# Daily COVID-19 Literature Surveillance

April 3rd, 2020

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# Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1

New England Journal of Medicine March 17, 2020
DOI: 10.1056/NEJMc2004973

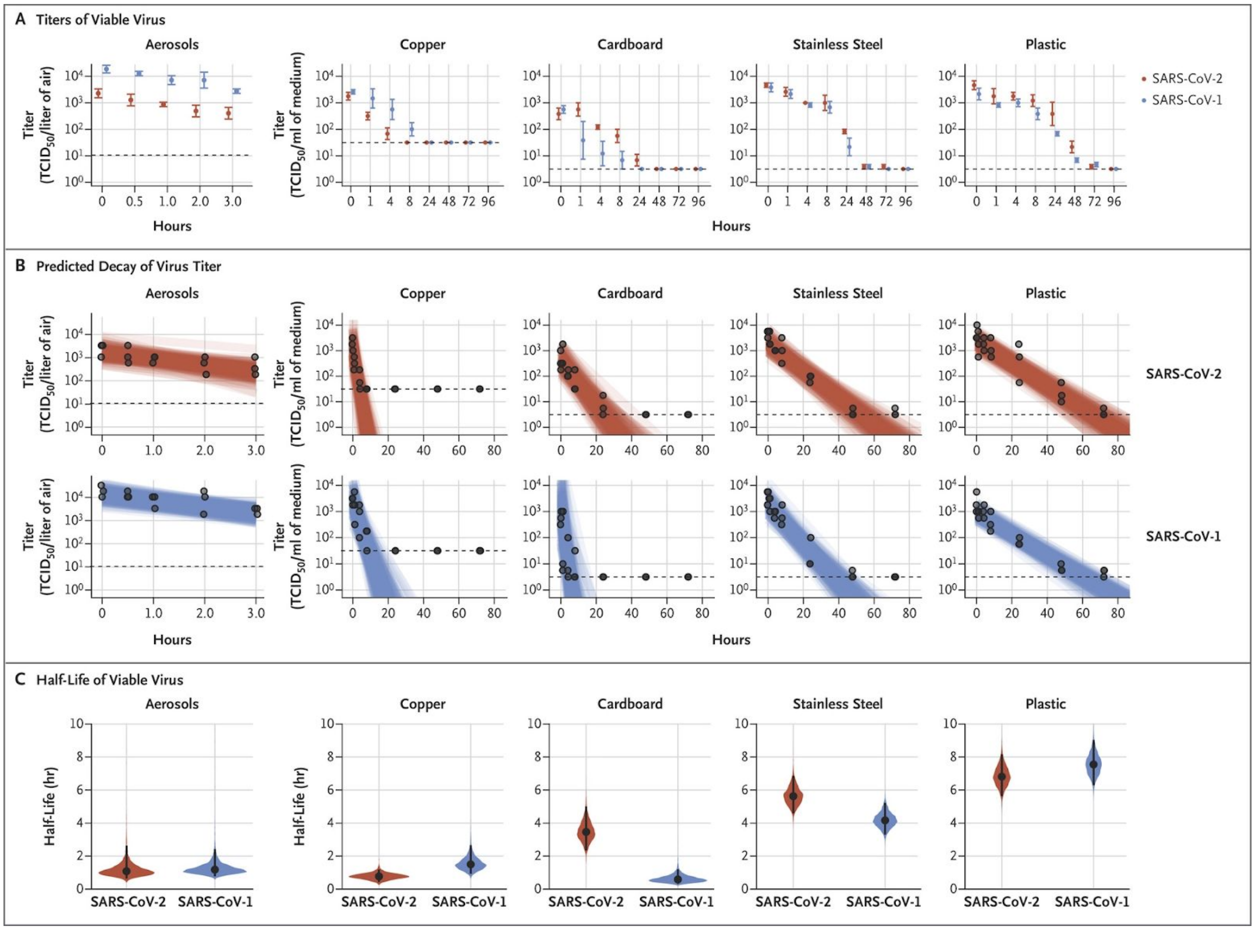



**Figure 1. Viability of SARS-CoV-1 and SARS-CoV-2 in Aerosols and on Various Surfaces.**

As shown in Panel A, the titer of aerosolized viable virus is expressed in 50% tissue-culture infectious dose (TCID50) per liter of air. Viruses were applied to copper, cardboard, stainless steel, and plastic maintained at 21 to 23°C and 40% relative humidity over 7 days. The titer of viable virus is expressed as TCID50 per milliliter of collection medium. All samples were quantified by end-point titration on Vero E6 cells. Plots show the means and standard errors ( bars) across three replicates. As shown in Panel B, regression plots indicate the predicted decay of virus titer over time; the titer is plotted on a logarithmic scale. Points show measured titers and are slightly jittered (i.e., they show small rapid variations in the amplitude or timing of a waveform arising from fluctuations) along the time axis to avoid overplotting. Lines are random draws from the joint posterior distribution of the exponential decay rate (negative of the slope) and intercept (initial virus titer) to show the range of possible decay patterns for each experimental condition. There were 150 lines per panel, including 50 lines from each plotted replicate. As shown in Panel C, violin plots indicate posterior distribution for the half-life of viable virus based on the estimated exponential decay rates of the virus titer. The dots indicate the posterior median estimates, and the black lines indicate a 95% credible interval. Experimental conditions are ordered according to the posterior median half-life of SARS-CoV-2. The dashed lines indicate the limit of detection, which was 3.33×100.5 TCID50 per liter of air for aerosols, 100.5 TCID50 per milliliter of medium for plastic, steel, and cardboard, and 101.5 TCID50 per milliliter of medium for copper.

