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Strategies for Prevention of COVID-19 Transmission in Hospitals: a Nationwide Survey of Controversial Issues Related to Infection Control and Prevention in Korea

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Abstract

Background: Infection-control measures against the coronavirus disease 2019 (COVID-19) within a hospital are often based on expert experience and intuition due to the lack of clear guidelines. This study aimed to survey the current strategies for the prevention of the spread of COVID-19 in medical institutions.

Methods: In a systematic review of national-level guidelines, 13 key topics were selected. Six hospitals were provided an open survey between August 11 and 25, 2020, to assess their responses to these topics. Using these data, an online questionnaire was developed and sent to the infection-control teams of 46 hospitals in South Korea. The survey was conducted between January 31, 2021, and February 20, 2021.

Results: All 46 hospitals responded to the survey. All hospitals operated screening clinics, while 89.1% (41/46) allowed symptomatic patients without COVID-19-associated symptoms to visit the general outpatient clinics. Most hospitals (87.2%; 34/39) conducted polymerase chain reaction (PCR) tests for all hospitalised patients. Moreover, 35 (76.1%) hospitals had preemptive isolation policies for hospitalised patients, of which 97.1% (34/35) released patients from isolation after a single negative PCR test. Most hospitals (76.9%; 20/26) allowed shared-room accommodation for patients who met the national criteria for release from isolation but showed positive PCR results with cycle threshold values above a certain threshold (34.6%; 9/26) or after a certain period that satisfied the national criteria (26.9%; 7/26).

Conclusions: Various guidelines were being applied by each medical institution, but an explicit set of national guidelines to support these guidelines was unavailable.

Background

Coronavirus disease 19 (COVID-19) is an emerging infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that was first identified in Wuhan, Hubei Province, China, in December 2019 [1]. Subsequently, it spread rapidly worldwide, and the World Health Organization (WHO) declared a global pandemic on March 11, 2020 [2]. The increasing numbers of serious outbreaks of COVID-19 and confirmed cases in communities have increased the risk of COVID-19 infection in medical institutions. Indeed, several COVID-19 outbreaks have been identified in various medical institutions over the past two years [3].

Since elderly patients with underlying comorbidities are mainly hospitalised for appropriate care, a COVID-19 outbreak in a hospital can result in a high mortality rate [4]. Although strict infection-control measures to prevent nosocomial COVID-19 infections are crucial, the development of appropriate and specific strategies for hospital settings is also important to account for the heterogeneity of the population in hospitals, which includes inpatients, healthcare workers, and outpatients, caregivers, and other professionals. Furthermore, the infrastructure and systems of individual hospitals vary, and the existing guidelines do not address every specific detail [5]. Thus, COVID-19 infection-control measures

implemented by hospitals often rely on the experience of in-house experts and are often benchmarked against other hospitals' strategies [6].

In the light of these issues, the present study aimed to evaluate the strategies for preventing the inflow of undetected COVID-19 patients into hospitals, preventing infections among healthcare workers when treating suspected or confirmed COVID-19 patients, and preventing the spread of COVID-19 infection in medical institutions by medical personnel. Through this study, we aimed to derive the optimal strategies to prevent the spread of COVID-19 within medical institutions.

Methods

Questionnaire design

In the initial phase of questionnaire development, controversial issues related to the prevention of COVID-19 transmission within medical institutions were selected via discussion among four infectious diseases (ID) specialists (B.K., E.S.K., K.H.S., and H.B.K.) (Supplement 1). To extract the critical questions related to these issues that are relevant in an actual hospital setting, a systematic literature review of the recommendations and guidelines issued by World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), European Centre for Disease Prevention and Control (ECDC), and Korea Disease Control and Prevention Agency (KDCA) between January 1, 2020, and September 30, 2020, was conducted by two researchers (W.J. and B.K.) (Supplement 2). In addition, we obtained information about real-world practices related to these issues from six ID specialists working at different hospitals by sending an e-mail with a questionnaire consisting of open questions (Supplement 3). Based on a review of the guidelines and information about real-world practices, a questionnaire consisting of closed questions was developed through discussions among investigators in this study (W.J., B.K., E.S.K., K.H.S., S.M.M., M.J.L., J.Y.P., J.Y.K., M.J.S., and H.B.K.) (Supplement 4). The developed questionnaire was refined on the SurveyMonkey® platform (Supplementary Fig. 1).

Conducting the survey

The survey was conducted over a period of 21 days (from January 31, 2021, to February 20, 2021), targeting the six hospitals where information about real-world practices for controversial topics was gathered and 40 sample hospitals in Korea that were managing COVID-19 patients at the time of the survey. The 40 sample hospitals were selected to account for four categories of hospitals: hospitals operating state-designated isolation beds, hospitals with 500 beds or more that did not operate state-designated isolation beds, hospitals with less than 500 beds, and hospitals without ID specialists. Ten hospitals of each category were selected while maintaining uniform distributions across regions.

