confirmed patients. *J. Thorac. Dis.* **12**, 3673–3681 (2020).
81. A. Lombardi *et al.*, Characteristics of 1573 healthcare workers who underwent nasopharyngeal swab testing for SARS-CoV-2 in Milan, Lombardy, Italy. *Clin. Microbiol. Infect.* **26**, 1413.e9–1413.e13 (2020).
82. L. Luo *et al.*, Contact settings and risk for transmission in 3410 close contacts of patients with COVID-19 in Guangzhou, China: A prospective cohort study. *Ann. Intern. Med.* **173**, 879–887 (2020).
83. Y. Luo *et al.*, Asymptomatic SARS-CoV-2 infection in household contacts of a healthcare provider, Wuhan, China. *Emerg. Infect. Dis.* **26**, 1930–1933 (2020).
84. T. Lytras *et al.*, High prevalence of SARS-CoV-2 infection in repatriation flights to Greece from three European countries. *J. Travel Med.* **27**, taaa054 (2020).
85. Y. Ma *et al.*, Characteristics of asymptomatic patients with SARS-CoV-2 infection in Jinan, China. *Microbes Infect.* **22**, 212–217 (2020).
86. K. Macartney *et al.*, Transmission of SARS-CoV-2 in Australian educational settings: A prospective cohort study. *Lancet Child Adolesc. Health* **4**, 807–816 (2020).
87. M. L. Martinez-Fierro *et al.*, The role of close contacts of COVID-19 patients in the SARS-CoV-2 transmission: An emphasis on the percentage of nonevaluated positivity in Mexico. *Am. J. Infect. Control* **49**, 15–20 (2021).
88. M. A. Merza, A. A. Haleem Al Mezori, H. M. Mohammed, D. M. Abdulah, COVID-19 outbreak in Iraqi Kurdistan: The first report characterizing epidemiological, clinical, laboratory, and radiological findings of the disease. *Diabetes Metab. Syndr.* **14**, 547–554 (2020).
89. K. J. Meyers *et al.*, A cross-sectional community-based observational study of asymptomatic SARS-CoV-2 prevalence in the greater Indianapolis area. *J. Med. Virol.* **92**, 2874–2879 (2020).
90. R. Migisha *et al.*, Early cases of SARS-CoV-2 infection in Uganda: Epidemiology and lessons learned from risk-based testing approaches - March-April 2020. *Global. Health* **16**, 114 (2020).
91. O.-T. Ng *et al.*, SARS-CoV-2 infection among travelers returning from Wuhan, China. *N. Engl. J. Med.* **382**, 1476–1478 (2020).
92. H. Njuguna *et al.*, Serial laboratory testing for SARS-CoV-2 infection among incarcerated and detained persons in a correctional and detention facility - Louisiana, April-May 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 836–840 (2020).
93. S. Y. Park *et al.*, Coronavirus disease outbreak in call center, South Korea. *Emerg. Infect. Dis.* **26**, 1666–1670 (2020).
94. J. H. Park, J. H. Jang, K. Lee, S. J. Yoo, H. Shin, COVID-19 outbreak and presymptomatic transmission in pilgrim travelers who returned to Korea from Israel. *J. Korean Med. Sci.* **35**, e424 (2020).
95. V. C. Passarelli *et al.*, Asymptomatic SARS-CoV-2 infections in hospitalized patients. *Infect. Control Hosp. Epidemiol.*, 10.1017/ice.2020.441 (2020).
96. V. C. Passarelli *et al.*, Asymptomatic COVID-19 in hospital visitors: The underestimated potential of viral shedding. *Int. J. Infect. Dis.* **102**, 412–414 (2021).
97. M. C. Patel *et al.*, Asymptomatic SARS-CoV-2 infection and COVID-19 mortality during an outbreak investigation in a skilled nursing facility. *Clin. Infect. Dis.* **71**, 2920–2926 (2020).
98. A. Pavli *et al.*, A cluster of COVID-19 in pilgrims to Israel. *J. Travel Med.* **27**, taaa102 (2020).

99. P. Q. Thai, et al., The first 100 days of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) control in Vietnam. *Clin. Infect. Dis.* **72**, e334–e342 (2021).
100. M. M. Plucinski et al., COVID-19 in Americans aboard the Diamond Princess cruise ship. *Clin. Infect. Dis.* **72**, e448–e457 (2021).
101. W. A. Pongpirul et al., Clinical characteristics of patients hospitalized with coronavirus disease, Thailand. *Emerg. Infect. Dis.* **26**, 1580–1585 (2020).
102. C. A. J. Puyllaert, et al., Yield of screening for COVID-19 in asymptomatic patients prior to elective or emergency surgery using chest CT and RT-PCR (SCOUT): Multi-center study. *Ann. Surg.* **272**, 919–924 (2020).
103. G. Qian et al., COVID-19 transmission within a family cluster by presymptomatic carriers in China. *Clin. Infect. Dis.* **71**, 861–862 (2020).
104. W. Qin et al., The descriptive epidemiology of coronavirus disease 2019 during the epidemic period in Lu'an, China: Achieving limited community transmission using proactive response strategies. *Epidemiol. Infect.* **148**, e132 (2020).
105. C. Qiu et al., Transmission and clinical characteristics of coronavirus disease 2019 in 104 outside-Wuhan patients, China. *J. Med. Virol.* **92**, 2027–2035 (2020).
106. M. Ralli, A. Morrone, A. Arcangeli, L. Ercoli, Asymptomatic patients as a source of transmission of COVID-19 in homeless shelters. *Int. J. Infect. Dis.* **103**, 243–245 (2021).
107. M. L. Reale et al., SARS-CoV-2 infection in cancer patients: A picture of an Italian Onco-Covid unit. *Front. Oncol.* **10**, 1722 (2020).
108. A. Rincón et al., The keys to control a COVID-19 outbreak in a haemodialysis unit. *Clin. Kidney J.* **13**, 542–549 (2020).
109. F. Rivera et al., Prevalence of SARS-CoV-2 asymptomatic infections in two large academic health systems in Wisconsin. *Clin. Infect. Dis.*, 10.1093/cid/ciaa1225 (2020).
110. L. Rivett et al., Screening of healthcare workers for SARS-CoV-2 highlights the role of asymptomatic carriage in COVID-19 transmission. *eLife* **9**, e58728 (2020).
111. K. Saeed et al., Investigations, actions and learning from an outbreak of SARS-CoV-2 infection among healthcare workers in the United Kingdom. *J. Infect. Prev.* **22**, 156–161 (2021).
112. R. R. Ossami Saidy, B. Globke, J. Pratschke, W. Schoening, D. Eurich, Successful implementation of preventive measures leads to low relevance of SARS-CoV-2 in liver transplant patients: Observations from a German outpatient department. *Transpl. Infect. Dis.* **22**, e13363 (2020).
113. V. Schwierzeck et al., First reported nosocomial outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in a pediatric dialysis unit. *Clin. Infect. Dis.* **72**, 265–270 (2021).
114. K. C. See et al., COVID-19: Four paediatric cases in Malaysia. *Int. J. Infect. Dis.* **94**, 125–127 (2020).
115. A. P. Senanayake et al., Features of Covid-19 patients detected during community screening: A study from a rural hospital in Sri Lanka. *Ceylon Med. J.* **65**, 67 (2020).
116. V. Setiawaty et al., The identification of first COVID-19 cluster in Indonesia. *Am. J. Trop. Med. Hyg.* **103**, 2339–2342 (2020).
117. J. Shen et al., Characteristics of nosocomial infections in children screened for SARS-CoV-2 infection in China. *Med. Sci. Monit.* **26**, e928835 (2020).
118. S. M. Shi et al., Risk factors, presentation, and course of coronavirus disease 2019 in a large, academic long-term care facility. *J. Am. Med. Dir. Assoc.* **21**, 1378–1383.e1 (2020).
119. H. Son et al., Epidemiological characteristics of and containment measures for COVID-19 in Busan, Korea. *Epidemiol. Health* **42**, e2020035 (2020).
120. W. Song et al., Clinical features of pediatric patients with coronavirus disease (COVID-19). *J. Clin. Virol.* **127**, 104377 (2020).
121. A. Soysal et al., Comparison of clinical and laboratory features and treatment options of 237 symptomatic and asymptomatic children infected with SARS-CoV-2 in the early phase of the COVID-19 pandemic in Turkey. *Jpn. J. Infect. Dis.* **74**, 273–279 (2021).
122. A. D. Stock et al., COVID-19 infection among healthcare workers: Serological findings supporting routine testing. *Front. Med. (Lausanne)* **7**, 471 (2020).
123. H. J. Suh et al., Clinical characteristics of COVID-19: Clinical dynamics of mild severe acute respiratory syndrome coronavirus 2 infection detected by early active surveillance. *J. Korean Med. Sci.* **35**, e297 (2020).
124. S. Szegedi, W. Huf, K. Miháľt, P. V. Vécsei-Marlovits, Prevalence of SARS-CoV-2 infection in patients presenting for intravitreal injection. *Spektrum Der Augenheilkunde* **35** (70), 74 (2020).