# [From SARS to COVID-19: pathogens, receptor, pathogenesis and principles of the treatment].

PMID: 32238232Apr 3, 2020

Wang, X; Ding, Y QZhonghua Bing Li Xue Za Zhi

COVID-19 is an infectious disease caused by 2019-nCoV and characterizes as an atypical pneumonia. Since 2019-nCoV is a newly emerging virus, the pathogenesis of COVID-19 is not well known. Most patients had a self-limited course, and some became severe even death. In this review, the authors compared two coronavirus outbreaks during the past two decades: the SARS-CoV and 2019-nCoV. Among the biological nature of the pathogens, viral receptor distribution on the human cells, and the pathological findings in the targeted organs and clinical features of the patients with the diseases, found similarities and differences between the two diseases. Due to the shared receptor ACE2 and the pathological similarities of the SARS-CoV and 2019-nCoV diseases. They proposed a pathogenesis model for COVID-19. Like the SARS-CoV disease, COVID-19 is a systematic disease and targets the lungs, vasculatures, and the immune system. The basic pathogenesis involves two interlinked processes: a severe lung inflammation and immune deficiency, both of which are related to an inappropriate immune response and over-production of cytokines. Thus, treatment approaches should include antiviral and anti-proinflammatory cytokines, anti-infectious and life support therapies, especially in patients with severe diseases.

# Case Report: Walking Pneumonia in Novel Coronavirus Disease (COVID-19): Mild Symptoms with Marked Abnormalities on Chest Imaging.

PMID: 32238223Apr 3, 2020

Sivakorn, Chaisith; Luvira, Viravarn; Muangnoicharoen, Sant; Piroonamornpun, Pittaya; Ouppapong, Tharawit; Mungaomklang, Anek; Iamsirithaworn, SoponAm J Trop Med Hyg

This case report underlines the appearance of a "walking pneumonia" in a novel coronavirus disease (COVID-19) patient, with evidence of progressive lung involvement on chest imaging studies. The patient traveled from Wuhan, Hubei, China, to Thailand in January 2020. One of her family members was diagnosed with COVID-19. She presented to the hospital because of her concern, but she was without fever or any respiratory symptoms. Three days earlier, her nasopharyngeal and throat swabs revealed a negative severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) test by real-time reverse transcriptase polymerase chain reaction (RT-PCR). Her initial chest radiography was abnormal, and her first sputum SARS-CoV-2 test yielded inconclusive results. A subsequent sputum test was positive for SARS-CoV-2. Diagnosis in this patient was facilitated by chest imaging and repeat viral testing. Thus, chest imaging studies might enhance capabilities for early diagnosis of COVID-19 pneumonia.

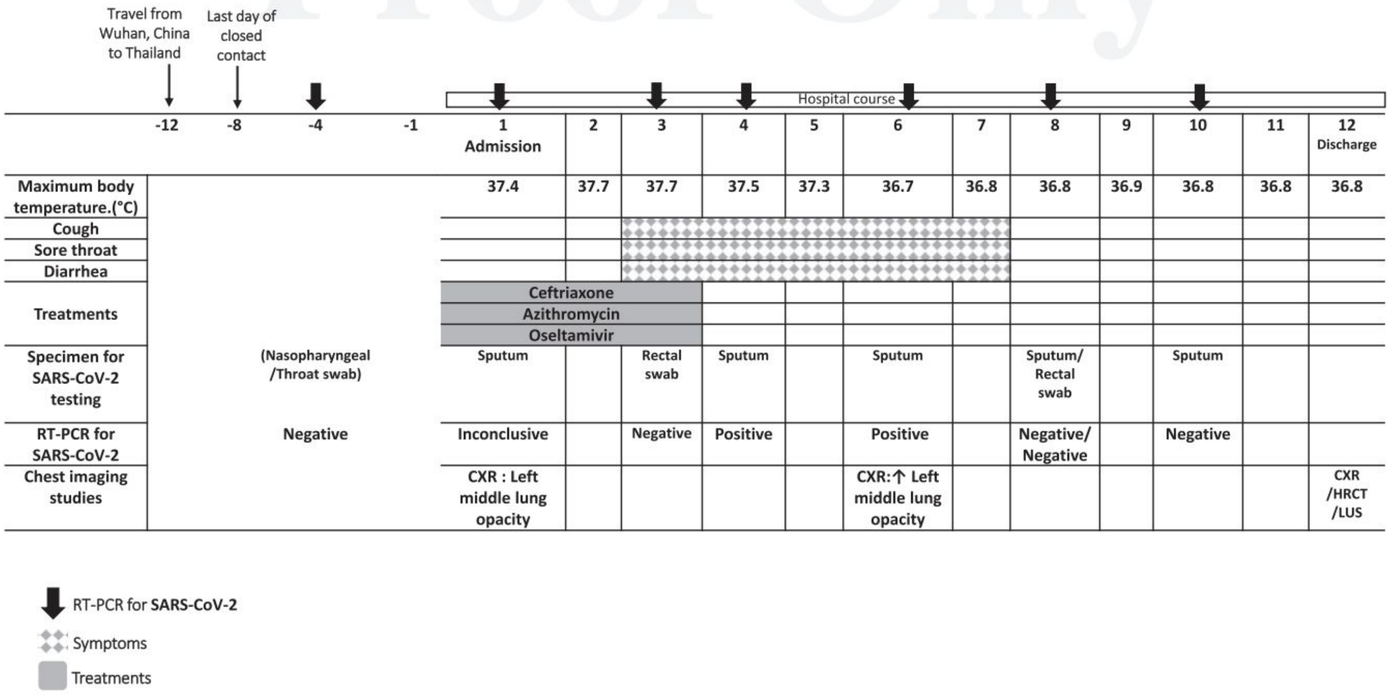



FIGURE 1. Timeline of exposure and disease course, from January 22, 2020 to February 14, 2020.