A link to the online-based survey was forwarded via e-mail to the physicians or nurses who belonged to the infection-control teams of each hospital. To encourage participation, reminders were sent on the 5th, 10th, and 15th days. Only one questionnaire was administered per hospital.

Statistical analysis

To evaluate the differences in strategy according to the experience of managing COVID-19 patients, we compared hospitals that managed 100 or more cases of COVID-19 (COVID-19 ≥ 100 group) with hospitals that had treated fewer than 100 cases of COVID-19 (COVID-19 < 100 group). All statistical analyses were performed using SPSS version 24.0 for Windows (IBM Corporation, Armonk, NY, USA). Categorical variables were analysed by the Chi-squared test or Fisher's exact test. Continuous variables were analysed using the Mann–Whitney U-test or independent t-test. Variables with *P* values < 0.05 were considered statistically significant.

Results

Basic information of medical institutions

Table 1 provides the basic information of the participating medical institutions. All 46 hospitals that were sent the questionnaire responded to the survey. Among them, 24 hospitals had treated 100 or more cases of COVID-19. The majority of hospitals in the COVID-19 < 100 group were private university-affiliated hospitals, while the majority of those in the COVID-19 ≥ 100 group were public non-university-affiliated hospitals. The proportion of hospitals without an ID specialist was significantly higher in the COVID-19 ≥ 100 group than in the COVID-19 < 100 group ($P = 0.011$).

Table 1
Basic information on survey respondents and medical institutions

	Total (n = 46)	**No. of COVID-19 cases <100 (n = 22)**	**No. of COVID-19 cases ≥100 (n = 24)**	***P*-value**
Characteristics of respondents				
Age	44 (38-50)	41 (37.75-49)	45.5 (39.25-50)	0.257
Female	29 (63.0)	13 (59.1)	16 (66.7)	0.595
Classification				
Infection control doctor	41 (89.1)	21 (95.5)	20 (83.3)	0.349
Infection control nurse	5 (10.9)	1 (4.5)	4 (16.7)	0.349
Length of working experience in infection control	6 (4-13.5)	7.5 (5-15.25)	5 (3.25-11.5)	0.192
Characteristics of medical institutions				
Type of hospital				
University-affiliated hospital: national or public	**6 (13.0)**	**0 (0)**	**6 (25.0)**	**0.022**
University-affiliated hospital: private	**15 (32.6)**	**12 (54.5)**	**3 (12.5)**	**0.002**
Non-university-affiliated hospital: national or public	**17 (37.0)**	**3 (13.6)**	**14 (58.3)**	**0.002**
Non-university-affiliated hospital: private	**8 (17.4)**	**7 (31.8)**	**1 (4.2)**	**0.020**
Number of hospital beds				
Less than 300	10 (21.7)	3 (13.6)	7 (29.2)	0.289
300-599	15 (32.6)	10 (45.5)	5 (20.8)	0.075

Note: Values are presented as median (interquartile range) or number (%)

Abbreviations: COVID-19, coronavirus disease 2019

	Total (n = 46)	No. of COVID-19 cases <100 (n = 22)	No. of COVID-19 cases ≥100 (n = 24)	*P*-value
600-899	11 (23.9)	8 (36.4)	3 (12.5)	0.058
900-1,199	4 (8.7)	0 (0)	4 (16.7)	0.110
More than 1,200	6 (13.0)	1 (4.5)	5 (20.8)	0.190
Absence of infectious diseases specialists	**10 (21.7)**	**1 (4.5)**	**9 (37.5)**	**0.011**
Note: Values are presented as median (interquartile range) or number (%)				
Abbreviations: COVID-19, coronavirus disease 2019				

Screening and selective treatment policies to prevent COVID-19 patients from entering the hospital

Table 2 lists the screening and selective treatment policies implemented to prevent COVID-19 patients from entering the hospital. All 46 hospitals operated screening clinics, which treated patients with respiratory symptoms, fever of unknown cause, and epidemiological association with COVID-19 patients, and accepted persons who wanted to undergo polymerase chain reaction (PCR) tests for COVID-19.

Table 2
Screening and selective treatment policy to prevent COVID-19 patients from entering the hospital

	Total (n = 46)	**No. of COVID-19 cases <100 (n = 22)**	**No. of COVID-19 cases ≥100 (n = 24)**	***P*-value**
Existence of screening clinic for COVID-19	46 (100)	22 (100)	24 (100)	-
The criteria of patients treated at the screening clinic[1]				
Fever of unknown cause	45 (97.8)	22 (100)	23 (95.8)	1.000
Respiratory symptoms	46 (100)	22 (100)	24 (100)	-
Epidemiological association with COVID-19 patients	43 (93.5)	20 (90.9)	23 (95.8)	0.600
Family members had fever, respiratory symptoms or epidemiological association with COVID-19 patients	35 (76.1)	17 (77.3)	18 (75.0)	0.857
Test for COVID-19 voluntarily	39 (84.8)	21 (95.5)	18 (75.0)	0.098
Entry into general outpatient clinics was allowed for patients with fever or respiratory symptoms likely not associated with COVID-19[1]	**41 (89.1)**	**22 (100)**	**19 (79.2)**	**0.050**
No epidemiological association with COVID-19 patients	11/41 (26.8)	5/22 (22.7)	6/19 (31.6)	0.524
Healthcare workers at the screening clinic determines that the possibility of COVID-19 is minimal	24/41 (58.5)	14/22 (63.6)	10/19 (52.6)	0.476
The patients were negative for COVID-19 testing within a certain period (e.g. two to three days)	38/41 (92.7)	22/22 (100)	16/19 (84.2)	0.091
Scheduled follow-up for diseases presenting fever or respiratory disease	26/41 (63.4)	13/22 (59.1)	13/19 (68.4)	0.536