125. S. Tabata et al., Clinical characteristics of COVID-19 in 104 people with SARS-CoV-2 infection on the Diamond Princess cruise ship: A retrospective analysis. *Lancet Infect. Dis.* **20**, 1043–1050 (2020).
126. Y.-P. Tan et al., Epidemiologic and clinical characteristics of 10 children with coronavirus disease 2019 in Changsha, China. *J. Clin. Virol.* **127**, 104353 (2020).
127. J. Taylor et al., Serial testing for SARS-CoV-2 and virus whole genome sequencing inform infection risk at two skilled nursing facilities with COVID-19 outbreaks - Minnesota, April-June 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 1288–1295 (2020).
128. H. Temel et al., Evaluation of the clinical features of 81 patients with COVID-19: An unpredictable disease in children. *J. Pediatr. Infect. Dis.* **16**, 47–52 (2021).
129. J. W. Vivian Thangaraj et al., A cluster of SARS-CoV-2 infection among Italian tourists visiting India, March 2020. *Indian J. Med. Res.* **151**, 438–443 (2020).
130. S. L. Thiel et al., Flattening the curve in 52 days: Characterisation of the COVID-19 pandemic in the Principality of Liechtenstein - An observational study. *Swiss Med. Wkly.* **150**, w20361 (2020).
131. Z.-D. Tong et al., Potential presymptomatic transmission of SARS-CoV-2, Zhejiang Province, China, 2020. *Emerg. Infect. Dis.* **26**, 1052–1054 (2020).
132. T.-P. Tsou et al., Epidemiology of the first 100 cases of COVID-19 in Taiwan and its implications on outbreak control. *J. Formos. Med. Assoc.* **119**, 1601–1607 (2020).
133. A. Wadhwa et al., Identification of presymptomatic and asymptomatic cases using cohort-based testing approaches at a large correctional facility - Chicago, Illinois, USA, May 2020. *Clin. Infect. Dis.* **72**, e128–e135 (2021).
134. Y. Wang et al., Characterization of an asymptomatic cohort of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infected individuals outside of Wuhan, China. *Clin. Infect. Dis.* **71**, 2132–2138 (2020).
135. G. Wang et al., Infection, screening, and psychological stress of health care workers with COVID-19 in a non-frontline clinical department. *Disaster Med. Public Health Prep.*, 10.1017/dmp.2020.428 (2020).
136. Y. M. Wi et al., Response system for and epidemiological features of COVID-19 in Gyeongsangnam-do Province in South Korea. *Clin. Infect. Dis.* **72**, 661–667 (2021).
137. J. Wong et al., High proportion of asymptomatic and presymptomatic COVID-19 infections in air passengers to Brunei. *J. Travel Med.* **27**, taaa066 (2020).
138. J. Wong, S. A. Jamaludin, M. F. Alikhan, L. Chaw, Asymptomatic transmission of SARS-CoV-2 and implications for mass gatherings. *Influenza Other Respir. Viruses* **14**, 596–598 (2020).
139. J. Wu et al., Household transmission of SARS-CoV-2, Zhuhai, China, 2020. *Clin. Infect. Dis.* **71**, 2099–2108 (2020).
140. S. Wu et al., Understanding factors influencing the length of hospital stay among non-severe COVID-19 patients: A retrospective cohort study in a Fangcang shelter hospital. *PLoS One* **15**, e0240959 (2020).
141. A. Xi et al., Epidemiological and clinical characteristics of discharged patients infected with SARS-CoV-2 on the Qinghai Plateau. *J. Med. Virol.* **92**, 2528–2535 (2020).
142. F. Xiong et al., Clinical characteristics of and medical interventions for COVID-19 in hemodialysis patients in Wuhan, China. *J. Am. Soc. Nephrol.* **31**, 1387–1397 (2020).
143. M.-C. Yang et al., A three-generation family cluster with COVID-19 infection: Should quarantine be prolonged? *Public Health* **185**, 31–33 (2020).
144. R. Yang, X. Gui, Y. Xiong, Comparison of clinical characteristics of patients with asymptomatic vs symptomatic coronavirus disease 2019 in Wuhan, China. *JAMA Netw. Open* **3**, e2010182 (2020).
145. N. Yang et al., In-flight transmission cluster of COVID-19: A retrospective case series. *Infect. Dis. (Lond.)* **52**, 891–901 (2020).
146. K. Yau et al., COVID-19 outbreak in an urban hemodialysis unit. *Am. J. Kidney Dis.* **76**, 690–695.e1 (2020).
147. F. Ye et al., Delivery of infection from asymptomatic carriers of COVID-19 in a familial cluster. *Int. J. Infect. Dis.* **94**, 133–138 (2020).
148. J. Zhang, S. Tian, J. Lou, Y. Chen, Familial cluster of COVID-19 infection from an asymptomatic. *Crit. Care* **24**, 119 (2020).
149. W. Zhang et al., Secondary transmission of coronavirus disease from presymptomatic persons, China. *Emerg. Infect. Dis.* **26**, 1924–1926 (2020).
150. H.-J. Zhang et al., Asymptomatic and symptomatic SARS-CoV-2 infections in close contacts of COVID-19 patients: A seroepidemiological study. *Clin. Infect. Dis.*, 10.1093/cid/ciaa771 (2020).
151. H. Zhang, R. Chen, J. Chen, B. Chen, COVID-19 transmission within a family cluster in Yancheng, China. *Front. Med. (Lausanne)* **7**, 387 (2020).
152. H. Zhang et al., A multi-family cluster of COVID-19 associated with asymptomatic and pre-symptomatic transmission in Jixi City, Heilongjiang, China, 2020. *Emerg. Microbes Infect.* **9**, 2509–2514 (2020).
153. D. Zhao et al., Asymptomatic infection by SARS-CoV-2 in healthcare workers: A study in a large teaching hospital in Wuhan, China. *Int. J. Infect. Dis.* **99**, 219–225 (2020).
154. X. Zheng et al., Asymptomatic patients and asymptomatic phases of Coronavirus Disease 2019 (COVID-19): A population-based surveillance study. *Natl. Sci. Rev.* **7**, 1527–1539 (2020).
155. C. Olmos et al., SARS-CoV-2 infection in asymptomatic healthcare workers at a clinic in Chile. *PLoS One* **16**, e0245913 (2021).
156. S. C. Roberts et al., Mass severe acute respiratory coronavirus 2 (SARS-CoV-2) testing of asymptomatic healthcare personnel - ERRATUM. *Infect. Control Hosp. Epidemiol.* **42**, 625–626 (2021).
157. J. Tan-Loh, B. M. K. Cheong, A descriptive analysis of clinical characteristics of COVID-19 among healthcare workers in a district specialist hospital. *Med. J. Malaysia* **76**, 24–28 (2021).
158. M. Goldenfeld et al., Characteristics of clinically asymptomatic patients with SARS-CoV-2 infections, case series. *Prehosp. Disaster Med.* **36**, 125–128 (2021).
159. R. Green et al., COVID-19 testing in outbreak-free care homes: What are the public health benefits? *J. Hosp. Infect.* **111**, 89–95 (2021).
160. M. Krone, A. Noffz, E. Richter, U. Vogel, M. Schwab, Control of a COVID-19 outbreak in a nursing home by general screening and cohort isolation in Germany, March to May 2020. *Euro Surveill.* **26**, 2001365 (2021).
161. S. Krüger et al., Performance and feasibility of universal PCR admission screening for SARS-CoV-2 in a German tertiary care hospital. *J. Med. Virol.* **93**, 2890–2898 (2021).
162. R. J. Reid, L. Rosella, N. Milijasevic, L. N. Small, Mass testing for asymptomatic COVID-19 infection among health care workers at a large Canadian hospital. *J. Assoc. Med. Microbiol. Infect. Dis. Can.* **5**, 245–250 (2020).
163. A. Choudhury et al., COVID-19 in liver transplant recipients—A series with successful recovery. *J. Clin. Transl. Hepatol.* **8**, 467–473 (2020).
164. K. J. Meyers et al., Follow-up of SARS-CoV-2 positive subgroup from the asymptomatic novel CORonavirus iNfection study. *J. Med. Virol.* **93**, 2925–2931 (2021).
165. M. Cruz-Lemini et al., Obstetric outcomes of SARS-CoV-2 infection in asymptomatic pregnant women. *Viruses* **13**, 112 (2021).
166. H. E. Ab raha et al., Clinical features and risk factors associated with morbidity and mortality among patients with COVID-19 in northern Ethiopia. *Int. J. Infect. Dis.* **105**, 776–783 (2021).
167. K. J. Beiting et al., Management and outcomes of a COVID-19 outbreak in a nursing home with predominantly Black residents. *J. Am. Geriatr. Soc.* **69**, 1155–1165 (2021).
168. H. Blain et al., Atypical symptoms, SARS-CoV-2 test results and immunisation rates in 456 residents from eight nursing homes facing a COVID-19 outbreak. *Age Ageing* **50**, 641–648 (2021).



169. J. Chan *et al.*, COVID-19 in the New York City jail system: Epidemiology and health care response, March–April 2020. *Public Health Rep.* **136**, 375–383 (2021).
170. N. Gupta *et al.*, Clinical profile and outcomes of asymptomatic vs. symptomatic travellers diagnosed with COVID-19: An observational study from a coastal town in South India. *Drug Discov. Ther.* **15**, 1–8 (2021).