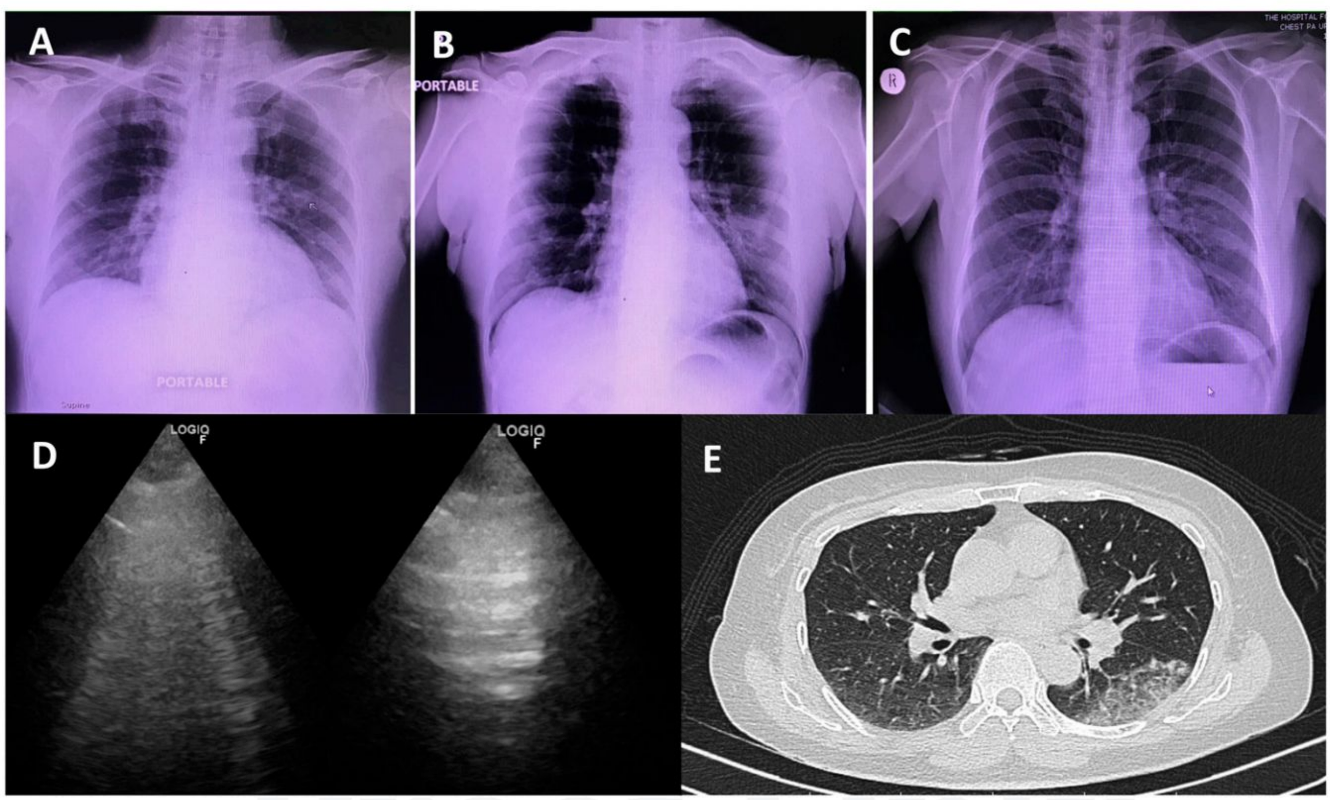



FIGURE 2. Three modalities of chest imaging studies in coronavirus disease 2019 patient. Chest radiographies (**A**, **B**, and **C**) were obtained on February 3, 8, and 14, 2020; chest ultrasonography and axial high-resolution computed tomography were obtained for the follow-up lung lesion on February 14, 2020.

# Diagnosis of the Coronavirus disease (COVID-19): rRT-PCR or CT?

PMID: 32229322Apr 2, 2020

Long, Chunqin; Xu, Huaxiang; Shen, Qinglin; Zhang, Xianghai; Fan, Bing; Wang, Chuanhong; Zeng, Bingliang; Li, Zicong; Li, Xiaofen; Li, HongluEur J Radiol

PURPOSE: To evaluate the diagnostic value of computed tomography (CT) and real-time reverse-transcriptase-polymerase chain reaction (rRT-PCR) for COVID-19 pneumonia.

METHODS: This retrospective study included all patients with COVID-19 pneumonia suspicion, who were examined by both CT and rRT-PCR at initial presentation. The sensitivities of both tests were then compared. For patients with a final confirmed diagnosis, clinical and laboratory data, in addition to CT imaging findings were evaluated.

RESULTS: A total of 36 patients were finally diagnosed with COVID-19 pneumonia. Thirty-five patients had abnormal CT findings at presentation, whereas one patient had a normal CT. Using rRT-PCR, 30 patients were tested positive, with 6 cases initially missed. Amongst these 6 patients, 3 became positive in the second rRT-PCR assay(after 2 days, 2 days and 3 days respectively), and the other 3 became positive only in the third round of rRT-PCR tests(after 5 days, 6 days and 8 days respectively). At presentation, CT sensitivity was therefore 97.2%, whereas the sensitivity of initial rRT-PCR was only 83.3%.

