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RESEARCH ARTICLE

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Analysis of the positive rate of 4254 cases of COVID-19 nucleic acid tests in different aites in Wuhan, China

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Abstract

There's an outbreak of coronavirus diesase 2019 (COVID-19) since December 2019, first in Wuhan. It has caused huge medical challenges to Hubei Province with currently more than 67 thousand confirmed cases till 8th March 2020. Identification, there is no clinically effective drug. Isolation and masks are essential to limit human-to-human transmission initially. The nucleic acid test (NAT) of COVID-19 currently was the most reliable established laboratory diagnosis method in clinical. From 8th February to 7th March 2020, 4254 cases were collected for analysis at six nucleic acid collection sites in the community medical team of Hubei Provincial Hospital of Traditional Chinese Medicine, which cover almost all groups who need NAT in Wuhan. Distribution of positive rates in different sites by genders, ages, or occupations were compared. The positive rates of different sites from high to low were: hospital wards (24.71%) > fever clinics (16.57%) > nursing homes (5.51%) > isolation hotels (5.30%) > rehabilitation stations (1.36%) >close contact sites (0.17%). The confirmed patients in isolation hotels, hospital ward, and fever clinical were mainly middle-aged and elderly, and most of them were women. The positive rate in isolation hotels and fever clinics gradually decreased over time. There were no significant differences between genders among those six nucleic acid collection sites ($P < .05$). The hospital wards have the highest positive rate; however, close contact sites have lowest one. Patients who are discharged from hospitals may still have potential risks. Middle-aged and older people remain the focus of epidemic prevention and control.

KEYWORDS

COVID-19, novel coronavirus pneumonia, nucleic acid test, positive rate

1 | INTRODUCTION

The reverse transcription-polymerase chain reaction (RT-PCR) detection of the viral nucleic acid test (NAT) currently is one of the most quickly established laboratory diagnosis methods in coronavirus disease 2019 (COVID-19). It has high sensitivity and specificity, detecting novel coronavirus quickly and accurately, and providing a basis for early clinical diagnosis and treatment.[1,2] The results of RT-PCR detection are also the main basis for discharge and isolation of confirmed patients. Since the establishment of the community medical team of Hubei Provincial Hospital of Traditional Chinese Medicine, it has been mainly responsible for the NAT of multiple isolation hotels (suspected cases) in Hongshan District, Wuhan City. Later, it also took charge of close contact sites (direct

contact with COVID-19), nursing homes, rehabilitation stations (discharged from the hospital), hospital wards (confirmed patients), and fever clinics. Almost all groups who be asked to do NAT are included in those six nucleic acid collection sites. In this paper, our medical team will analyze the RT-PCR results of the six nucleic acid collection sites to discuss the distribution of positive rates of COVID-19.

2 | DATA AND METHODS

2.1 | Data collection

Four thousand two-hundred and fifty-four cases from 8th February to 7th March were tested at different nucleic acid collection sites in the Hongshan District of Wuhan. Cases information, including name, gender, age, ID, etc, was collected after NAT with oropharyngeal swabs. Close contact sites were the cases that contact with confirmed patients with COVID-19 directly. Isolation hotels mainly receive suspected cases. Rehabilitation stations accept patients with COVID-19 who discharged from the hospital, and needed to be isolated for 2 weeks before returning home. Nursing homes, as a special place, are paid attention to people gradually in the later period since the first infected patient was confirmed in prison. Hospital wards are the patients who confirmed. Fever clinics are patients with fever as the main complaint. This study was approved by the Ethics Committee of the Hubei University of Traditional Chinese Medicine (HBZY2020-C25-01), the need for informed consent was waived.