171. M. J. Gutman *et al.*, What was the prevalence of COVID-19 in asymptomatic patients undergoing orthopaedic surgery in one large United States City Mid-pandemic? *Clin. Orthop. Relat. Res.* **479**, 1691–1699 (2021).
172. N. Handal *et al.*, Comparison of SARS-CoV-2 infections in healthcare workers with high and low exposures to Covid-19 patients in a Norwegian University Hospital. *Infect. Dis. (Lond.)* **53**, 420–429 (2021).
173. S. Lamichhane, S. Gupta, G. Akinjobi, N. Ndubuka, Familial cluster of asymptomatic COVID-19 cases in a First Nation community in Northern Saskatchewan, Canada. *Can. Commun. Dis. Rep.* **47**, 94–96 (2021).
174. P. Liu *et al.*, Epidemiological and clinical features in patients with coronavirus disease 2019 outside of Wuhan, China: Special focus in asymptomatic patients. *PLoS Negl. Trop. Dis.* **15**, e0009248 (2021).
175. J. N. Malagón-Rojas, M. Mercado, C. P. Gómez-Rendón, SARS-CoV-2 and work-related transmission: Results of a prospective cohort of airport workers, 2020. *Rev. Bras. Med. Trab.* **18**, 371–380 (2021).
176. M. Marks *et al.*, Transmission of COVID-19 in 282 clusters in Catalonia, Spain: A cohort study. *Lancet Infect. Dis.* **21**, 629–636 (2021).
177. D. Nicolás *et al.*, A prospective cohort of SARS-CoV-2-infected health care workers: Clinical characteristics, outcomes, and follow-up strategy. *Open Forum Infect. Dis.* **8**, ofaa592 (2021).
178. U. P. Patil, P. Krishnan, S. Abudinen-Vasquez, S. Maru, L. Noble, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) positive newborns of COVID-19 mothers after dyad-care: A case series. *Cureus* **13**, e12528 (2021).
179. S. Rajme-López *et al.*, Large-scale screening for severe acute respiratory coronavirus virus 2 (SARS-CoV-2) among healthcare workers: Prevalence and risk factors for asymptomatic and pauci-symptomatic carriers, with emphasis on the use of personal protective equipment (PPE). *Infect. Control Hosp. Epidemiol.*, 10.1017/ice.2021.68 (2021).
180. R. Ren *et al.*, Asymptomatic SARS-CoV-2 infections among persons entering China from April 16 to October 12, 2020. *JAMA* **325**, 489–492 (2021).
181. R. Sharma *et al.*, Perinatal outcome and possible vertical transmission of coronavirus disease 2019: Experience from North India. *Clin. Exp. Pediatr.* **64**, 239–246 (2021).
182. B. Stessel *et al.*, Evaluation of a comprehensive pre-procedural screening protocol for COVID-19 in times of a high SARS CoV-2 prevalence: A prospective cross-sectional study. *Ann. Med.* **53**, 337–344 (2021).
183. J. K. Tan *et al.*, The prevalence and clinical significance of Presymptomatic COVID-19 patients: How we can be one step ahead in mitigating a deadly pandemic. *BMC Infect. Dis.* **21**, 249 (2021).
184. S. Abeyasuriya *et al.*, Universal screening for SARS-CoV-2 in pregnant women at term admitted to an East London maternity unit. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **252**, 444–446 (2020).
185. F. Adorni *et al.*, Self-reported symptoms of SARS-CoV-2 infection in a non-hospitalized population: Results from the large Italian web-based EPICoVID19 cross-sectional survey. *JMIR Public Health Surveill.* **6**, e21866 (2020).
186. S. Aherfi, P. Gautret, H. Chaudet, D. Raoult, B. La Scola, Clusters of COVID-19 associated with Purim celebration in the Jewish community in Marseille, France, March 2020. *Int. J. Infect. Dis.* **100**, 88–94 (2020).
187. M. Albalade *et al.*, High prevalence of asymptomatic COVID-19 in hemodialysis. Daily learning during first month of COVID-19 pandemic. *Nefrologia (Engl. Ed.)* **40**, 279–286 (2020).
188. M. Andrikopoulou *et al.*, Symptoms and critical illness among obstetric patients with Coronavirus Disease 2019 (COVID-19) infection. *Obstet. Gynecol.* **136**, 291–299 (2020).
189. T. P. Baggett, H. Keyes, N. Sporn, J. M. Gaeta, Prevalence of SARS-CoV-2 infection in residents of a large homeless shelter in Boston. *JAMA* **323**, 2191–2192 (2020).
190. Y. Bai *et al.*, Presumed asymptomatic carrier transmission of COVID-19. *JAMA* **323**, 1406–1407 (2020).
191. S. L. Bai *et al.*, Analysis of the first cluster of cases in a family of novel coronavirus pneumonia in Gansu Province. *Zhonghua Yu Fang Yi Xue Za Zhi* **54**, E005 (2020).
192. A. S. Berghoff *et al.*, SARS-CoV-2 testing in patients with cancer treated at a tertiary care hospital during the COVID-19 pandemic. *J. Clin. Oncol.* **38**, 3547–3554 (2020).
193. Q. Bi *et al.*, Epidemiology and transmission of COVID-19 in 391 cases and 1286 of their close contacts in Shenzhen, China: A retrospective cohort study. *Lancet Infect. Dis.* **20**, 911–919 (2020).
194. M. J. Blitz *et al.*, Universal testing for coronavirus disease 2019 in pregnant women carried for delivery: Prevalence of peripartum infection and rate of asymptomatic carriers at four New York hospitals within an integrated healthcare system. *Am. J. Obstet. Gynecol. MFM* **2**, 100169 (2020).
195. T. J. Blumberg *et al.*, Universal screening for COVID-19 in children undergoing orthopaedic surgery: A multicenter report. *J. Pediatr. Orthop.* **40**, e990–e993 (2020).
196. S. Brandstetter *et al.*, Symptoms and immunoglobulin development in hospital staff exposed to a SARS-CoV-2 outbreak. *Pediatr. Allergy Immunol.* **31**, 841–847 (2020).
197. K. H. Campbell *et al.*, Prevalence of SARS-CoV-2 among patients admitted for childbirth in Southern Connecticut. *JAMA* **323**, 2520–2522 (2020).
198. R. Cardona-Hernandez *et al.*, Children and youth with diabetes are not at increased risk for hospitalization due to COVID-19. *Pediatr. Diabetes* **22**, 202–206 (2021).
199. C. Carroll *et al.*, Routine testing of close contacts of confirmed COVID-19 cases—National COVID-19 contact management programme, Ireland, May to August 2020. *Public Health* **190**, 147–151 (2021).
200. A. M. Cattelan *et al.*, An integrated strategy for the prevention of SARS-CoV-2 infection in healthcare workers: A prospective observational study. *Int. J. Environ. Res. Public Health* **17**, 5785 (2020).
201. M. C. Chang, W.-S. Seo, D. Park, J. Hur, Analysis of SARS-CoV-2 screening clinic (including drive-through system) data at a single university Hospital in South Korea from 27 January 2020 to 31 March 2020 during the COVID-19 outbreak. *Healthcare (Basel)* **8**, 145 (2020).
202. N. Chekhlabi *et al.*, The epidemiological and clinical profile of COVID-19 in children: Moroccan experience of the Cheikh Khalifa University Center. *Pan Afr. Med. J.* **35**, 57 (2020).
203. P. Chen *et al.*, Clinical and demographic characteristics of cluster cases and sporadic cases of Coronavirus Disease 2019 (COVID-19) in 141 patients in the main district of Chongqing, China, between January and February 2020. *Med. Sci. Monit.* **26**, e923985 (2020).
204. P. Chen *et al.*, Epidemiological and clinical characteristics of 136 cases of COVID-19 in main district of Chongqing. *J. Formos. Med. Assoc.* **119**, 1180–1184 (2020).
205. Y. Chen *et al.*, Epidemiological characteristics of infection in COVID-19 close contacts in Ningbo city. *Zhonghua Liu Xing Bing Xue Za Zhi* **41**, 667–671 (2020).
206. J. Chen *et al.*, Potential transmission of SARS-CoV-2 on a flight from Singapore to Hangzhou, China: An epidemiological investigation. *Travel Med. Infect. Dis.* **36**, 101816 (2020).
207. G. Chen *et al.*, Epidemiological analysis of 18 patients with COVID-19. *Eur. Rev. Med. Pharmacol. Sci.* **24**, 12522–12526 (2020).
208. H.-Y. Cheng *et al.*, Contact tracing assessment of COVID-19 transmission dynamics in Taiwan and risk at different exposure periods before and after symptom onset. *JAMA Intern. Med.* **180**, 1156–1163 (2020).
209. C.-H. Chiu *et al.*, Familial cluster of pneumonia and asymptomatic cases of COVID-19 in Taiwan. *J. Formos. Med. Assoc.* **119**, 1560–1561 (2020).
210. C. Clarke *et al.*, High prevalence of asymptomatic COVID-19 infection in hemodialysis patients detected using serologic screening. *J. Am. Soc. Nephrol.* **31**, 1969–1975 (2020).