**CONCLUSION: rRT-PCR may produce initial false negative results. We suggest that patients with typical CT findings but negative rRT-PCR results should be isolated, and rRT-PCR should be repeated to avoid misdiagnosis.**

**Table 1**
Demographic and Clinical Characteristics of the 87 patients suspected with COVID-19 pneumonia ($x \pm s$)

| Variable | COVID-19 (N = 36) | Control group (N = 51) | P |
|---|---|---|---|
| Gender | | | |
| Female | 16 | 25 | 0.674 |
| Male | 20 | 26 | |
| Age(year) | 44.8 ± 18.2 | 47.1 ± 18.8 | 0.597 |
| Exposure History | 33(91.7%) | 29(56.8%) | 0.000 |
| Duration of fever (days) | 2.6 ± 1.7 | 3.2 ± 1.6 | 0.781 |
| leukocyte count (normal or decreased) | 33(91.7%) | 21(41.2%) | 0.000 |
| lymphocytes (decreased) | 23(63.8%) | 12(23.5%) | 0.000 |
| fasting glucose (increased) | 17(47.2%) | 14(27.5%) | 0.058 |

Exposure History was defined as having been to Wuhan within 2 weeks or having been exposed to infected patients. Normal leukocyte counts: (4.0-10.0)$\times 10^9$/L, normal percentage of lymphocytes: 20%-50%, normal fasting glucose level: 3.9-6.1 mmol/L.

**Table 2**
CT Imaging findings in the 87 patients suspected with COVID-19 pneumonia.

| Group | COVID-19 pneumonia (n=36) | Control group (n=51) | *P* |
|---|---|---|---|
| Distribution of the lesions | | | |
| left upper lobe | 20/36 (55.6%) | 17/51 (33.3%) | 0.039 |
| left lower lobe | 24/36 (66.7%) | 35/51 (68.6%) | 0.847 |
| right upper lobe | 19/36 (52.7%) | 19/51 (37.3%) | 0.151 |
| right middle lobe | 20/36 (55.6%) | 26/51 (50.9%) | 0.674 |
| right lower lobe | 26/36 (72.2%) | 33/51 (64.7%) | 0.460 |
| Peripheral/central | 26: 10 (2.6 : 1) | 24: 26 (0.92 : 1) | 0.025 |
| multiple/single | 25: 11 (2.27 : 1) | 31: 20 (1.55 : 1) | 0.406 |
| Pattern of the lesions | | | |
| GGO | 11/36 (30.6%) | 8/51 (15.7%) | 0.098 |
| Consolidation | 6/36 (16.7%) | 22/51 (43.1%) | 0.001 |
| GGO with consolidation | 19/36 (52.7%) | 21/51 (41.2%) | 0.285 |
| Lymphadenopathy | 1/36 (2.78%) | 4/51 (7.84%) | 0.317 |
| pleural effusion | 2/36 (5.56%) | 7/51 (13.73%) | 0.218 |

# Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases.

PMID: 32101510Feb 27, 2020

Ai, Tao; Yang, Zhenlu; Hou, Hongyan; Zhan, Chenao; Chen, Chong; Lv, Wenzhi; Tao, Qian; Sun, Ziyong; Xia, LimingRadiology

Background: Chest CT is used for diagnosis of 2019 novel coronavirus disease (COVID-19), as an important complement to the reverse-transcription polymerase chain reaction (RT-PCR) tests. Purpose To investigate the diagnostic value and consistency of chest CT as compared with comparison to RT-PCR assay in COVID-19.

Methods: From January 6 to February 6, 2020, 1014 patients in Wuhan, China who underwent both chest CT and RT-PCR tests were included. With RT-PCR as reference standard, the performance of chest CT in diagnosing COVID-19 was assessed. Besides, for patients with multiple RT-PCR assays, the dynamic conversion of RT-PCR results (negative to positive, positive to negative, respectively) was analyzed as compared with serial chest CT scans for those with time-interval of 4 days or more.

Results: Of 1014 patients, 59% (601/1014) had positive RT-PCR results, and 88% (888/1014) had positive chest CT scans. The sensitivity of chest CT in suggesting COVID-19 was 97% (95%CI, 95-98%, 580/601 patients) based on positive RT-PCR results. In patients with negative RT-PCR results, 75% (308/413) had positive chest CT findings; of 308, 48% were considered as highly likely cases, with 33% as probable cases. By analysis of serial RT-PCR assays and CT scans, the mean interval time between the initial negative to positive RT-PCR results was 5.1 +/- 1.5 days; the initial positive to subsequent negative RT-PCR result was 6.9 +/- 2.3 days). 60% to 93% of cases had initial positive CT consistent with COVID-19 prior (or parallel) to the initial positive RT-PCR results. 42% (24/57) cases showed improvement in follow-up chest CT scans before the RT-PCR results turning negative.

**Table 1. Characteristics of the included 1014 patients.**

| Characteristic | Results |
|---|---|
| **Age (years)** | |
| Mean age | 51 ± 15, Range of 2 to 95 |
| < 20 | 7 (1) |
| 20-39 | 267 (26) |
| 40-59 | 409 (40) |
| ≥ 60 | 331 (33) |
| **Male** | 467 (46) |
| **Median time-interval between chest CT scan and RT-PCR assay (days)** | 1, Range of 0 to 7 |
| **Results of RT-PCR assay** | |
| Positive | 601 (59) |
| Negative | 413 (41) |
| **Findings and manifestations of chest CT** | |
| Consistent with viral pneumonia (positive) | 888 (88) |
| Ground-glass opacity | 409/888 (46) |
| Consolidation | 447/888 (50) |
| Reticulation/thickened interlobular septa | 8/888 (1) |
| Nodular lesions | 24/888 (3) |
| No CT findings of viral pneumonia | 126 (12) |

Note.-Data are patients (n =7) with percentages in parentheses. Age is mean ± standard deviation. Time-interval is shown as median.
RT-PCR= reverse transcription polymerase chain reaction.