Note: Values are presented as number (%)

Abbreviations: COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction

[1] This question requested the respondent to select multiple items

[2] Suspected cases of COVID-19 include fever, respiratory symptoms, and epidemiological associations with COVID-19 patients

	Total (n = 46)	No. of COVID-19 cases <100 (n = 22)	No. of COVID-19 cases ≥100 (n = 24)	*P*-value
Existence of measures to prevent the influx of COVID-19 into the hospital through caregivers and family/acquaintances[1]	42 (91.3)	22 (100)	20 (83.3)	0.110
Restrictions on access to general wards by visitors other than the patient's essential caregivers	38/42 (90.5)	21/22 (95.5)	17/20 (85.0)	0.333
Total restrictions on visits to general wards	21/42 (50.0)	9/22 (40.9)	12/20 (60.0)	0.217
Total restrictions on visits to intensive care units and special wards	28/42 (66.7)	13/22 (59.1)	15/20 (75.0)	0.275
Regular monitoring of fever and respiratory symptoms of the caregivers	24/42 (57.1)	13/22 (59.1)	11/20 (55.0)	0.789
Mandatory PCR test for caregivers	27/42 (64.3)	17/22 (77.3)	10/20 (50.0)	0.065
Existence of system to pre-screen scheduled patients to prevent the influx of suspected cases of COVID-19[1,2]	35 (76.1)	19 (86.4)	16 (66.7)	0.118
Texts are sent to suspected cases of COVID-19 advising them to not visit the general outpatient area	28/35 (80.0)	17/19 (89.5)	11/16 (68.8)	0.207
Self-examinations for suspected cases of COVID-19 are conducted through the internet or mobile before visiting the hospital	21/35 (60.0)	13/19 (68.4)	8/16 (50.0)	0.268
Phone call interviews are conducted on suspected cases of COVID-19	3/35 (8.6)	3/19 (15.8)	0/16 (0)	0.234
Management and education concerning wearing masks for patients and caregivers in the hospital[1]	46 (100)	22 (100)	24 (100)	-
Education on wearing masks is provided to patients and caregivers when hospitalized	33 (71.7)	16 (72.7)	17 (70.8)	0.887
Banners and postings on wearing masks thoroughly and properly are placed throughout the institution	41 (89.1)	20 (90.9)	21 (87.5)	1.000

Note: Values are presented as number (%)

Abbreviations: COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction

[1] This question requested the respondent to select multiple items

[2] Suspected cases of COVID-19 include fever, respiratory symptoms, and epidemiological associations with COVID-19 patients

	Total (n = 46)	No. of COVID-19 cases <100 (n = 22)	No. of COVID-19 cases ≥100 (n = 24)	*P*-value
Regular public address announcements on the need for patients and guardians to wear masks	**35 (76.1)**	**20 (90.9)**	**15 (62.5)**	**0.024**
Designated staff monitor patients and guardians and provide guidance on wearing masks in the hospital	10 (21.7)	4 (18.2)	6 (25.0)	0.725
Performing PCR tests for non-suspected cases of COVID-19[1]	39 (84.8)	20 (90.9)	19 (79.2)	0.418
The subject of testing				
Patients requiring general anesthesia	19/39 (48.7)	9/20 (45.0)	10/19 (52.6)	0.634
All patients requiring hospitalization	34/39 (87.2)	19/20 (95.0)	15/19 (78.9)	0.182
Patients requiring hospitalization in a closed psychiatric ward	9/39 (23.1)	3/20 (15.0)	6/19 (31.6)	0.273
Patients who came from a different institution or a nursing home	16/39 (41.0)	7/20 (35.0)	9/19 (47.4)	0.433
Patients requiring hospitalization in the intensive care unit	9/39 (23.1)	5/20 (25.0)	4/19 (21.1)	1.000
Note: Values are presented as number (%)				
Abbreviations: COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction				
[1] This question requested the respondent to select multiple items				
[2] Suspected cases of COVID-19 include fever, respiratory symptoms, and epidemiological associations with COVID-19 patients				

Most hospitals allowed patients with symptoms generally unrelated to COVID-19 to visit the general outpatient clinics; the COVID-19 < 100 group tended to allow such patients more frequently than the COVID-19 ≥ 100 group ($P = 0.050$). Most hospitals used negative COVID-19 test results within a certain period to determine whether symptomatic patients could enter the general outpatient clinics.