211. G. A. G. Cramer *et al.*, Reduced maximal aerobic capacity after COVID-19 in young adult recruits, Switzerland, May 2020. *Euro Surveill.* **25**, 2001542 (2020).
212. F. D'Ambrosi *et al.*, Management of gestational diabetes in women with a concurrent severe acute respiratory syndrome coronavirus 2 infection, experience of a single center in Northern Italy. *Int. J. Gynaecol. Obstet.* **152**, 335–338 (2020).
213. T. Stock da Cunha *et al.*, The spectrum of clinical and serological features of COVID-19 in urban hemodialysis patients. *J. Clin. Med.* **9**, 2264 (2020).
214. J. H. D. Silva, E. C. D. Oliveira, T. Y. Hattori, E. R. S. D. Lemos, A. C. P. Terças-Trettel, Description of a COVID-19 cluster: isolation and testing in asymptomatic people as prevention strategies for local spread in Mato Grosso. *Epidemiol. Serv. Saude* **29**, e2020264 (2020).
215. M. C. S. Jesus *et al.*, Family COVID-19 cluster analysis of an infant without respiratory symptoms. *Rev. Soc. Bras. Med. Trop.* **53**, e20200494 (2020).
216. A. Dhuyvetter, H. E. Cejtin, M. Adam, A. Patel, Coronavirus disease 2019 in pregnancy: The experience at an urban safety net hospital. *J. Community Health* **46**, 267–269 (2021).
217. P. Díaz-Corvillón *et al.*, Routine screening for SARS CoV-2 in unselected pregnant women at delivery. *PLoS One* **15**, e0239887 (2020).
218. M. Donahue *et al.*, Notes from the field: Characteristics of meat processing facility workers with confirmed SARS-CoV-2 infection - Nebraska, April–May 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 1020–1022 (2020).
219. H. Du *et al.*, Clinical characteristics of 182 pediatric COVID-19 patients with different severities and allergic status. *Allergy* **76**, 510–532 (2021).
220. D. Wang *et al.*, Clinical analysis of 31 cases of 2019 novel coronavirus infection in children from six provinces (autonomous region) of northern China. *Zhonghua Er Ke Za Zhi* **58**, 269–274 (2020).
221. A. G. Edlow *et al.*, Assessment of maternal and neonatal SARS-CoV-2 viral load, transplacental antibody transfer, and placental pathology in pregnancies during the COVID-19 pandemic. *JAMA Netw. Open* **3**, e2030455 (2020).
222. C. Felice, G. L. Di Tanna, G. Zanus, U. Grossi, Impact of COVID-19 outbreak on healthcare workers in Italy: Results from a national E-survey. *J. Community Health* **45**, 675–683 (2020).
223. A. Gaur *et al.*, Clinico-radiological presentation of COVID-19 patients at a tertiary care center at Bhilwara Rajasthan, India. *J. Assoc. Physicians India* **68**, 29–33 (2020).
224. I. T. Goldfarb *et al.*, Universal SARS-CoV-2 testing on admission to the labor and delivery unit: Low prevalence among asymptomatic obstetric patients. *Infect. Control Hosp. Epidemiol.* **41**, 1095–1096 (2020).
225. X. Gong *et al.*, Three infection clusters related with potential pre-symptomatic transmission of coronavirus disease (COVID-19), Shanghai, China, January to February 2020. *Euro Surveill.* **25**, 2000228 (2020).
226. N. S. N. Graham *et al.*, SARS-CoV-2 infection, clinical features and outcome of COVID-19 in United Kingdom nursing homes. *J. Infect.* **81**, 411–419 (2020).
227. O. Grechukhina *et al.*, Coronavirus disease 2019 pregnancy outcomes in a racially and ethnically diverse population. *Am. J. Obstet. Gynecol. MFM* **2**, 100246 (2020).
228. J. Greiner *et al.*, Characteristics and mechanisms to control a COVID-19 outbreak on a leukemia and stem cell transplantation unit. *Cancer Med.* **10**, 237–246 (2021).
229. J. A. Gruskay *et al.*, Universal testing for COVID-19 in essential orthopaedic surgery reveals a high percentage of asymptomatic infections. *J. Bone Joint Surg. Am.* **102**, 1379–1388 (2020).
230. C.-X. Guo *et al.*, Epidemiological and clinical features of pediatric COVID-19. *BMC Med.* **18**, 250 (2020).
231. T. Han, Outbreak investigation: Transmission of COVID-19 started from a spa facility in a local community in Korea. *Epidemiol. Health* **42**, e2020056 (2020).

232. T. Han *et al.*, The epidemiological characteristics of cluster transmission of coronavirus disease 2019 (COVID-19): A multi-center study in Jiangsu Province. *Am. J. Transl. Res.* **12**, 6434–6444 (2020).
233. M. He *et al.*, Epidemiological and clinical characteristics of 35 children with COVID-19 in Beijing, China. *Pediatr. Investig.* **4**, 230–235 (2020).
234. L. Hempel *et al.*, SARS-CoV-2 infections in cancer outpatients—most infected patients are asymptomatic carriers without impact on chemotherapy. *Cancer Med.* **9**, 8020–8028 (2020).
235. I. Herraiz *et al.*, Universal screening for SARS-CoV-2 before labor admission during Covid-19 pandemic in Madrid. *J. Perinat. Med.* **48**, 981–984 (2020).
236. D. Hijnen *et al.*, SARS-CoV-2 transmission from presymptomatic meeting attendee, Germany. *Emerg. Infect. Dis.* **26**, 1935–1937 (2020).
237. J.-M. Hong *et al.*, Epidemiological characteristics and clinical features of patients infected with the COVID-19 virus in Nanchang, Jiangxi, China. *Front. Med. (Lausanne)* **7**, 571069 (2020).
238. X. Hu *et al.*, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) vertical transmission in neonates born to mothers with Coronavirus Disease 2019 (COVID-19) pneumonia. *Obstet. Gynecol.* **136**, 65–67 (2020).
239. A. J. Ing, C. Cocks, J. P. Green, COVID-19: In the footsteps of Ernest Shackleton. *Thorax* **75**, 693–694 (2020).
240. S. Inui *et al.*, Chest CT findings in cases from the cruise ship *Diamond Princess* with Coronavirus Disease (COVID-19). *Radiol. Cardiothorac. Imaging* **2**, e200110 (2020).
241. L. P. Jatt *et al.*, Widespread severe acute respiratory coronavirus virus 2 (SARS-CoV-2) laboratory surveillance program to minimize asymptomatic transmission in high-risk inpatient and congregate living settings. *Infect. Control Hosp. Epidemiol.* **41**, 1331–1334 (2020).
242. J.-Y. Liu, T.-J. Chen, S.-J. Hwang, Analysis of community-acquired COVID-19 cases in Taiwan. *J. Chin. Med. Assoc.* **83**, 1087–1092 (2020).
243. C.-Y. Jung *et al.*, Clinical characteristics of asymptomatic patients with COVID-19: A nationwide cohort study in South Korea. *Int. J. Infect. Dis.* **99**, 266–268 (2020).
244. J. Just, M.-T. Puth, F. Regenold, K. Weckbecker, M. Bleckwenn, Risk factors for a positive SARS-CoV-2 PCR in patients with common cold symptoms in a primary care setting - A retrospective analysis based on a joint documentation standard. *BMC Fam. Pract.* **21**, 251 (2020).
245. Expert Taskforce for the COVID-19 Cruise Ship Outbreak, Epidemiology of COVID-19 outbreak on cruise ship quarantined at Yokohama, Japan, February 2020. *Emerg. Infect. Dis.* **26**, 2591–2597 (2020).
246. A. M. Kassem *et al.*, SARS-CoV-2 infection among healthcare workers of a gastroenterological service in a tertiary care facility. *Arab J. Gastroenterol.* **21**, 151–155 (2020).
247. K. Bai *et al.*, Clinical analysis of 25 COVID-19 infections in children. *Pediatr. Infect. Dis. J.* **39**, e100–e103 (2020).
248. A. Khalil, R. Hill, S. Ladhani, K. Pattison, P. O'Brien, Severe acute respiratory syndrome coronavirus 2 in pregnancy: Symptomatic pregnant women are only the tip of the iceberg. *Am. J. Obstet. Gynecol.* **223**, 296–297 (2020).
249. M. Ki, Task Force for 2019-nCoV, Epidemiologic characteristics of early cases with 2019 novel coronavirus (2019-nCoV) disease in Korea. *Epidemiol. Health* **42**, e2020007 (2020).
250. N. Koizumi, A. B. Siddique, A. Andalibi, Assessment of SARS-CoV-2 transmission among attendees of live concert events in Japan using contact-tracing data. *J. Travel Med.* **27**, taaa096 (2020).
251. COVID-19 National Emergency Response Center, Epidemiology and Case Management Team, Korea Centers for Disease Control and Prevention, Early epidemiological and clinical characteristics of 28 cases of coronavirus disease in South Korea. *Osong Public Health Res. Perspect.* **11**, 8–14 (2020).
252. V. B. Kute *et al.*, Clinical profile and outcome of COVID-19 in 250 kidney transplant recipients: A multicenter cohort study from India. *Transplantation* **105**, 851–860 (2021).