**Table 2: The performance of chest CT for COVID-19 infection with RT-PCR result as reference.**

| | Results (n) | | | | Test performance (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | TP | TN | FP | FN | Sensitivity [95% CI] | Specificity [95% CI] | PPV [95% CI] | NPV [95% CI] | Accuracy [95% CI] |
| **Overall** | | | | | | | | | |
| | 580 | 105 | 308 | 21 | 97 (580/601) [95-98] | 25 (105/413) [22-30] | 65 (580/888) [62-68] | 83 (105/126) [76-89] | 68 (685/1014) [65-70] |
| **Age** | | | | | | | | | |
| **< 60 years** | 362 | 81 | 225 | 15 | 96 (362/377) [94-98] | 27 (81/306) [22-32] | 62 (362/587) [58-66] | 84 (81/96) [76-90] | 65 (443/683) [61 -68] |
| **≥ 60 years** | 218 | 24 | 83 | 6 | 97 (218/224) [94 -99] | 22 (24/107) [16-31] | 72 (218/301) [67-77] | 80 (24/30) [63-91] | 73 (242/331) [68-78] |
| **Sex** | | | | | | | | | |
| **Male** | 272 | 35 | 148 | 12 | 96 (272/284) [93-98] | 19 (35/183) [14-25] | 65 (272/420) [60-69] | 75 (35/47) [61-85] | 66 (307/467) [61-70] |
| **Female** | 308 | 70 | 160 | 9 | 97 (308/317) [95-99] | 30 (70/230) [25-37] | 66 (308/468) [61-70] | 89 (70/79) [80-94] | 69 (378/547) [65 -73] |

TP= true positive, TN=true negative, FP=false positive, FN=false negative, PPV= positive predictive value, NPV=negative predictive value, RT-PCR= reverse transcription polymerase chain reaction.
Data in parentheses are numbers of patients used to calculate percentages. Data in brackets are 95% confidence intervals.

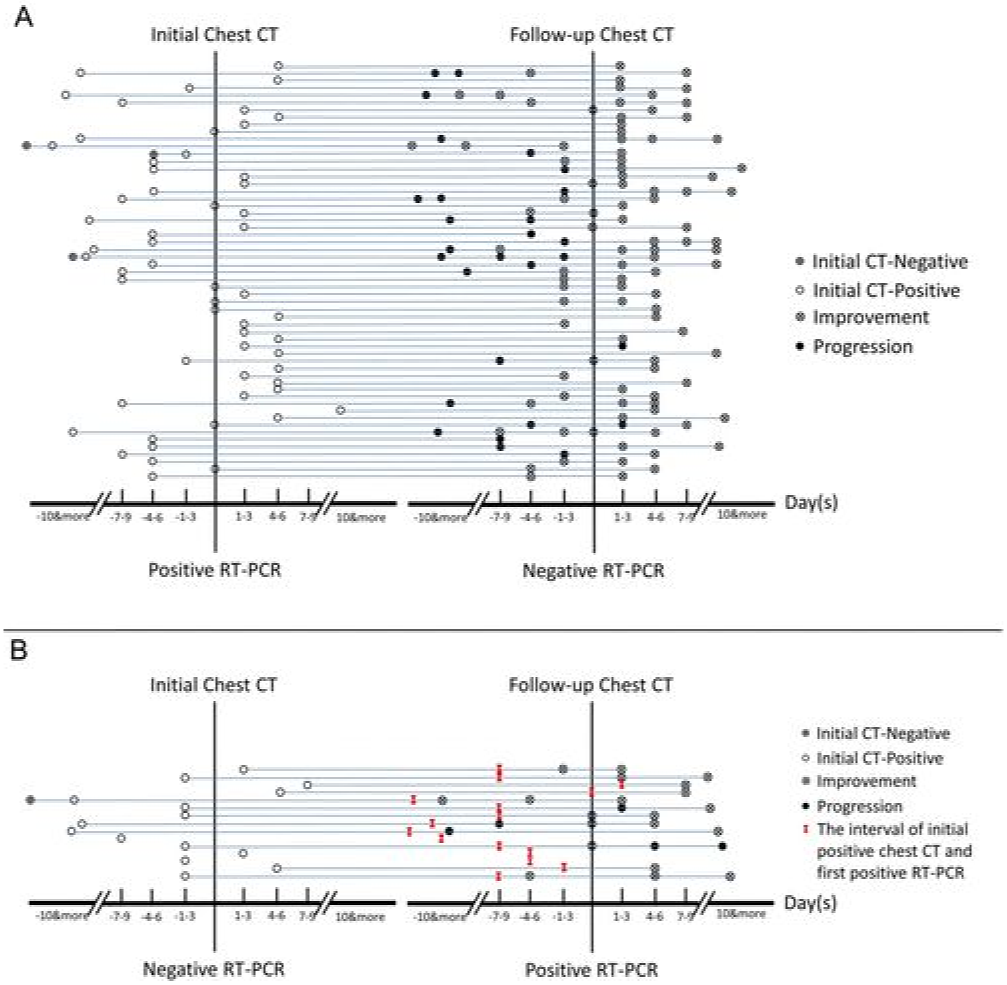



**Figure 7:** Analysis of serial RT-PCR assays in correlation with serial chest CT scans. (A) The subgroup of positive to negative RT-PCR results (n = 57). (B) The subgroup of negative to positive RT-PCR results (n = 15). The horizontal axis is the time point of initial chest CT and follow-up chest CT scans relative to the time point of the consecutive two RT-PCR tests (before positive RT-PCR, negative numbers; after RT-PCR, positive numbers).