Most hospitals implemented measures to prevent the influx of COVID-19 into the hospital through caregivers and family/acquaintances. Among these hospitals, 90.5% allowed general ward access only to the patients' essential caregivers, 57.1% regularly monitored fever and respiratory symptoms of caregivers, and 64.3% performed mandatory PCR tests for caregivers.

All medical institutions provided education concerning the use of masks for patients and caregivers, while 35 hospitals made regular public address announcements guiding patients and caregivers to wear masks; these strategies were used more frequently in the COVID-19 < 100 group ($P = 0.024$). Only 10 hospitals had designated staff who monitored patients and guardians and provided guidance on wearing masks in the hospital. PCR tests were performed even for non-suspected cases of COVID-19 in most hospitals, and most of these hospitals conducted PCR tests for all patients requiring hospitalisation. Additional screening and selective treatment policies for patients with suspected COVID-19 are provided in the Supplementary Table 1.

Preemptive isolation policies for patients with suspected COVID-19

Table 3 presents the data for preemptive isolation policies for patients with suspected COVID-19. Thirty-five hospitals implemented preemptive isolation for inpatients with suspected COVID-19, of which 34 released patients from preemptive isolation only after the first negative PCR test after hospitalisation, and two released patients from isolation after 10-14 days of symptom onset or exposure to COVID-19, regardless of the PCR test results. Regarding the criteria for preemptive isolation before confirmation with PCR results, 23/35 hospitals applied preemptive isolation to all patients admitted into the hospital, while 12 hospitals applied preemptive isolation for patients with suspected symptoms of COVID-19, those with imaging results suspected to be pneumonia, and those with an epidemiological association with a COVID-19 patient. Additional isolation policies for patients with suspected or confirmed COVID-19 are provided in the Supplementary Table 1.

Table 3
Preemptive isolation policy for patients with suspected COVID-19

	Total (n = 35)	**No. of COVID-19 cases <100 (n = 21)**	**No. of COVID-19 cases ≥100 (n = 14)**	***P*-value**
The healthcare workers who determine preemptive isolation[1]				
Preemptive isolation for all patients or patients who meet specific conditions	**7 (20.0)**	**7 (33.3)**	**0 (0)**	**0.027**
The doctor who directly treated the patient	26 (74.3)	14 (66.7)	12 (85.7)	0.262
Healthcare workers belonging to specific departments[2]	22 (62.9)	12 (57.1)	10 (71.4)	0.392
Type of preemptive isolation rooms[1]				
Single isolation room	31 (88.6)	18 (85.7)	13 (92.9)	0.635
Cohort isolation room	6 (17.1)	3 (14.3)	3 (21.4)	0.664
Partly operated as cohort isolation room, and other single rooms	8 (22.9)	6 (28.6)	2 (14.3)	0.431
Criteria for removing the patients from preemptive isolation[1]				
COVID-19 PCR test confirmed negative once	34 (97.1)	21 (100)	13 (92.9)	0.400
COVID-19 PCR test confirmed negative twice	3 (8.6)	3 (14.3)	0 (0)	0.259
After 10–14 days of symptom onset, exposure to COVID-19, or suspicion of exposure, regardless of the PCR test results	2 (5.7)	0 (0)	2 (14.3)	0.153

Note: Only hospitals with preemptive isolation policies were included. Values are presented as number (%)

Abbreviations: COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction

[1] This question requested the respondent to select multiple items

[2] It includes infectious diseases, pulmonology, and the infection control and prevention office

[3] It includes intensive care units and hematopoietic stem cell transplant wards

	Total (n = 35)	No. of COVID-19 cases <100 (n = 21)	No. of COVID-19 cases ≥100 (n = 14)	*P*-value
Determined by healthcare workers belonging to specific departments[2]	10 (28.6)	5 (23.8)	5 (35.7)	0.474
Range of patients put into preemptive isolation before PCR results are confirmed[1]				
All patients admitted into the hospital	23 (65.7)	15 (71.4)	8 (57.1)	0.477
Existence of suspected symptoms of COVID-19	12 (34.3)	6 (28.6)	6 (42.9)	0.477
Existence of results of imaging tests that are suspected to be pneumonia	12 (34.3)	6 (28.6)	6 (42.9)	0.477
Existence of epidemiological association with a COVID-19 patient	12 (34.3)	6 (28.6)	6 (42.9)	0.477
Patients being admitted to high-risk wards[3]	3 (8.6)	2 (9.5)	1 (7.1)	1.000
Patients came from a nursing home or were transferred from a different institution	3 (8.6)	1 (4.8)	2 (14.3)	0.551

Note: Only hospitals with preemptive isolation policies were included. Values are presented as number (%)

Abbreviations: COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction

[1] This question requested the respondent to select multiple items

[2] It includes infectious diseases, pulmonology, and the infection control and prevention office

[3] It includes intensive care units and hematopoietic stem cell transplant wards

Policy for COVID-19 patients who showed consistently positive PCR results but whose symptoms had improved and were released from isolation

Table 4 summarises the policies for COVID-19 patients who showed consistently positive PCR results but also showed improvement in symptoms and were released from isolation. Of the hospitals that

responded to the survey, 27 treated COVID-19 patients whose PCR results were consistently positive but were released from isolation. As for personal protective equipment (PPE), 17 and 11 hospitals used N95/KF94 masks and surgical masks without using other PPE, respectively. The proportion of usage of surgical masks without other PPE was higher in the COVID-19 ≥ 100 group ($P = 0.010$). Additional information about PPE for healthcare workers providing care for COVID-19 patients is provided in the Supplementary Table 2.