253. S. M. LaCourse *et al.*, Low prevalence of SARS-CoV-2 among pregnant and postpartum patients with universal screening in Seattle, Washington. *Clin. Infect. Dis.* **72**, 869–872 (2021).
254. X. Lai *et al.*, Coronavirus Disease 2019 (COVID-2019) infection among health care workers and implications for prevention measures in a Tertiary Hospital in Wuhan, China. *JAMA Netw. Open* **3**, e209666 (2020).
255. E. Lavezzo *et al.*, Suppression of a SARS-CoV-2 outbreak in the Italian municipality of Vo'. *Nature* **584**, 425–429 (2020).
256. A. G. Letizia *et al.*, SARS-CoV-2 transmission among marine recruits during quarantine. *N. Engl. J. Med.* **383**, 2407–2416 (2020).
257. S. S. Lewis *et al.*, Early experience with universal pre-procedural testing for SARS-CoV-2 in a relatively low-prevalence area. *Infect. Control Hosp. Epidemiol.* **42**, 341–343 (2021).
258. Y. Li *et al.*, Asymptomatic and symptomatic patients with non-severe Coronavirus Disease (COVID-19) have similar clinical features and virological courses: A retrospective single center study. *Front. Microbiol.* **11**, 1570 (2020).
259. J. Li *et al.*, Aggressive quarantine measures reduce the high morbidity of COVID-19 in patients on maintenance hemodialysis and medical staff of hemodialysis facilities in Wuhan, China. *Kidney Dis.* **6**, 271–283 (2020).
260. X. Li *et al.*, Differences in clinical features and laboratory results between adults and children with SARS-CoV-2 infection. *BioMed Res. Int.* **2020**, 6342598 (2020).
261. S. Lin *et al.*, Epidemiological and clinical characteristics of 161 discharged cases with coronavirus disease 2019 in Shanghai, China. *BMC Infect. Dis.* **20**, 780 (2020).
262. J.-Y. Liu, T.-J. Chen, S.-J. Hwang, Analysis of imported cases of COVID-19 in Taiwan: A nationwide study. *Int. J. Environ. Res. Public Health* **17**, 3311 (2020).
263. Epidemiology Working Group for NCIP Epidemic Response, Chinese Center for Disease Control and Prevention, The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China. *Zhonghua Liu Xing Bing Xue Za Zhi* **41**, 145–151 (2020).
264. L. Liu *et al.*, Optimizing screening strategies for coronavirus disease 2019: A study from Middle China. *J. Infect. Public Health* **13**, 868–872 (2020).
265. S. Liu *et al.*, Clinical characteristics and risk factors of patients with severe COVID-19 in Jiangsu province, China: A retrospective multicentre cohort study. *BMC Infect. Dis.* **20**, 584 (2020).
266. J. Liu, J. Huang, D. Xiang, Large SARS-CoV-2 outbreak caused by asymptomatic traveler, China. *Emerg. Infect. Dis.* **26**, 2260–2263 (2020).
267. P. Liu *et al.*, Characteristics and effectiveness of the Coronavirus disease 2019 (COVID-19) prevention and control in a representative city in China. *Med. Sci. Monit.* **26**, e927472 (2020).
268. E. M. Lokken *et al.*, Clinical characteristics of 46 pregnant women with a severe acute respiratory syndrome coronavirus 2 infection in Washington State. *Am. J. Obstet. Gynecol.* **223**, 911.e1–911.e14 (2020).
269. V. London *et al.*, The relationship between status at presentation and outcomes among pregnant women with COVID-19. *Am. J. Perinatol.* **37**, 991–994 (2020).
270. A. S. Lopez *et al.*, Transmission dynamics of COVID-19 outbreaks associated with child care facilities—Salt Lake City, Utah, April–July 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 1319–1323 (2020).
271. X. Lu *et al.*, SARS-CoV-2 infection in children. *N. Engl. J. Med.* **382**, 1663–1665 (2020).
272. Field briefing: Diamond Princess COVID-19 cases, 20 Feb update. <https://www.niid.go.jp/niid/en/2019-ncov-e/9417-covid-dp-fe-o2.html>. Accessed 29 January 2021.
273. T. D. A. Ly *et al.*, Pattern of SARS-CoV-2 infection among dependant elderly residents living in long-term care facilities in Marseille, France, March–June 2020. *Int. J. Antimicrob. Agents* **56**, 106219 (2020).
274. F. Maechler *et al.*, Epidemiological and clinical characteristics of SARS-CoV-2 infections at a testing site in Berlin, Germany, March and April 2020—a cross-sectional study. *Clin. Microbiol. Infect.* **26**, 1685.e7–1685.e12 (2020).
275. F. Maggiolo *et al.*, SARS-CoV-2 infection in persons living with HIV: A single center prospective cohort. *J. Med. Virol.* **93**, 1145–1149 (2021).
276. R. Malheiro *et al.*, Effectiveness of contact tracing and quarantine on reducing COVID-19 transmission: A retrospective cohort study. *Public Health* **189**, 54–59 (2020).
277. H. C. Maltezou *et al.*, Transmission dynamics of SARS-CoV-2 within families with children in Greece: A study of 23 clusters. *J. Med. Virol.* **93**, 1414–1420 (2021).
278. H. C. Maltezou *et al.*, Children and adolescents with SARS-CoV-2 infection: Epidemiology, clinical course and viral loads. *Pediatr. Infect. Dis. J.* **39**, e388–e392 (2020).
279. S. Mao *et al.*, Epidemiological analysis of 67 local COVID-19 clusters in Sichuan Province, China. *BMC Public Health* **20**, 1525 (2020).
280. A. Marossy *et al.*, A study of universal SARS-CoV-2 RNA testing of residents and staff in a large group of care homes in South London. *J. Infect. Dis.* **223**, 381–388 (2021).
281. C. Martin *et al.*, Dynamics of SARS-CoV-2 RT-PCR positivity and seroprevalence among high-risk healthcare workers and hospital staff. *J. Hosp. Infect.* **106**, 102–106 (2020).
282. F. Martini *et al.*, On cancer, COVID-19, and CT scans: A monocentric retrospective study. *J. Clin. Med.* **9**, 3935 (2020).
283. C. Massarotti *et al.*, Asymptomatic SARS-CoV-2 infections in pregnant patients in an Italian city during the complete lockdown. *J. Med. Virol.* **93**, 1758–1760 (2021).
284. M. K. Meena, M. Singh, P. K. Panda, M. K. Bairwa, Non-COVID area of a tertiary care hospital: A major source of nosocomial COVID-19 transmission. *J. Family Community Med.* **27**, 212–215 (2020).
285. M. Melgosa *et al.*, SARS-CoV-2 infection in Spanish children with chronic kidney pathologies. *Pediatr. Nephrol.* **35**, 1521–1524 (2020).
286. N. Menachemi *et al.*, Population point prevalence of SARS-CoV-2 infection based on a statewide random sample—Indiana, April 25–29, 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 960–964 (2020).
287. T. Menting *et al.*, Low-threshold SARS-CoV-2 testing facility for hospital staff: Prevention of COVID-19 outbreaks? *Int. J. Hyg. Environ. Health* **231**, 113653 (2021).
288. E. S. Miller, W. A. Grobman, A. Sakowicz, J. Rosati, A. M. Peaceman, Clinical implications of universal Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) testing in pregnancy. *Obstet. Gynecol.* **136**, 232–234 (2020).
289. A. Mostafa *et al.*, Universal COVID-19 screening of 4040 health care workers in a resource-limited setting: An Egyptian pilot model in a university with 12 public hospitals and medical centers. *Int. J. Epidemiol.* **50**, 50–61 (2021).
290. E. Namal, Single center experience on screening oncology patients for covid-19 before anti-cancer treatment. *Int. J. Hematol. Oncol.* **30**, 207–212 (2020).
291. H. Nishiura *et al.*, The rate of underascertainment of novel coronavirus (2019-nCoV) infection: Estimation using Japanese passengers data on evacuation flights. *J. Clin. Med.* **9**, 419 (2020).
292. L. Norsa *et al.*, Asymptomatic severe acute respiratory syndrome coronavirus 2 infection in patients with inflammatory bowel disease under biologic treatment. *Gastroenterology* **159**, 2229–2231.e2 (2020).
293. S. Ornaghi *et al.*, Performance of an extended triage questionnaire to detect suspected cases of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection in obstetric patients: Experience from two large teaching hospitals in Lombardy, Northern Italy. *PLoS One* **15**, e0239173 (2020).
294. S. Ossareh, M. Bagheri, M. Abbasi, S. Abolfathi, A. Bohlooli, Role of screening for COVID-19 in hemodialysis wards, results of a single center study. *Iran. J. Kidney Dis.* **14**, 389–398 (2020).
295. Y. Oster *et al.*, Proactive screening approach for SARS-CoV-2 among healthcare workers. *Clin. Microbiol. Infect.* **27**, 155–156 (2021).
296. L. Panagiotakopoulos *et al.*, SARS-CoV-2 infection among hospitalized pregnant women: Reasons for admission and pregnancy characteristics—Eight U.S. Health Care Centers, March 1–May 30, 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 1355–1359 (2020).