2.2 | Nucleic acid tests

All of cases collect oropharyngeal secretions. The nurse checks information carefully under the third-level protection. Afterwards, the doctor holds an oropharynx swab to scrape the patient's secretion, and puts it into a nucleic acid kit for storage. We will send all specimens for inspection on the same day. The nucleic acid kit of hospital wards was sent to the laboratory of Hubei Provincial Hospital of Traditional Chinese Medicine for testing (cell preservation solution: Zhongzhi Biology, SC-001; disposable oropharynx swab: Shenzhen Merikelin Technology Company, 2020020146). While others were sent to Wuhan Kedwis Medical Laboratory (cell preservation solution: Youkang Biology, 01200218; sampling swab: Youkang Hengye, Y25200101). Laboratory strictly accordance with the "novel coronavirus infection pneumonia laboratory technology Guide (2nd edition)"[3] and the "National Health Commission Office of Health on the issuance of new coronavirus Laboratory Biosafety Guidelines (2nd edition) Notice"[4] relevant documents for biosafety protection and experimental operations. RT-PCR technology was used for RNA extraction and amplification detection. According to the kit instructions, with RdRP, E and N gene were taken as target genes, $C_t/C_q = 43$ is the baseline for interpretation of the results (negative [N], single-positive [SP], double-positive [DP]).

2.3 | Real-time reverse-transcription polymerase chain reaction

A 25 μL reaction contained 5 μL of RNA, 12.5 μL of 2× reaction buffer provided with the Superscript III one step RT-PCR system with Platinum Taq Polymerase (Invitrogen, Darmstadt, Germany; containing 0.4 mM of each deoxyribont triphosphates and 3.2 mM magnesium sulfate), 1 μL of reverse transcriptase/Taq mixture from the kit, 0.4 μL of a 50 mM magnesium sulfate solution (Invitrogen), and 1 μg of nonacetylated bovine serum albumin (Roche). All oligonucleotides were synthesized and provided by Tib-Molbiol (Berlin, Germany). Thermal cycling was performed at 55°C for 10 minutes for reverse transcription, followed by 95°C for 3 minutes and then 45 cycles of 95°C for 15 seconds, 58°C for 30 seconds.

2.4 | Statistical analysis

SPSS 18.0 was used for statistical analysis. The count data were expressed in terms of cases and percentages. The χ^2 test and rank analysis were used to compare intergroup differences. Statistical significance was defined as $P < .05$.

3 | RESULTS

3.1 | Basic information

A total of 4254 effective nucleic acid detection specimens were collected within 1 month (4 weeks) from six nucleic acid collection sites (Table 1). Among them, there were 1997 males and 2257 females. The age of patients was from 2 days to 99 years with the average age of 54.98 years. The positive rate of close contact sites is the lowest (0.17%), however, which of hospital ward is the highest one (24.71%).

3.2 | Close contact sites

Only 1 positive case was confirmed in close contact sites, while 2 out of 288 were single positive. Both of them were women (Table 2). Comparing the differences in nucleic acid detection results between males and females, the χ^2 test (put SP and DP as a group) showed $P = .236 > .05$. There was no statistically significant difference.

3.3 | Isolation hotels

Isolation hotels are the suspected patients of fever, fatigue, or dry cough, but have not been detected nucleic acid or NAT results were negative. A total of 1716 cases were collected, including 767 males and 949 females (Table 3). The double-positive rate is 5.22% for males, while the female is 5.37%. Comparison of the nucleic acid detection results of the differences between genders. There is

TABLE 1 The nucleic acid test results of nucleic acid collection sites

Sites	Total	Gender		N	SP	DP	N rate (%)	SP rate (%)	DP rate (%)	Date, wk
		M	F							
Close contact sites	583	295	288	580	2	1	99.49	0.34	0.17	4st
Isolation hotels	1716	767	949	1599	26	91	93.18	1.52	5.30	1-4th
Recovery points	661	342	319	654	1	6	98.49	0.15	1.36	4th
Nursing homes	272	95	177	240	17	15	88.24	6.25	5.51	3rd
Hospital wards	340	158	182	256	0	84	75.29	0.00	24.71	4th
Fever clinics	682	340	342	550	19	113	80.65	2.79	16.57	1-4th

Abbreviations: DP, double-positive; N, negative; SP, single-positive.