**Conclusion: Chest CT has a high sensitivity for diagnosis of COVID-19. Chest CT may be considered as a primary tool for the current COVID-19 detection in epidemic areas.**

# The Role of Emergency Radiology in COVID-19: From Preparedness to Diagnosis.

PMID: 32233876 Apr 3, 2020

Nasir, Muhammad Umer; Roberts, James; Muller, Nestor L; Macri, Francesco; Mohammed, Mohammed F; Akhlaghpoor, Shahram; Parker, William; Eftekhari, Arash; Rezaei, Susan; Mayo, John; Nicolaou, Savvas Can Assoc Radiol J

"Although PCR is the gold standard for confirming infection, chest CT has been shown to be more sensitive for the detection of COVID-19. Polymerase chain reaction–negative cases with positive CT findings and high clinical suspicion may benefit from repeat PCR testing.[10] Despite the higher sensitivity of CT, up to 15% to 20% of patients with confirmed infection will have no parenchymal findings on chest CT within the earliest phase of infection,[11,12] Bai et al has reported high specificity (93%-100%) of CT in differentiating COVID-19 from other viral pneumonia; however, the sensitivity is in the range of 70 to 93%.[13] Chest radiographs can be used in monitoring disease progression, coinfection, or stability especially in critically ill patients."

# Asymptomatic and Presymptomatic SARS-CoV-2 Infections in Residents of a Long-Term Care Skilled Nursing Facility - King County, Washington, March 2020.

PMID: 32240128 Apr 3, 2020

Kimball, Anne; Hatfield, Kelly M; Arons, Melissa; James, Allison; Taylor, Joanne; Spicer, Kevin; Bardossy, Ana C; Oakley, Lisa P; Tanwar, Sukarma; Chisty, Zeshan; Bell, Jeneita M; Methner, Mark; Harney, Josh; Jacobs, Jesica R; Carlson, Christina M; McLaughlin, Heather P; Stone, Nimalie; Clark, Shauna; Brostrom-Smith, Claire; Page, Libby C; Kay, Meagan; Lewis, James; Russell, Denny; Hiatt, Brian; Gant, Jessica; Duchin, Jeffrey S; Clark, Thomas A; Honein, Margaret A; Reddy, Sujan C; Jernigan, John AMMWR Morb Mortal Wkly Rep

Older adults are susceptible to severe coronavirus disease 2019 (COVID-19) outcomes as a consequence of their age and, in some cases, underlying health conditions (1). A COVID-19 outbreak in a long-term care skilled nursing facility (SNF) in King County, Washington that was first identified on February 28, 2020, highlighted the potential for rapid spread among residents of these types of facilities (2). On March 1, a health care provider at a second long-term care skilled nursing facility (facility A) in King County, Washington, had a positive test result for SARS-CoV-2, the novel coronavirus that causes COVID-19, after working while symptomatic on February 26 and 28. By March 6, seven residents of this second facility were symptomatic and had positive test results for SARS-CoV-2. On March 13, CDC performed symptom assessments and SARS-CoV-2 testing for 76 (93%) of the 82 facility A residents to evaluate the utility of symptom screening for identification of COVID-19 in SNF residents. Residents were categorized as asymptomatic or symptomatic at the time of testing, based on the absence or presence of fever, cough, shortness of breath, or other symptoms on the day of testing or during the preceding 14 days. **Among 23 (30%) residents with positive test results, 10 (43%) had symptoms on the date of testing, and 13 (57%) were asymptomatic.** Seven days after testing, 10 of these 13 previously asymptomatic residents had developed symptoms and were recategorized as presymptomatic at the time of testing. The reverse transcription-polymerase chain reaction (RT-PCR) testing cycle threshold (Ct) values indicated large quantities of viral RNA in asymptomatic, presymptomatic, and symptomatic residents, suggesting the potential for transmission regardless of symptoms. **Symptom-based screening in SNFs could fail to identify approximately half of residents with COVID-19.** Long-term care facilities should take proactive steps to prevent introduction of SARS-CoV-2 (3). Once a confirmed case is identified in an SNF, all residents should be placed on isolation precautions if possible (3), with considerations for extended use or reuse of personal protective equipment (PPE) as needed (4).

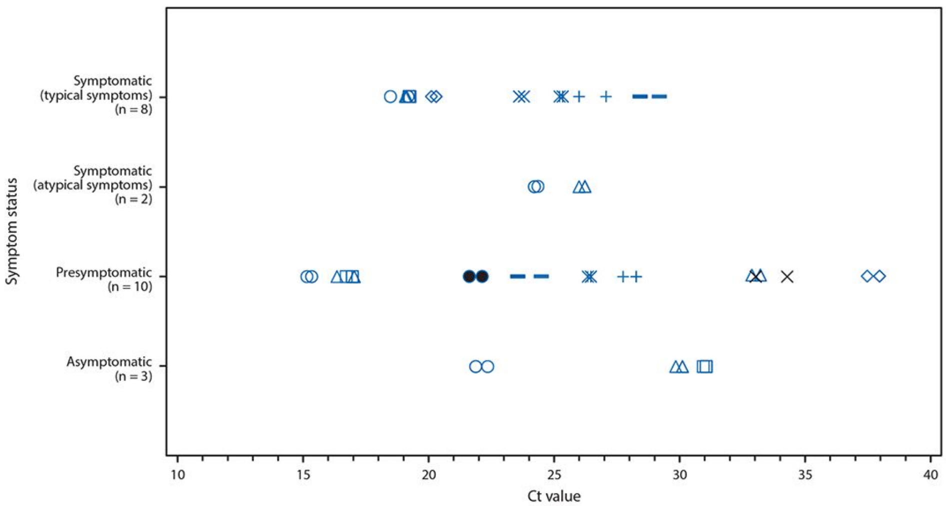
| Characteristic | Initial SARS-CoV-2 test results | |
|---|---|---|
| | **Negative, no. (%)** | **Positive, no. (%)** |
| Overall | 53 (100) | 23 (100) |
| Women | 32 (60.4) | 16 (69.6) |
| Age, mean (SD) | 75.1 (10.9) | 80.7 (8.4) |
| Current smoker† | 7 (13.2) | 1 (4.4) |
| Long-term admission type to facility A | 35 (66.0) | 15 (65.2) |
| Length of stay in facility A before test date, days, median (IQR) | 94 (40–455) | 70 (21–504) |
| Symptoms in last 14 days | | |
| Symptomatic | 13 (24.5) | 10 (43.5) |
| At least one typical COVID-19 symptom§ | 9 (17.0) | 8 (34.8) |
| Only atypical COVID-19 symptoms¶ | 4 (7.5) | 2 (8.7) |
| Asymptomatic | 40 (75.5) | 13 (56.5) |
| No symptoms | 32 (60.4) | 8 (34.8) |