297. N. Parri *et al.*, Characteristic of COVID-19 infection in pediatric patients: Early findings from two Italian pediatric research networks. *Eur. J. Pediatr.* **179**, 1315–1323 (2020).
298. N. Parri *et al.*, COVID-19 in 17 Italian pediatric emergency departments. *Pediatrics* **146**, e20201235 (2020).
299. E. T. Patberg *et al.*, Coronavirus disease 2019 infection and placental histopathology in women delivering at term. *Am. J. Obstet. Gynecol.* **224**, 382.e1–382.e18 (2021).
300. A. B. Patel *et al.*, SARS-CoV-2 point prevalence among asymptomatic hospitalized children and subsequent healthcare worker evaluation. *J. Pediatric Infect. Dis. Soc.* **9**, 617–619 (2020).
301. A. Pavli *et al.*, In-flight transmission of COVID-19 on flights to Greece: An epidemiological analysis. *Travel Med. Infect. Dis.* **38**, 101882 (2020).
302. D. C. Payne *et al.*, SARS-CoV-2 infections and serologic responses from a sample of U.S. Navy Service Members—USS Theodore Roosevelt, April 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 714–721 (2020).
303. I. Petersen, A. Phillips, Three quarters of people with SARS-CoV-2 infection are asymptomatic: Analysis of English household survey data. *Clin. Epidemiol.* **12**, 1039–1043 (2020).
304. J.-P. Pirnay *et al.*, Study of a SARS-CoV-2 outbreak in a Belgian military education and training center in Maradi, Niger. *Viruses* **12**, 949 (2020).
305. M. Pollán *et al.*, Prevalence of SARS-CoV-2 in Spain (ENE-COVID): A nationwide, population-based seroepidemiological study. *Lancet* **396**, 535–544 (2020).
306. M. Prabhu *et al.*, Pregnancy and postpartum outcomes in a universally tested population for SARS-CoV-2 in New York City: A prospective cohort study. *BJOG* **127**, 1548–1556 (2020).
307. I. W. Pray *et al.*, COVID-19 outbreak at an overnight summer school retreat—Wisconsin, July–August 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 1600–1604 (2020).
308. P. Xingqiang *et al.*, Study on transmission dynamic of 15 clusters of coronavirus disease 2019 cases in Ningbo. *Zhonghua Liu Xing Bing Xue Za Zhi* **41**, E066 (2020).
309. H. Qiu *et al.*, Clinical and epidemiological features of 36 children with coronavirus disease 2019 (COVID-19) in Zhejiang, China: An observational cohort study. *Lancet Infect. Dis.* **20**, 689–696 (2020).
310. J. H. Rogers *et al.*, Characteristics of COVID-19 in homeless shelters: A community-based surveillance study. *Ann. Intern. Med.* **174**, 42–49 (2021).
311. A. C. Roxby *et al.*, Outbreak investigation of COVID-19 among residents and staff of an independent and assisted living community for older adults in Seattle, Washington. *JAMA Intern. Med.* **180**, 1101–1105 (2020).
312. G. Sacco, G. Foucault, O. Briere, C. Annweiler, COVID-19 in seniors: Findings and lessons from mass screening in a nursing home. *Maturitas* **141**, 46–52 (2020).
313. I. H. Huerta Saenz, J. C. Elias Estrada, K. Campos Del Castillo, R. Muñoz Taya, J. C. Coronado, Características materno perinatales de gestantes COVID-19 en un hospital nacional de Lima, Perú [in Spanish]. *Rev. Peru. Ginecol. Obstet.*, 10.31403/rpgo.v66i2245 (2020).
314. A. Sakowicz *et al.*, Risk factors for severe acute respiratory syndrome coronavirus 2 infection in pregnant women. *Am. J. Obstet. Gynecol. MFM* **2**, 100198 (2020).
315. M. Saluja, D. Pillai, S. Jeliya, N. Baudhdh, R. Chandel, COVID 19-clinical profile, radiological presentation, prognostic predictors, complications and outcome: A perspective from the Indian subcontinent. *J. Assoc. Physicians India* **68**, 13–18 (2020).
316. S. M. Samrah *et al.*, COVID-19 outbreak in Jordan: Epidemiological features, clinical characteristics, and laboratory findings. *Ann. Med. Surg. (Lond.)* **57**, 103–108 (2020).
317. G. V. Sanchez *et al.*, Initial and repeated point prevalence surveys to inform SARS-CoV-2 infection prevention in 26 skilled nursing facilities—Detroit, Michigan, March–May 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**, 882–886 (2020).
318. S. R. Sastry *et al.*, Universal screening for the SARS-CoV-2 virus on hospital admission in an area with low COVID-19 prevalence. *Infect. Control Hosp. Epidemiol.* **41**, 1231–1233 (2020).
319. S. Saurabh *et al.*, Dynamics of SARS-CoV-2 transmission among Indian nationals evacuated from Iran. *Disaster Med. Public Health Prep.*, 10.1017/dmp.2020.393 (2020).
320. R. Savirón-Cornudella *et al.*, Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) universal screening in gravids during labor and delivery. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **256**, 400–404 (2021).
321. Q. Shen *et al.*, Novel coronavirus infection in children outside of Wuhan, China. *Pediatr. Pulmonol.* **55**, 1424–1429 (2020).
322. A. K. Sharma *et al.*, Epidemiological and clinical profile of COVID-19 in Nepali children: An initial experience. *J. Nepal Paediatr. Soc.* **40**, 202–209 (2020).
323. L. Shi *et al.*, Quarantine at home may not enough!—from the epidemiological data in Shaanxi Province of China. *BMC Res. Notes* **13**, 506 (2020).
324. R. G. Shmakov *et al.*, Clinical course of novel COVID-19 infection in pregnant women. *J. Matern. Fetal Neonatal Med.*, 10.1080/14767058.2020.1850683 (2020).
325. J. S. Singer *et al.*, Low prevalence (0.13%) of COVID-19 infection in asymptomatic pre-operative/pre-procedure patients at a large, academic medical center informs approaches to perioperative care. *Surgery* **168**, 980–986 (2020).
326. N. Sugano, W. Ando, W. Fukushima, Cluster of severe acute respiratory syndrome coronavirus 2 infections linked to music clubs in Osaka, Japan. *J. Infect. Dis.* **222**, 1635–1640 (2020).
327. D. Sun *et al.*, Children infected with SARS-CoV-2 from family clusters. *Front. Pediatr.* **8**, 386 (2020).
328. D. Sutton, K. Fuchs, M. D'Alton, D. Goffman, Universal screening for SARS-CoV-2 in women admitted for delivery. *N. Engl. J. Med.* **382**, 2163–2164 (2020).
329. M. P. Tambe *et al.*, An epidemiological study of laboratory confirmed COVID-19 cases admitted in a tertiary care hospital of Pune, Maharashtra. *Indian J. Public Health* **64**, S183–S187 (2020).
330. T. Xin *et al.*, Clinical characteristics analysis of 13 cases of novel coronavirus infection in children in Changsha. *Chinese Journal of Contemporary Pediatrics* **22**, 294–298 (2020).
331. O. Tang *et al.*, Outcomes of nursing home COVID-19 patients by initial symptoms and comorbidity: Results of universal testing of 1970 residents. *J. Am. Med. Dir. Assoc.* **21**, 1767–1773.e1 (2020).
332. T. Ali *et al.*, Coronavirus disease-19: Disease severity and outcomes of solid organ transplant recipients: Different spectrum of disease in different populations? *Transplantation* **105**, 121–127 (2021).
333. J. W. Thompson Jr. *et al.*, An epidemiologic study of COVID-19 patients in a state psychiatric hospital: High penetrance with early CDC guidelines. *Psychiatr. Serv.* **71**, 1285–1287 (2020).
334. S. Tian *et al.*, Characteristics of COVID-19 infection in Beijing. *J. Infect.* **80**, 401–406 (2020).
335. M.-J. Trahan, C. Mitric, I. Malhamé, H. A. Abenhaim, Screening and testing pregnant patients for SARS-CoV-2: First-wave experience of a designated COVID-19 hospitalization centre in Montreal. *J. Obstet. Gynaecol. Can.* **43**, 571–575 (2021).
336. T. Venkataram *et al.*, Deployment of neurosurgeons at the warfront against coronavirus disease of 2019 (COVID-19). *World Neurosurg.* **144**, e561–e567 (2020).
337. M. Wang *et al.*, Epidemiological characteristics and transmission dynamics of paediatric cases with coronavirus disease 2019 in Hubei province, China. *J. Paediatr. Child Health* **57**, 637–645 (2021).
338. S. Wanwan *et al.*, Epidemiological characteristics of 2019 novel coronavirus family clustering in Zhejiang Province. *Chin. J. Prev. Med* **54**, E027 (2020).
339. X. Xu *et al.*, The cumulative rate of SARS-CoV-2 infection in Chinese hemodialysis patients. *Kidney Int. Rep.* **5**, 1416–1421 (2020).
340. J. Yan *et al.*, Coronavirus disease 2019 in pregnant women: A report based on 116 cases. *Am. J. Obstet. Gynecol.* **223**, 111.e1–111.e14 (2020).