TABLE 2 The nucleic acid test results of close contact sites

Gender	Total	N	SP	DP	N rate (%)	SP rate (%)	DP rate (%)
Male	295	295	0	0	0.00	0.00	0.00
Female	288	285	2	1	98.96	0.69	0.35
χ^2		1.389					
P value		.236					

Abbreviations: DP, double-positive; N, negative; SP, single-positive.

TABLE 3 The nucleic acid test results of isolation hotels

Gender	Total	N	SP	DP	N rate (%)	SP rate (%)	DP rate (%)
Male	767	713	14	40	92.96	1.83	5.22
Female	949	886	12	51	93.36	1.26	5.37
χ^2		0.908					
P value		.635					

Abbreviations: DP, double-positive; N, negative; SP, single-positive.

no obvious gender difference statistically during sample collection ($P < .05$).

All personnel in the isolation hotels are classified according to the testing date (by weeks), and the number of specimens and positive rate are shown in Table 4. Except for the first week, the positive rate of NAT gradually decreased over time. Statistical analysis of the weekly nucleic acid test results, the χ^2 test result showed there was a significant difference. The rate of DP from 2nd to 4th are 8.46% >4.16% >0%.

A total of 91 (5.30%) cases of NAT results are positive. Among them, 40 (43.96%) cases are males while 51 (56.04%) cases are females.

TABLE 4 The nucleic acid test results of isolation hotels at different weeks

Date, wk	Total	Gender		N	SP	DP	N rate (%)	SP rate (%)	DP rate (%)
		M	F						
1st	356	157	199	344	7	5	96.63	1.97	1.40
2nd	792	349	443	716	9	67	90.40	1.14	8.46
3rd	457	213	244	430	8	19	94.09	1.75	4.16
4th	111	48	63	109	2	0	98.20	1.80	0.00
χ^2				35.007					
P value				<.0001					

Abbreviations: DP, double-positive; N, negative; SP, single-positive.

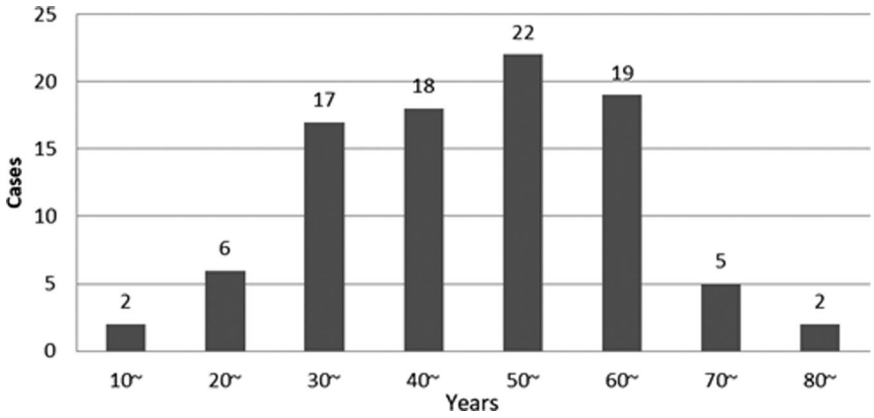

FIGURE 1 Age distribution of positive patients in isolation hotels

The results of the rank-sum test showed that $Z = -9.487$, $P < .0001 < .05$. There was a significant difference between genders, indicating that female has a higher DP rate than male.

The total rate of age from 30 to 69 years is 83.52%, especially in 50 to 59 years old (24.18%) (Figure 1). People who less than 20 or more than 80 years old absolutely has a lower positive rate.

3.4 | Rehabilitation stations

Rehabilitation stations mainly accepted patients with COVID-19 who have been diagnosed and cured in hospital. A total of 661 cases were collected, including 342 males and 319 females (Table 5). the χ^2 test (put SP and DP as a group) showed $P = .958 > .05$, there was no statistically significant difference.