Table 4
Policy for patients with COVID-19 whose PCR results are consistently positive but whose symptoms have improved and are released from isolation

	Total (n = 27)	No. of COVID-19 cases <100 (n = 13)	No. of COVID-19 cases ≥100 (n = 14)	*P*-value
Personal protective equipment for the treatment of the patients[1]				
Coveralls with PAPR	0 (0)	0 (0)	0 (0)	-
Coveralls with N95/KF94 mask	0 (0)	0 (0)	0 (0)	-
N95/KF94 mask + disposable gown + gloves + goggles/face shields + hair cover + shoe covers	0 (0)	0 (0)	0 (0)	-
N95/KF94 mask + disposable gown + gloves + goggles/face shields + hair cover	2 (7.4)	1 (7.7)	1 (7.1)	1.000
N95/KF94 mask + disposable gown + gloves + goggles/face shields	3 (11.1)	3 (23.1)	0 (0)	0.098
N95/KF94 mask + disposable gown + gloves	4 (14.8)	2 (15.4)	2 (14.3)	1.000
N95/KF94 mask + gloves	4 (14.8)	2 (15.4)	2 (14.3)	1.000
N95/KF94 mask	17 (63.0)	7 (53.8)	10 (71.4)	0.440
Surgical mask	**11 (40.7)**	**2 (15.4)**	**9 (64.3)**	**0.010**
Allocation of hospital room[1,2]				
Shared room in a general ward	20/26 (76.9)	8 (61.5)	12/13 (92.3)	0.160
Regardless of the PCR test results (Ct value) or the time of release from isolation	5/26 (19.2)	1 (7.7)	4/13 (30.8)	0.322

Note: Only hospitals that had a policy for patients with COVID-19 whose PCR results are consistently positive but whose symptoms have improved and are released from isolation were included. Values are presented as number (%)

Abbreviations: COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction; Ct, cycle threshold; PAPR, powered air-purifying respirator

[1] This question requested the respondent to select multiple items

[2] One hospital wrote a non-categorical answer for the question, and the hospital made a decision after consulting with the infectious diseases specialist

	Total (n = 27)	No. of COVID-19 cases <100 (n = 13)	No. of COVID-19 cases ≥100 (n = 14)	*P*-value
If PCR test results (Ct value) meet certain criteria	9/26 (34.6)	5 (38.5)	4/13 (30.8)	1.000
After a certain period from the time of release from isolation, regardless of the PCR test results (Ct value)	7/26 (26.9)	3 (23.1)	4/13 (30.8)	1.000
Single room for isolation, without negative pressure	4/26 (15.4)	3 (23.1)	1/13 (7.7)	0.593
Regardless of the PCR test results (Ct value) or the time of release from isolation	1/26 (3.8)	0 (0)	1/13 (7.7)	1.000
If PCR test results (Ct value) meet certain criteria	3/26 (11.5)	3 (23.1)	0/13 (0)	0.220
After a certain period from the time of release from isolation, regardless of the PCR test results (Ct value)	1/26 (3.8)	1 (7.7)	0/13 (0)	1.000
Single room for isolation with negative pressure	2/26 (7.7)	2 (15.4)	0/13 (0)	0.480
Cohort room for isolation with negative pressure	0/26 (0)	0 (0)	0/13 (0)	-

Note: Only hospitals that had a policy for patients with COVID-19 whose PCR results are consistently positive but whose symptoms have improved and are released from isolation were included. Values are presented as number (%)

Abbreviations: COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction; Ct, cycle threshold; PAPR, powered air-purifying respirator

[1] This question requested the respondent to select multiple items

[2] One hospital wrote a non-categorical answer for the question, and the hospital made a decision after consulting with the infectious diseases specialist

Most hospitals (20/26) accommodated such patients in a shared room in a general ward, while 9/26 hospitals allowed shared-room accommodation when the cycle threshold (Ct) value in the PCR test was above a certain threshold, and 7/26 hospitals allowed shared-room accommodation after a certain interval from the time of meeting the national isolation release criteria.

The strategy of procedures or operations for patients with suspected or confirmed COVID-19

Table 5 shows the strategy of procedures or operations for patients with suspected or confirmed COVID-19. Thirty-five responding institutions performed emergency procedures or operations for suspected COVID-19 patients; emergency procedures or operations were performed in a higher proportion of hospitals in the COVID-19 < 100 group ($P = 0.024$).