| | | |
|---|---|---|
| Only stable, chronic symptoms | 8 (15.1) | 5 (21.7) |
| Specific signs and symptoms reported as new or worse in last 14 days | | |
| Typical symptoms | | |
| Fever | 3 (5.7) | 1 (4.3) |
| Cough | 6 (11.3) | 7 (30.4) |
| Shortness of breath | 0 (0) | 1 (4.4) |
| Atypical symptoms | | |
| Malaise | 1 (1.9) | 4 (17.4) |
| Nausea | 0 (0) | 3 (13.0) |
| Sore throat | 2 (3.8) | 2 (8.7) |
| Confusion | 2 (3.8) | 1 (4.4) |
| Dizziness | 1 (1.9) | 1 (4.4) |
| Diarrhea | 3 (5.7) | 1 (4.4) |
| Rhinorrhea/Congestion | 1 (1.9) | 0 (0) |
| Myalgia | 0 (0) | 0 (0) |
| Headache | 0 (0) | 0 (0) |
| Chills | 0 (0) | 0 (0) |

| | | |
|---|---|---|
| Any preexisting medical condition listed | 53 (100) | 22 (95.7) |
| Specific conditions** | | |
| Chronic lung disease | 16 (30.2) | 10 (43.5) |
| Diabetes | 20 (37.7) | 9 (39.1) |
| Cardiovascular disease | 36 (67.9) | 20 (87.0) |
| Cerebrovascular accident | 19 (35.9) | 8 (34.8) |
| Renal disease | 18 (34.0) | 9 (39.1) |
| Received hemodialysis | 2 (3.8) | 2 (8.7) |
| Cognitive Impairment | 28 (52.8) | 13 (56.5) |
| Obesity | 11 (20.8) | 6 (26.1) |

Abbreviations: COVID-19 = coronavirus disease 2019; IQR = interquartile range, SD = standard deviation.
* Testing performed on March 13, 2020.
† Unknown for one resident with negative test results.
§ Typical symptoms include fever, cough, and shortness of breath.
¶ Atypical symptoms include chills, malaise, sore throat, increased confusion, rhinorrhea or nasal congestion, myalgia, dizziness, headache, nausea, and diarrhea.
** Residents might have multiple conditions

**FIGURE. Cycle threshold (Ct) values* for residents of a long-term care skilled nursing facility with positive test results for SARS-CoV-2 by real-time reverse transcription–polymerase chain reaction on March 13, 2020 (n = 23), by symptom status†,§ at time of test — facility A, King County, Washington**




* Ct values are the number of cycles needed for detection of each genetic marker identified by real-time reverse transcription–polymerase chain reaction testing. A lower Ct value indicates a higher amount of viral RNA. Paired values for each resident are depicted using a different shape. Each resident has two Ct values for the two genetic markers (N1 and N2 nucleocapsid protein gene regions).

† Typical symptoms include fever, cough, and shortness of breath.

§ Atypical symptoms include chills, malaise, sore throat, increased confusion, rhinorrhea or nasal congestion, myalgia, dizziness, headache, nausea, and diarrhea.

# SARS-CoV-2 is not detectable in the vaginal fluid of women with severe COVID-19 infection.

PMID: 32241022Apr 3, 2020

Qiu, Lin; Liu, Xia; Xiao, Meng; Xie, Jing; Cao, Wei; Liu, Zhengyin; Morse, Abraham; Xie, Yuhua; Li, Taisheng; Zhu, LanClin Infect Dis

**BACKGROUND:** Severe acute respiratory syndrome coronavirus 2(SARS-CoV-2) is mainly spread through respiratory droplets or direct contact. But the infection condition of genital system is still unknown. This study aimed to evaluate whether or not SARS-CoV-2 is found in the vaginal fluid of women with COVID-19 illness.

**METHODS:** 10 women with confirmed severe COVID-19 pneumonia admitted to in Tongji Zhongfa Hospital Intensive care union(ICU) ward from Feb 4, 2020 to Feb 24, 2020 were included. Clinical records, laboratory results, and computer tomography(CT)-scan examination were retrospectively reviewed. The evidence of genital infection potential was accessed by testing for the presence of SARS-CoV-2 in vaginal fluids obtained from vaginal swab samples. Reverse transcriptase polymerase chain reaction(RT-PCR) was used to confirm the SARS-CoV-2 infection in vaginal fluids. [COVID-19 was diagnosed on the basis of WHO interim guidance World Health Organization9 . A confirmed case of COVID-19 was defined as a positive result on RTPCR assay of nasal and/or pharyngeal swab specimens2 . RT-PCR assays were performed in accordance with the protocol established by the WHO .

**RESULTS:** The clinical characteristics of these ten women were similar to those reported severe COVID-19 patients. All ten patients were tested for SARS-CoV-2 in vaginal fluid, and all samples tested negative for the virus. CONCLUSION: Findings from this small group of cases suggest that no SARS-CoV-2 virus existing in the vaginal fluids of severe COVID-19 patients.