3.5 | Nursing homes

As a special concentration place, nursing homes are the most elder people, also included nursing home staff and accompanying family members. A total of 272 cases were collected, including 95 males and 177 females (Table 6), with an average age of 70.9 ± 14.45 years. Comparing the differences between males and females, the results of the rank-sum test showed that $Z = -1.191$, $P = .234 > .05$, no statistically significant.

3.6 | Hospital wards

Hospital wards treat patients who meet the diagnosis and treatment plan for the new coronavirus pneumonia (5th and 6th editions).[5,6]

TABLE 5 The nucleic acid test results of rehabilitation stations

Gender	Total	N	SP	DP	N rate (%)	SP rate (%)	DP rate (%)
Male	342	329	0	3	96.20	0.00	0.88
Female	319	315	1	3	98.75	0.31	0.94
χ^2		0.003					
P value		.958					

Abbreviations: DP, double-positive; N, negative; SP, single-positive.

TABLE 6 The nucleic acid test results of nursing homes

Gender	Total	N	SP	DP	N rate (%)	SP rate (%)	DP rate (%)
Male	95	87	3	5	91.58	3.16	5.26
Female	177	153	14	10	86.44	7.91	5.65
χ^2		204.027					
P value		<.0001					

Abbreviations: DP, double-positive; N, negative; SP, single-positive.

TABLE 7 The nucleic acid test results of hospital wards

Gender	Total	N	SP	DP	N rate (%)	SP rate (%)	DP rate (%)
Male	158	118	0	40	74.68	100.00	25.32
Female	182	138	0	44	75.82	200.00	24.18
χ^2		0.059					
P value		.808					

Abbreviations: DP, double-positive; N, negative; SP, single-positive.

A total of 340 cases were collected, including 158 males and 182 females. Comparing the differences between genders with the χ^2 test (N and DP) showed $P = .908 > .05$, there was no statistically significant difference (Table 7).

Distribution of different ages and occupations in hospital wards were showed in Figure 2 and Figure 3. More than 85.23% (290 out of 340) confirmed patients were concentrated in 30 to 69 years old. Workers and retirees have a major rate (24% and 23%) in occupational distribution. However, medical personnel has a lowest rate (4%) (Figure 4).

3.7 | Fever clinics

A total of 682 cases came to our fever clinic during these 4 weeks. The DP rate of COVID-19 is 16.57% (113 out of 682). There was no statistically significant difference between genders with χ^2 testing. The same statistical method was used among those 4 weeks showed that the *P* value is less than .0001 (Table 8). Therefore, a pairwise comparison was made between these 4 weeks ($\alpha = .007$). All of the *P* value is less than .007 except 1st to 2nd week. That means the positive rate of NAT gradually decreased over time.

Age distribution of fever clinics were concentried in 30 to 69 years (83.19%) which were similar with patients who in isolation hotels and hospital wards. Patients concentrited in 40 to 49 years have the most positive rate (28.32%).

4 | DISCUSSION

Coronavirus infections are mostly mediated by intermediate hosts, which will enhance their pathogenicity to humans. Then breakthrough species boundaries finally lead to human infections.[7] Currently, seven known coronaviruses can infect humans, of which there are three species main threats to humans that can cause serious diseases: severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), and the newly discovered novel coronavirus (SARS-CoV-2 [SARS-coronavirus 2]). [8-13] SARS-CoV-2 is less pathogenic than SARS and MERS, however, its infectivity is significantly higher than both. There are more than 3.6 million cases confirmed, of which 0.26 million cases died until 7th May. Currently, the COVID-19 epidemic has been effectively controlled under the joint efforts of the people of the whole country. The resumption of work and production of enterprises and the opening of schools are in order gradually. According to official data (13 April), the positive rate of NAT of more than 143 000 resumption workers in Wuhan is 0.08%. The positive rate of NAT (2 May) for senior students in high school is 0.05% (3 out of 5864) in the Wuchang District.