Table 5
The strategy of procedures or operations for patients with suspected or confirmed COVID-19

	Total (n = 46)	**No. of COVID-19 cases <100 (n = 22)**	**No. of COVID-19 cases ≥100 (n = 24)**	***P*-value**
The decision-making process for operations or procedures on patients suspected of COVID-19 in an emergency situation[1]				
No operations or procedures are performed for patients suspected of COVID-19	**11 (23.9)**	**2 (9.1)**	**9 (37.5)**	**0.024**
Even in an emergency, all surgeries and procedures are prohibited until a negative PCR result is confirmed	8 (17.4)	6 (27.3)	2 (8.3)	0.128
Decisions are made by the person in charge of the specific department[2]	16 (34.8)	9 (40.9)	7 (29.2)	0.404
Decisions are made by the doctor who is in charge of the patient	12 (26.1)	4 (18.2)	8 (33.3)	0.242
Decisions are made through the discussion of a consultative committee in the hospital	5 (10.9)	4 (18.2)	1 (4.2)	0.178
Operations and procedures are performed based on the patient confirmed with COVID-19	21 (45.7)	12 (54.5)	9 (37.5)	0.246
Performing emergency procedures or operations on patients suspected of COVID-19	**35 (76.1)**	**20 (90.9)**	**15 (62.5)**	**0.024**
Elective procedures or operations on patients suspected of COVID-19 requiring preemptive isolation[3]				
All procedures or operations are postponed until the patient is released from preemptive isolation	29/34 (85.3)	18/21 (85.7)	11/13 (84.6)	1.000
Procedures or operations are performed without delay, wearing personal protective equipment for COVID-19	5/34 (14.7)	3/21 (14.3)	2/13 (15.4)	1.000
Procedures or operations are performed without delay, without wearing personal protective equipment for COVID-19	0/34 (0)	0/21 (0)	0/13 (0)	-
Elective procedures or operations on patients confirmed with COVID-19[4]				
All procedures or operations are postponed until the patient is released from isolation	26/33 (78.8)	12/14 (85.7)	14/19 (73.7)	0.670
Procedures or operations are performed without delay, wearing personal protective equipment for COVID-19	7/33 (21.2)	2/14 (14.3)	5/19 (26.3)	0.670

	Total (n = 46)	No. of COVID-19 cases <100 (n = 22)	No. of COVID-19 cases ≥100 (n = 24)	*P*-value
Elective procedures or operations on patients with COVID-19 whose PCR results are consistently positive but whose symptoms have improved and are released from isolation[5]				
All procedures or operations are postponed until a negative PCR result is confirmed	3/25 (12.0)	2/13 (15.4)	1/12 (8.3)	1.000
Procedures or operations are performed without delay, wearing personal protective equipment for COVID-19	1/25 (4.0)	1/13 (7.7)	0/12 (0)	1.000
Procedures or operations are performed without delay, without wearing personal protective equipment for COVID-19	5/25 (20.0)	1/13 (7.7)	4/12 (33.3)	0.160
Procedures or operations are performed if PCR test results (Ct value) meet certain criteria	10/25 (40.0)	6/13 (46.2)	4/12 (33.3)	0.688
Procedures or operations are performed after a certain period from the time of release from isolation, regardless of the PCR test results (Ct value)	6/25 (24.0)	3/13 (23.1)	3/12 (25.0)	1.000
Note: Values are presented as number (%)				
Abbreviations: COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction; Ct, cycle threshold				
[1] This question requested the respondent to select multiple items				
[2] It includes infectious diseases, pulmonology, and the infection control and prevention office				
[3] 11 hospitals that did not have a preemptive isolation policy for patients suspected of COVID-19 and 1 hospital that did not perform elective procedures or operations were excluded				
[4] 7 hospitals that did not have an isolation policy for patients confirmed with COVID-19 and 6 hospitals that did not perform elective procedures or operations were excluded				
[5] 19 hospitals that did not have a policy for patients with COVID-19 whose PCR results are consistently positive but whose symptoms have improved and are released from isolation and 2 hospitals that did not perform elective procedures or operations were excluded				

As for elective procedures or operations, 29/34 of the hospitals postponed all procedures or operations for suspected COVID-19 patients until the patient was released from preemptive isolation, and 26/33 postponed all procedures or operations for confirmed patients until the isolation was removed. Of the hospitals that treated COVID-19 patients who showed consistently positive PCR results with improvement

in symptoms and were released from isolation, 10/25 performed procedures or operations when the Ct value of the PCR test met certain criteria, and 6/25 performed the procedures after a certain interval from the time of release from isolation regardless of the PCR test results.

Hospital work-restriction policy for healthcare workers

Table 6 presents the data for hospital work-restriction policies for healthcare workers. For healthcare workers who had visited high-risk areas of COVID-19 without fever or respiratory symptoms, 19/44 medical institutions restricted the workers from working and performed PCR tests if they became symptomatic. However, all hospitals restricted healthcare workers with a fever or respiratory symptoms from work and conducted PCR tests. Over 60% of the participating institutions restricted healthcare workers from performing certain activities outside the hospital. As for the conditions for returning to work among COVID-19 infected employees who met the national isolation release criteria, 14/46 hospitals required COVID-19-infected employees to show negative PCR results before returning to work, and the proportion of such hospitals was higher in the COVID-19 < 100 group. Only 12/46 medical institutions allowed healthcare workers to return to work immediately after meeting the national isolation release criteria. Additional data for decision-making system for COVID-19 related issues is provided in the Supplementary Table 3.