**Caveats:** Vaginal samples were taken from post menopausal woman, 14+ days after symptom onset

# An investigation of transmission control measures during the first 50 days of the COVID-19 epidemic in China.

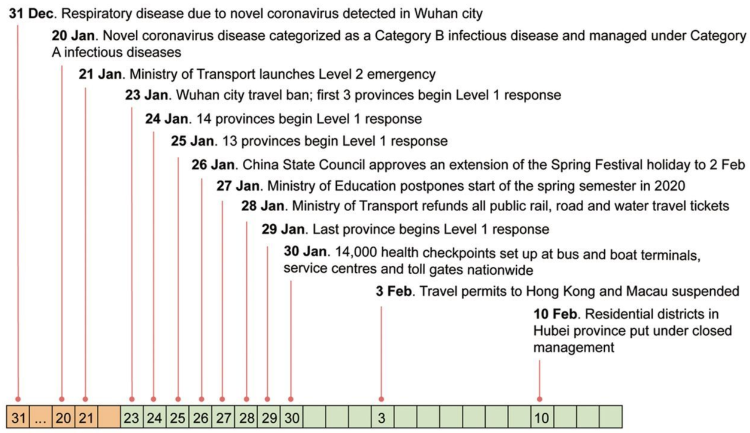
PMID: 32234804Apr 3, 2020

Tian, Huaiyu; Liu, Yonghong; Li, Yidan; Wu, Chieh-Hsi; Chen, Bin; Kraemer, Moritz U G; Li, Bingying; Cai, Jun; Xu, Bo; Yang, Qiqi; Wang, Ben; Yang, Peng; Cui, Yujun; Song, Yimeng; Zheng, Pai; Wang, Quanyi; Bjornstad, Ottar N; Yang, Ruifu; Grenfell, Bryan T; Pybus, Oliver G; Dye, Christopher Science

**Abstract**

Responding to an outbreak of a novel coronavirus (agent of COVID-19) in December 2019, China banned travel to and from Wuhan city on 23 January and implemented a national emergency response. We investigated the spread and control of COVID-19 using a unique data set including case reports, human movement and public health interventions. The Wuhan shutdown was associated with the delayed arrival of COVID-19 in other cities by 2.91 days (95%CI: 2.54-3.29). Cities that implemented control measures pre-emptively reported fewer cases, on average, in the first week of their outbreaks (13.0; 7.1-18.8) compared with cities that started control later

(20.6; 14.5-26.8). Suspending intra-city public transport, closing entertainment venues and banning public gatherings were associated with reductions in case incidence. The national emergency response appears to have delayed the growth and limited the size of the COVID-19 epidemic in China, averting hundreds of thousands of cases by 19 February (day 50).



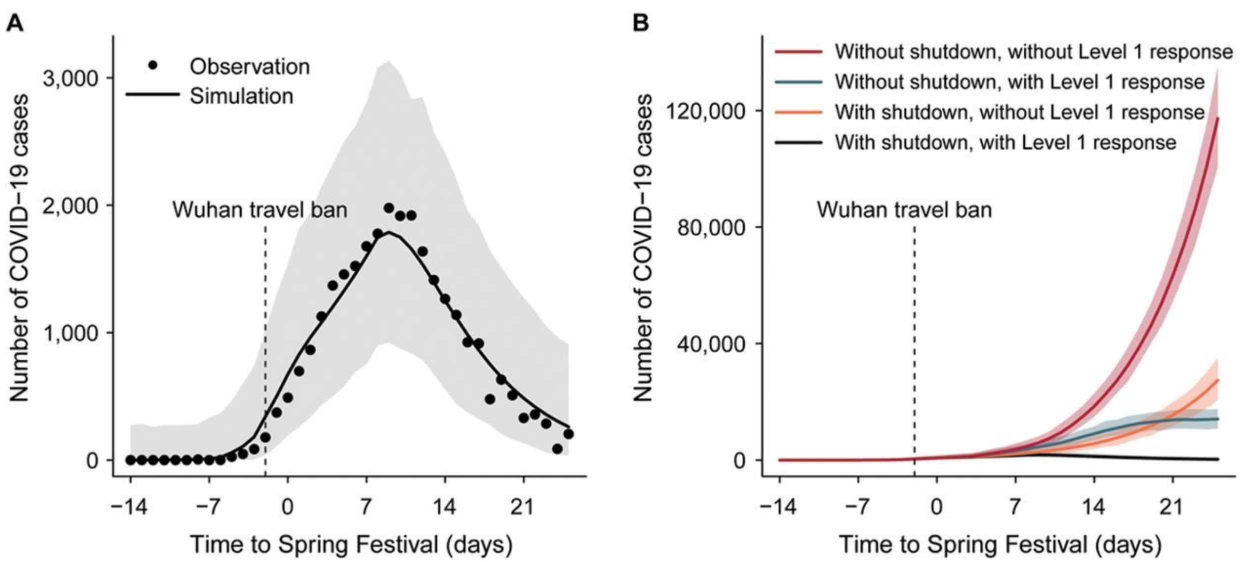




**Fig. 4 The role of interventions in controlling the COVID-19 outbreak across China.**

(**A**) Epidemic model (line) fitted to daily reports of confirmed cases (points) summed across 31 provinces. Hubei excludes Wuhan city. (**B**) Expected epidemic trajectories without the Wuhan travel ban (shutdown), and with (green) or without (red) interventions carried out as part of the Level 1 national emergency response; with the Wuhan travel ban, and with (black) or without the intervention (orange). Vertical dashed lines in both panels mark the date of the Wuhan travel ban and the start of the emergency response, on 23 January. Shaded regions in A and B mark the 95% prediction envelopes.