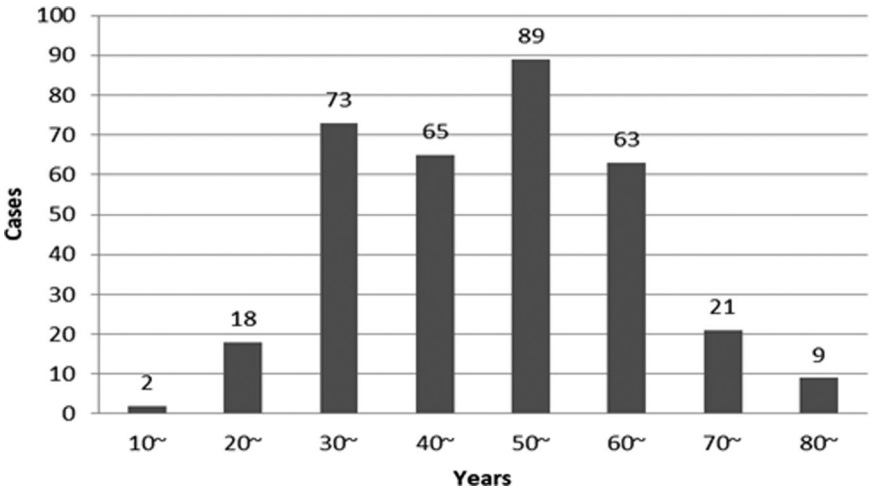

FIGURE 2 Age distribution of positive patients in hospital wards

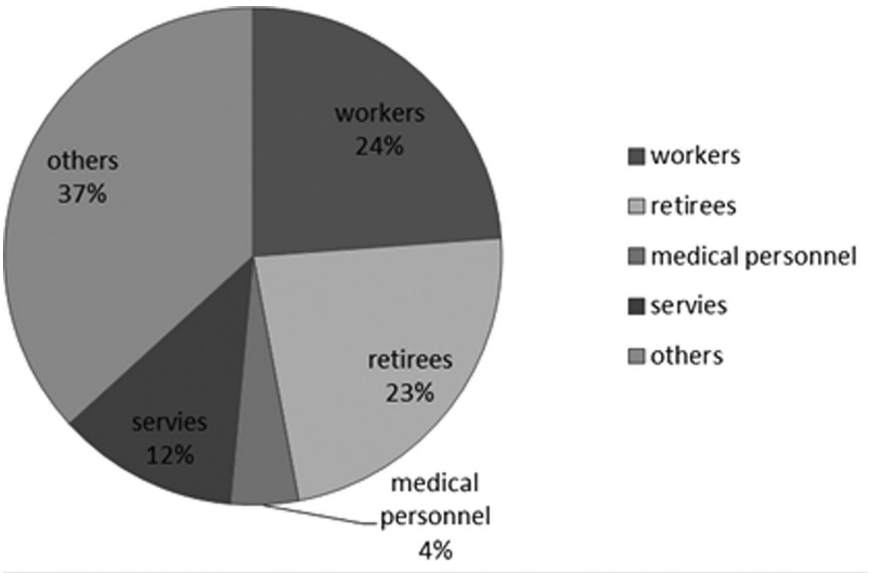

FIGURE 3 Distribution of occupations in hospital wards

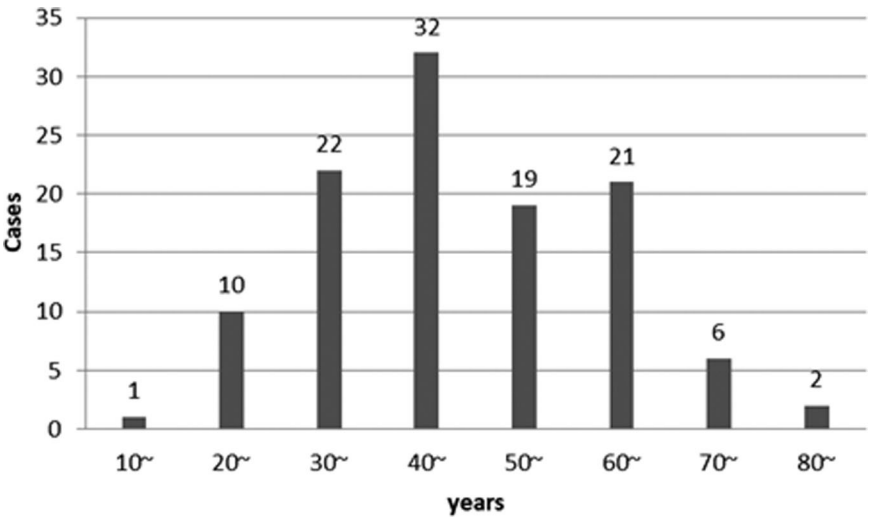

FIGURE 4 Age distribution of positive patients in fever clinics

When returning to normal life gradually, we still need to continue to strengthen our awareness of prevention.

The study evaluated RT-PCR results on personnel at six nucleic acid collection sites, covering almost all people who need to do NAT. The results showed that the positive rate of close contact sites was the lowest (0.17%), followed by rehabilitation stations (1.36%). However, positive rate in the hospital wards were the highest (24.71%). The positive results were tested in discharged patients

TABLE 8 The nucleic acid test results of fever clinics

Date, wk	Total	N	SP	DP	N rate (%)	SP rate (%)	DP rate (%)
1st	200	137	16	47	68.50	8.00	23.50
2nd	178	128	3	47	71.91	1.69	26.40
3rd	163	146	0	17	89.57	0.00	10.43
4th	141	139	0	2	98.58	0.00	1.42
χ^2		64.982					
P value		<.0001					

(1.36%) may be due to the "false negative," "dead virus" remaining in the patient's body, or the suspicious relapse of COVID-19. Through comparative observation that lasts for a month (4 weeks), positive rate in isolation hotels and fever clinics gradually decreases over time. There were no statistically significant differences between genders among those six nucleic acid collection sites.

With the confirmation of COVID-19 cases in Wuhan Women's Prison, nursing homes and other special places have entered people's attention. Our medical team also began to undertake nucleic acid collectiong in some nursing homes. Among the elderly people, 15 out of 272 (5.51%) were in SP and 17 out of 272 (6.25%) were in double-positive. More than 10% of the elderly had problems with nucleic acid detection, indicating that these special places are still the focus of future epidemic prevention and control.