Table 6
Hospital work restriction policy for healthcare workers

	Total (n = 46)	No. of COVID-19 cases <100 (n = 22)	No. of COVID-19 cases ≥100 (n = 24)	*P*-value
Those who have visited high-risk areas of COVID-19, without fever or respiratory symptoms[1]				
Work is restricted for a certain period without PCR test	5/44 (11.4)	1/22 (4.5)	4/22 (18.2)	0.345
Work is restricted for a certain period, performing PCR test	3/44 (6.8)	1/22 (4.5)	2/22 (9.1)	1.000
Work is restricted until negative PCR results are confirmed	**15/44 (34.1)**	**12/22 (54.5)**	**3/22 (13.6)**	**0.004**
Monitored without PCR test. If they become symptomatic, a PCR test is conducted, and they are restricted from work	19/44 (43.2)	8/22 (36.4)	11/22 (50.0)	0.361
Those who have fever or respiratory symptoms				
Work is restricted for a certain period without PCR test	0 (0)	0 (0)	0 (0)	-
Work is restricted for a certain period, performing PCR test	0 (0)	0 (0)	0 (0)	-
PCR tests are performed, and work is restricted until negative results are confirmed	46 (100)	22 (100)	24 (100)	-
Existence of restrictions on certain activities outside the hospital[2]	29 (63.0)	16 (72.7)	13 (54.2)	0.193
Prohibition on attending offline conferences or symposiums	19/29 (65.5)	11/16 (68.8)	8/13 (61.5)	0.714
Prohibition on eating out or attending get-togethers	20/29 (69.0)	10/16 (62.5)	10/13 (76.9)	0.454

Note: Values are presented as number (%)

Abbreviations: PCR, polymerase chain reaction; COVID-19, coronavirus disease 2019; Ct, cycle threshold

[1] Two hospitals that did not have a work restriction policy for healthcare workers those who had visited high-risk areas were excluded. Two hospitals wrote non-categorical answers for the question. One hospital monitored the employees after performing PCR tests without work restriction, and another hospital made a decision in the infection control office.

[2] This question requested the respondent to select multiple items

	Total (n = 46)	No. of COVID-19 cases <100 (n = 22)	No. of COVID-19 cases ≥100 (n = 24)	*P*-value
Prohibition on travelling overseas	26/29 (89.7)	15/16 (93.8)	11/13 (84.6)	0.573
Prohibition on using multi-use facilities	17/29 (58.6)	9/16 (56.3)	8/13 (61.5)	0.774
Prohibition on using public transport	0/29 (0)	0/16 (0)	0/13 (0)	-
Prohibition on visiting other regions	3/29 (10.3)	2/16 (12.5)	1/13 (7.7)	1.000
The conditions for returning to work among COVID-19 infected employees after national isolation release criteria has been met				
Immediately after meeting national isolation release criteria	**12 (26.1)**	**2 (9.1)**	**10 (41.7)**	**0.012**
After a certain period following release from isolation, regardless of PCR test results	9 (19.6)	4 (18.2)	5 (20.8)	1.000
The PCR test results (Ct value) meet certain criteria	11 (23.9)	6 (27.3)	5 (20.8)	0.609
After confirming negative PCR results	**14 (30.4)**	**10 (45.5)**	**4 (16.7)**	**0.034**

Note: Values are presented as number (%)

Abbreviations: PCR, polymerase chain reaction; COVID-19, coronavirus disease 2019; Ct, cycle threshold

[1] Two hospitals that did not have a work restriction policy for healthcare workers those who had visited high-risk areas were excluded. Two hospitals wrote non-categorical answers for the question. One hospital monitored the employees after performing PCR tests without work restriction, and another hospital made a decision in the infection control office.

[2] This question requested the respondent to select multiple items

Discussion

This study investigated the measures taken by medical institutions to prevent the spread of COVID-19 in the Republic of Korea. Through the study, we could identify real-world strategies for controversial areas since no clear guidelines have been established.

All hospitals operated screening clinics, and nearly 90% allowed patients with symptoms not considered to be associated with COVID-19 to enter their general outpatient clinics. Because screening clinics are equipped with minimal facilities and a workforce that can only provide a minimal examination [7], most hospitals manage patients with fever and respiratory symptoms who are unlikely to have COVID-19 at the general outpatient clinic, where careful evaluation and management can be provided. Unfortunately, there are no clear criteria for the entry of symptomatic patients in general outpatient clinics, which can lead to confusion among frontline medical professionals [5]. As observed in this study, many hospitals implemented efficient strategies for patient selection that can be benchmarked by other hospitals, including (i) negative COVID-19 test results within two to three days, (ii) previously treated in general outpatient clinics for a disease related to the current symptoms, and (iii) minimal probability of COVID-19 as determined by experts.