341. J. Yang *et al.*, Clinical characteristics and eosinophils in young SARS-CoV-2-positive Chinese travelers returning to Shanghai. *Front. Public Health* **8**, 368 (2020).
342. M. Yassa *et al.*, Outcomes of universal SARS-CoV-2 testing program in pregnant women admitted to hospital and the adjuvant role of lung ultrasound in screening: A prospective cohort study. *J. Matern. Fetal Neonatal Med.* **33**, 3820–3826 (2020).
343. B. C. Cura Yayla *et al.*, Characteristics and management of children with COVID-19 in Turkey. *Balkan Med. J.* **37**, 341–347 (2020).
344. B. C. C. Yayla, K. Aykac, Y. Ozsurekci, M. Ceyhan, Characteristics and management of children with COVID-19 in a tertiary care hospital in Turkey. *Clin. Pediatr.* **60**, 170–177 (2021).
345. K. Yilmaz *et al.*, Evaluation of the novel coronavirus disease in Turkish children: Preliminary outcomes. *Pediatr. Pulmonol.* **55**, 3587–3594 (2020).
346. L. X. Ye *et al.*, Investigation of a cluster epidemic of COVID-19 in Ningbo. *Zhonghua Liu Xing Bing Xue Za Zhi* **41**, 2029–2033 (2020).
347. J. C. Yombi, J. De Greef, P. Bernard, L. Belkhir, Testing of patients and coronavirus disease 2019 (COVID-19) infection before scheduled deliveries. *J. Perinat. Med.* **48**, 995–996 (2020).
348. H. Yue *et al.*, Clinical characteristics of coronavirus disease 2019 in Gansu province, China. *Ann. Palliat. Med.* **9**, 1404–1412 (2020).
349. T. Zhan *et al.*, Retrospective analysis of clinical characteristics of 405 patients with COVID-19. *J. Int. Med. Res.* **48**, 300060520949039 (2020).
350. M. 'A. I. A. Zamzuri *et al.*, Epidemiological characteristics of COVID-19 in Seremban, Negeri Sembilan, Malaysia. *Open Access Maced. J. Med. Sci.* **8**, 471–475 (2020).
351. L. Zhang, S. Huang, Clinical features of 33 cases in children infected with SARS-CoV-2 in Anhui Province, China—A multi-center retrospective cohort study. *Front. Public Health* **8**, 255 (2020).
352. S. Zhang *et al.*, Factors associated with asymptomatic infection in health-care workers with severe acute respiratory syndrome coronavirus 2 infection in Wuhan, China: A multicentre retrospective cohort study. *Clin. Microbiol. Infect.* **26**, 1670–1675 (2020).
353. Z. Q. Deng *et al.*, Analysis on transmission chain of a cluster epidemic of COVID-19, Nanchang. *Zhonghua Liu Xing Bing Xue Za Zhi* **41**, 1420–1423 (2020).
354. L. Zou *et al.*, SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *N. Engl. J. Med.* **382**, 1177–1179 (2020).
355. R. H. El-Sokkary *et al.*, Characteristics and predicting factors of Corona Virus Disease-2019 (COVID-19) among healthcare providers in a developing country. *PLoS One* **16**, e0245672 (2021).
356. M. F. Kristiansen *et al.*, Epidemiology and clinical course of first wave coronavirus disease cases, Faroe Islands. *Emerg. Infect. Dis.* **27**, 749–758 (2021).
357. S. C. Reale *et al.*, Patient characteristics associated with SARS-CoV-2 infection in parturients admitted for labour and delivery in Massachusetts during the spring 2020 surge: A prospective cohort study. *Paediatr. Perinat. Epidemiol.* **35**, 24–33 (2021).
358. Y. Min *et al.*, Clinical characteristics of deceased hemodialysis patients affected by COVID-19. *Int. Urol. Nephrol.* **53**, 797–802 (2021).
359. J. A. Huete-Pérez *et al.*, First report on prevalence of SARS-CoV-2 infection among health-care workers in Nicaragua. *PLoS One* **16**, e0246084 (2021).
360. F. W. Arnold, S. Bishop, L. Oppy, L. Scott, G. Stevenson, Surveillance testing reveals a significant proportion of hospitalized patients with SARS-CoV-2 are asymptomatic. *Am. J. Infect. Control* **49**, 281–285 (2021).
361. B. F. Bigelow *et al.*, Outcomes of universal COVID-19 testing following detection of incident cases in 11 long-term care facilities. *JAMA Intern. Med.* **181**, 127–129 (2021).
362. C. Bayle *et al.*, Asymptomatic SARS COV-2 carriers among nursing home staff: A source of contamination for residents? *Infect. Dis. Now* **51**, 197–200 (2021).
363. L. Wang *et al.*, Source investigation on a familial cluster of coronavirus disease 2019 in Dandong city of Liaoning Province. *Zhonghua Yu Fang Yi Xue Za Zhi* **55**, 120–122 (2021).

364. T. Scheier et al., Universal admission screening for SARS-CoV-2 infections among hospitalized patients, Switzerland, 2020. *Emerg. Infect. Dis.* **27**, 404–410 (2021).
365. H. H. Adetola et al., Clinical presentations and management of COVID-19 infected children seen in a district health facility in Kambia, northern Sierra Leone. *Pan Afr. Med. J.* **37**, 28 (2020).
366. E. Camara et al., Epidemiological and clinical profile of children with Coronavirus disease (COVID-19) at the Center for the Treatment of Epidemics and Infection Prevention (CTEIP) of the University Hospital of Donka in Conakry. *Pan Afr. Med. J.* **37**, 363 (2020).
367. A. Jones et al., Assessment of day-7 postexposure testing of asymptomatic contacts of COVID-19 patients to evaluate early release from quarantine—Vermont, May–November 2020. *MMWR Morb. Mortal. Wkly. Rep.* **70**, 12–13 (2021).
368. T. Khondaker et al., Clinical profile and outcome of COVID-19 in children with pre-existing renal disease. *Int. J. Pediatr. Nephrol.* **9**, 1–6 (2021).
369. N. Marcus et al., Minor clinical impact of COVID-19 pandemic on patients with primary immunodeficiency in Israel. *Front. Immunol.* **11**, 614086 (2021).
370. C. Martin-Villares, M. Bernal-Sprekelsen, C. P. Molina-Ramirez, M. Bartolome-Benito, COVID-19 ESP Collaborative Group, Risk of contagion of SARS-CoV-2 among otorhinolaryngologists in Spain during the “Two waves.” *Eur. Arch. Otorhinolaryngol.*, 10.1007/s00405-020-06582-8 (2021).
371. M. A. Almadhi et al., The high prevalence of asymptomatic SARS-CoV-2 infection reveals the silent spread of COVID-19. *Int. J. Infect. Dis.* **105**, 656–661 (2021).
372. H. G. Atakla et al., COVID-19 infection in pediatric subjects: Study of 36 cases in Conakry. *Pan Afr. Med. J.* **37**, 42 (2020).
373. J. K. Bender, M. Brandl, M. Höhle, U. Buchholz, N. Zeitmann, Analysis of asymptomatic and presymptomatic transmission in SARS-CoV-2 outbreak, Germany, 2020. *Emerg. Infect. Dis.* **27**, 1159–1163 (2021).
374. M. Berry et al., Clinical stratification of pregnant COVID-19 patients based on severity: A single academic center experience. *Am. J. Perinatol.* **38**, 515–522 (2021).
375. M. N. S. Cabraal, R. I. U. Samarawickrama, K. A. R. R. Kodithuwakku, S. D. Viswakula, S. R. Lantra, Nationwide descriptive study of COVID-19 in children below the age of 14 years in Sri Lanka. *Sri Lanka J. Child Health* **50**, 103 (2021).
376. C. Cesilia, S. Sudarmaji, D. Setiabudi, H. M. Nataprawira, Case report of a COVID-19 family cluster originating from a boarding school. *Paediatr. Indones.* **61**, 53–60 (2021).
377. L. Dbeibo et al., Assessment of a universal preprocedural screening program for COVID-19. *Infect. Control Hosp. Epidemiol.*, 10.1017/ice.2021.40 (2021).
378. B. E. Dixon et al., Symptoms and symptom clusters associated with SARS-CoV-2 infection in community-based populations: Results from a statewide epidemiological study. *PLoS One* **16**, e0241875 (2021).
379. H. Fakhim et al., Asymptomatic carriers of coronavirus disease 2019 among healthcare workers in Isfahan, Iran. *Future Virol.* **16**, 93–98 (2021).
380. S. Hu et al., Infectivity, susceptibility, and risk factors associated with SARS-CoV-2 transmission under intensive contact tracing in Hunan, China. *Nat. Commun.* **12**, 1533 (2021).
381. S. Isoldi et al., The comprehensive clinic, laboratory, and instrumental evaluation of children with COVID-19: A 6-months prospective study. *J. Med. Virol.* **93**, 3122–3132 (2021).
382. S. Jani et al., Clinical characteristics of mother-infant dyad and placental pathology in COVID-19 cases in predominantly African American population. *AJP Rep.* **11**, e15–e20 (2021).
383. V. B. Kute et al., A multicenter cohort study from India of 75 kidney transplants in recipients recovered after COVID-19. *Transplantation* **105**, 1423–1432 (2021).