The isolation hotels were the key goals of our medical team. A total of 1716 cases were collected, of which 91 cases were diagnosed with COVID-19 mostly in women (56.04%). The age distribution of positive patients is mainly middle-aged and elderly. For middle-aged people, although they have better immunity, more contact opportunities will increase the risk of infection. For the elderly, the source of epidemic information is relatively backward, the awareness of prevention is also insufficient. Besides, the major organism and body's immunity also decline gradually. What's more, many chronic diseases are often combined to make it difficult to resist the invasion of diseases. Therefore they are belonging to the high-risk population.

The positive rate of the NAT in this study is lower than in other studies.[14-16] The possible reasons are summarized as follows: (a) Tested population. Most non-diagnosed patients, such as close contact sites or isolation hotels, the possibility of actually infect or carry the virus is low. (b) Operation of oropharynx swab. Although the medical staff has undergone rigorous training for many times, the location or depth of collection, and patient cooperation during operation with oropharynx swab will affect the test results. (c) Types of kits, storage, transportation, testing, etc. (d) Virus toxicity. With the spread of the virus, its toxicity gradually weakens, the clinical symptoms of the population are mostly mild after infection in the late period, and even asymptomatic infections occur. Therefore, serological tests will be used to detect the expression of novel coronavirus-specific immunoglobulin M antibodies in conditional medical institutions depending on the "Novel Coronavirus Pneumonia Diagnosis and Treatment Program" (7th Edition).[17] (5) Gradually updated diagnostic criteria.