384. J. E. Marcus et al., Risk factors associated with COVID-19 transmission among US air force trainees in a congregant setting. *JAMA Netw. Open* **4**, e210202 (2021).
385. R. Miyahara et al., Familial clusters of coronavirus disease in 10 prefectures, Japan, February–May 2020. *Emerg. Infect. Dis.* **27**, 915–918 (2021).
386. P. S. Myles et al., COVID-19 risk in elective surgery during a second wave: A prospective cohort study. *ANZ J. Surg.* **91**, 22–26 (2021).
387. K. Nakajo, H. Nishiura, Transmissibility of asymptomatic COVID-19: Data from Japanese clusters. *Int. J. Infect. Dis.* **105**, 236–238 (2021).
388. M. de Miguel Negro et al., Pre-operative prevalence of asymptomatic carriers of COVID-19 in hospitals in Catalonia during the first wave after the resumption of surgical activity. *Cir. Esp. (Engl. Ed.)*, 10.1016/j.ciresp.2021.01.014 (2021).
389. E. Oduro-Mensah et al., Clinical features of COVID-19 in Ghana: Symptomatology, illness severity and comorbid non-communicable diseases. *Ghana Med. J.* **5**, 23–32 (2020).
390. R. V. Randremanana et al., The COVID-19 epidemic in Madagascar: Clinical description and laboratory results of the first wave, March–September 2020. *Influenza Other Respi. Viruses* **15**, 457–468 (2021).
391. G. Sabetian et al., COVID-19 infection among healthcare workers: A cross-sectional study in southwest Iran. *Virol. J.* **18**, 58 (2021).
392. R. Savirón-Cornudella et al., Screening of severe acute respiratory syndrome coronavirus-2 infection during labor and delivery using polymerase chain reaction and immunoglobulin testing. *Life Sci.* **271**, 119200 (2021).
393. V. Singh, A. Choudhary, M. R. Datta, A. Ray, Maternal and neonatal outcomes of COVID-19 in pregnancy: A single-centre observational study. *Cureus* **13**, e13184 (2021).
394. N. Sharma, N. Seehra, S. Kabra, Pregnancy with covid-19 infection and fetomaternal outcomes. *J. Evol. Med. Dent. Sci.* **10**, 23–27 (2021).
395. A. Soriano-Arandes et al., Household SARS-CoV-2 transmission and children: A network prospective study. *Clin. Infect. Dis.*, 10.1093/cid/ciab228 (2021).
396. R. N. Stadler et al., Systematic screening on admission for SARS-CoV-2 to detect asymptomatic infections. *Antimicrob. Resist. Infect. Control* **10**, 44 (2021).
397. S. Tawar, G. Diva Reddy, S. Ray, N. Chawla, S. Garg, Rapid response and mitigation measures in control of COVID-19 cases in an industrial warehouse of Western Maharashtra, India. *J. Mar. Med. Soc.* **22**, 220 (2020).
398. L. K. Tompkins et al., Mass SARS-CoV-2 testing in a dormitory-style correctional facility in Arkansas. *Am. J. Public Health* **111**, 907–916 (2021).
399. J. Villa et al., Results of preoperative screening for COVID-19 correlate with the incidence of infection in the general population—A tertiary care experience. *Hosp. Pract.* **49**, 216–220 (2021).
400. W. Xie et al., Infection and disease spectrum in individuals with household exposure to SARS-CoV-2: A family cluster cohort study. *J. Med. Virol.* **93**, 3033–3046 (2021).
401. N. Van Vinh Chau et al., The natural history and transmission potential of asymptomatic SARS-CoV-2 infection. *Clin. Infect. Dis.* **71**, 2679–2687 (2020).
402. H. Xu et al., A follow-up study of children infected with SARS-CoV-2 from western China. *Ann. Transl. Med.* **8**, 10 (2020).
403. H. P. Wu, Clinical features of coronavirus disease 2019 in children aged <18 years in Jiangxi, China: An analysis of 23 cases. *Chinese Journal of Contemporary Pediatrics* **22**, 419–424 (2020).
404. M. Yaoling, Analysis of the clinical characteristics of 115 children with novel coronavirus infection. *Chinese Journal of Contemporary Pediatrics* **22**, 290 (2020).
405. Z. Yun, Clinical features and chest CT findings of 2019 coronavirus disease in infants and young children. *Chinese Journal of Contemporary Pediatrics* **22**, 215 (2020).
406. N. van Doremalen et al., Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N. Engl. J. Med.* **382**, 1564–1567 (2020).
407. P. K. C. Cheng et al., Viral shedding patterns of coronavirus in patients with probable severe acute respiratory syndrome. *Lancet* **363**, 1699–1700 (2004).
408. D. P. Oran, E. J. Topol, Prevalence of asymptomatic SARS-CoV-2 infection: A narrative review. *Ann. Intern. Med.* **173**, 362–367 (2020).
409. A. Kronbichler et al., Asymptomatic patients as a source of COVID-19 infections: A systematic review and meta-analysis. *Int. J. Infect. Dis.* **98**, 180–186 (2020).
410. The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team, The novel coronavirus pneumonia emergency response epidemiology team, the epidemiological characteristics of an outbreak of 2019 novel Coronavirus Diseases (COVID-19)—China, 2020. *China CDC Weekly* **2**, 113–122 (2020).
411. X. Zhou, Y. Li, T. Li, W. Zhang, Follow-up of asymptomatic patients with SARS-CoV-2 infection. *Clin. Microbiol. Infect.* **26**, 957–959 (2020).
412. N. H. L. Leung, C. Xu, D. K. M. Ip, B. J. Cowling, Review article: The fraction of influenza virus infections that are asymptomatic: A systematic review and meta-analysis. *Epidemiology* **26**, 862–872 (2015).
413. L. Furuya-Kanamori et al., Heterogeneous and dynamic prevalence of asymptomatic influenza virus infections. *Emerg. Infect. Dis.* **22**, 1052–1056 (2016).
414. A. Wilder-Smith et al., Asymptomatic SARS coronavirus infection among healthcare workers, Singapore. *Emerg. Infect. Dis.* **11**, 1142–1145 (2005).
415. F. Perrotta et al., COVID-19 and the elderly: Insights into pathogenesis and clinical decision-making. *Aging Clin. Exp. Res.* **32**, 1599–1608 (2020).
416. P. Mehta et al., COVID-19: Consider cytokine storm syndromes and immunosuppression. *Lancet* **395**, 1033–1034 (2020).
417. M. E. Carter-Timofte et al., Deciphering the role of host genetics in susceptibility to severe COVID-19. *Front. Immunol.* **11**, 1606 (2020).
418. P. Conti, A. Younes, Coronavirus COVID-19/SARS-CoV-2 affects women less than men: Clinical response to viral infection. *J. Biol. Regul. Homeost. Agents* **34**, 339–343 (2020).
419. N. Le Bert et al., SARS-CoV-2-specific T cell immunity in cases of COVID-19 and SARS, and uninfected controls. *Nature* **584**, 457–462 (2020).
420. D. Whyte et al., Mumps epidemiology in the mid-west of Ireland 2004–2008: Increasing disease burden in the university/college setting. *Euro Surveill.* **14**, 19182 (2009).
421. Centers for Disease Control and Prevention, Mumps outbreak on a university campus—California, 2011. *MMWR Morb. Mortal. Wkly. Rep.* **61**, 986–989 (2012).
422. J. Lessler et al., Outbreak of 2009 pandemic influenza A (H1N1) at a New York City school. *N. Engl. J. Med.* **361**, 2628–2636 (2009).
423. C. Stein-Zamir et al., A large COVID-19 outbreak in a high school 10 days after schools’ reopening, Israel, May 2020. *Euro Surveill.* **25**, 2001352 (2020).
424. World Health Organization, Coronavirus disease (COVID-19). <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>. Accessed 14 August 2020.
425. G. J. Griffith et al., Collider bias undermines our understanding of COVID-19 disease risk and severity. *Nat. Commun.* **11**, 5749 (2020).
426. Centers for Disease Control and Prevention, Coronavirus Disease 2019 (COVID-19). <https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html>. Accessed 27 May 2020.
427. World Health Organization, Global research on coronavirus disease (COVID-19). <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov>. Accessed 4 May 2020.
428. J. A. Sterne et al., ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* **355**, i4919 (2016).
429. M. Borenstein, L. V. Hedges, J. P. T. Higgins, H. R. Rothstein, A basic introduction to fixed-effect and random-effects models for meta-analysis. *Res. Synth. Methods* **1**, 97–111 (2010).
430. R. DerSimonian, N. Laird, Meta-analysis in clinical trials. *Control. Clin. Trials* **7**, 177–188 (1986).
431. A. Agresti, B. A. Coull, Approximate is better than “exact” for interval estimation of binomial proportions. *null* **52**, 119–126 (1998).
432. J. Hartung, G. Knapp, On tests of the overall treatment effect in meta-analysis with normally distributed responses. *Stat. Med.* **20**, 1771–1782 (2001).
433. M. Egger, G. Davey Smith, M. Schneider, C. Minder, Bias in meta-analysis detected by a simple, graphical test. *BMJ* **315**, 629–634 (1997).