In this study, the collection of nucleic acids was mostly out-of-hospital, the basic information of the cases that could be collected was limited, and there was a lack of epidemiological history, clinical symptoms, imaging examinations, laboratory examinations, and other data. Our medical team will try to increase sample size and improve epidemiological data to provide more reference for the clinical diagnosis and treatment of COVID-19.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

KD and HL: Conceptualization, methodology, data curation, writing original draft, writing review and editing. XM, BY, and BT: Conceptualization, methodology, investigation. XY, YC, and QZ: Methodology, data curation, software. KBD, HL, and XM designed the study and analyzed the data. XLY and BBY collected and analyzed the data. KBD and HL wrote the paper. YC, BT, and QZ read and approved the final manuscript.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this article.

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REFERENCES

1. Zhu N, Zhang D, Wang W, et al. A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med*. 2020;382(8):727-733.
2. Hui DS, I Azhar E, Madani TA, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health The latest 2019 novel coronavirus outbreak in Wuhan, China. *Int J Infect Dis*. 2020;91:264-266.
3. The General Office of the National Health Commission, the National Science and Technology Education Office. Notice on the issuance of the new coronavirus laboratory biosafety guidelines (7th edition). 2020. http://www.nhc.gov.cn/qjjys/s7948/202001/0909555408d842a58828611dde2e6a26.shtm
4. The General Office of the National Health Commission. Notice of the General Office of the National Health Commission on printing and distributing biosafety guidelines for new coronavirus laboratories (2nd edition). 2020. http://www.nhc.gov.cn/qjjys/s7948/202001/0909555408d842a58828611dde2e6a26.shtml
5. The General Office of the National Health Commission. Notice on the issuance of a new coronavirus infection pneumonia diagnosis and treatment plan (5th version). 2020. http://www.nhc.gov.cn/qjjys/s7948/202001/0909555408d842a58828611dde2e6a26.shtml
6. The General Office of the National Health Commission. On the issuance of pneumonia treatment programs novel coronavirus infection (6th edition). 2020. https://thewww.nhc.gov.cn/yzygj/s7653p/202002/8334a8326dd94d329df351d7da8aefc2.shtml
7. Paules CI, Marston HD, Fauci AS. Coronavirus infections—more than just the common cold. *JAMA*. 2020;323(8):707-708.
8. Long X, Fang J, Qing-wu J. β-Coronavirus epidemic and control of human disease. *Shanghai Prev Med*. 2020;32(1):57-65.
9. Drosten C, Günther S, Preiser W, et al. Identification of a novel coronavirus in patients with severe acute respiratory syndrome. *N Engl J Med*. 2003;348(20):1967-1976.
10. de Groot RJ, Baker SC, Baric RS, et al. Middle East respiratory syndrome coronavirus (MERS CoV): announcement of the coronavirus study group. *J Virol*. 2013;87(14):7790-7792.
11. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet*. 2020;395(10223):507-513.
12. Wang C, Horby PW, Hayden FG, Gao GF. A novel coronavirus outbreak of global health concern. *Lancet*. 2020;395(10223):470-473.

13. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395(10223):497-506.
14. Zhang W, Du RH, Li B, et al. Molecular and serological investigation of 2019-nCoV infected patients: implication of multiple shedding routes. *Emerg Microbes Infect*. 2020;9(1):386-389.
15. Yanbin Liu, Tao Liu, Yue Cui, et al. Comparative study of two sampling methods of nasal and pharyngeal swabs in the screening of novel coronavirus nucleic acid. *Chinese Respir Crit Care Med*. 2020;19(2):1-4.
16. Liu R, Han H, Liu F, et al. Positive rate of RT-PCR detection of SARS-CoV-2 infection in 4880 cases from one hospital in Wuhan, China, from Jan to Feb 2020. *Clin Chim Acta*. 2020;505:172-175.
17. The General Office of the National Health Commission. Notice about the issuance of a new coronavirus pneumonia diagnosis and treatment plan (for trial implementation of the seventh edition). 2020. Http://www.gov.cn/zhengce/zhengceku/2020-03/04/content_5486705.htm

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