The proportion of asymptomatic patients among COVID-19 cases was about 20–30%, and viral shedding can occur from such patients [8–10]. Because of concerns regarding the transmission of COVID-19 by asymptomatic patients, CDC recommended PCR tests for screening of COVID-19 even for hospitalised patients without COVID-19-related symptoms [11]. A study conducted in long-term care facilities in the United States showed that the prevalence of COVID-19 in facilities that performed broad preemptive PCR tests on inpatients was 0.5%, while it was 28.0% in facilities that did not perform them [12]. Nevertheless, approximately 15% of the hospitals in this study did not perform PCR tests on patients without fever or respiratory symptoms. Although this strategy seems to be effective for detecting asymptomatic COVID-19 patients, its cost-effectiveness remains unproven. Thus, considering the local COVID-19 prevalence, it is necessary to determine whether to proceed with PCR tests when asymptomatic patients are hospitalised [13]. According to the Infectious Diseases Society of America (IDSA), screening asymptomatic patients is expected to be effective in regions with more than 2% prevalence, considering the results of missing a COVID-19 diagnosis and the sensitivity of PCR tests [14]. However, based on the strategy used by many of the hospitals in this study, screening PCR tests for selected patients such as those requiring general anaesthesia, those admitted to the intensive care unit, and those transferred from other medical institutions and nursing homes can be considered in communities with a low prevalence of COVID-19. Furthermore, considering the ongoing COVID-19 vaccination programme in the country and the 95% efficacy of the messenger ribonucleic acid (mRNA) vaccine, limiting PCR tests to unvaccinated patients or caregivers with unclear COVID-19-related symptoms can be a viable option [15].

Three-quarters of the hospitals in the present study implemented preemptive isolation for suspected COVID-19 patients, and most hospitals applied a negative COVID-19 PCR test result as the criterion for release from preemptive isolation. In a single-centre study in South Korea, 350 patients with suspected COVID-19 on the basis of symptoms and epidemiological associations with COVID-19 patients were preemptively isolated, and none of them were confirmed to have COVID-19 [16]. Thus, preemptive isolation for inpatients showing no clear epidemiological association with COVID-19 patients could be considered only in the presence of suspected COVID-19 symptoms or pneumonia in imaging examinations. Since the mean latent period of COVID-19 is 5.2 days after exposure to SARS-CoV-2, even

though most hospitals discontinued preemptive isolation after a single negative PCR test result, a second PCR test should be considered for patients with a strong suspicion of COVID-19 [13, 17–19].

Although the probability of infectious SARS-CoV-2 is very low after 10 days from the onset of COVID-19 symptoms in most cases, severely ill or immunocompromised patients can transmit infectious virus particles even after 10 days [18, 20–23], and the continuing possibility of COVID-19 transmission from these hospitalised patients, especially those who need aerosol-generating procedures, has been a topic of concern [22, 24–26]. For these reasons, only 19% of the hospitals treated these patients in a shared room in a general ward regardless of the PCR test results or the time of release from isolation in this survey. Since 50% of patients show positive results in real-time polymerase chain reaction (RT-PCR) tests of nasopharyngeal swabs at around 18 days after the onset of symptoms, and some patients show a positive result even eight weeks later, the inclusion of negative PCR test results in the criteria for release from isolation is likely to lead to unnecessary isolation and excessive use of PPE [26, 27]. Since the cut-off values for quantitative RT-PCR and quantitative immunoassays tend to be correlated with the infectivity of COVID-19, some researchers have suggested that certain cut-off values could be used as surrogate markers for the decision to release hospitalised patients from isolation [22, 28, 29].

Although the current guidelines include many recommendations on PPE for healthcare workers, clear guidelines for the management of healthcare workers were not available. As a result, work-restriction policies for healthcare workers differed across hospitals. Since medical personnel can also spread COVID-19 to other people in medical institutions, many hospitals applied stricter return-to-work criteria than the national guidelines for healthcare workers infected with or exposed to COVID-19. However, strict criteria for returning to work could result in a lack of a sufficient workforce [30]. Thus, the implementation of suitable criteria considering the specificity of the hospitals' situations is essential.

This study had some potential limitations. First, the survey was conducted in February 2021, and the situation may have changed by the time the results are presented. Second, this survey was performed only in South Korea, and since the prevalence of and social response to COVID-19 differs among countries, additional investigations might be required in other regions or countries. Nevertheless, the findings remain significant since they highlight the importance of appropriate guidelines and indicate key topics relevant to real hospital settings for further research based on the results of this study.

Conclusions

In conclusion, because of the lack of clear guidance on infection-control strategies for preventing COVID-19 transmission within hospitals, individual hospitals are currently relying on experience to frame relevant guidelines. Thus, systematic research on these areas and guidance at the national level is needed for greater consistency and standardisation in hospitals' measures to prevent COVID-19 outbreaks.

List Of Abbreviations

COVID-19, Coronavirus disease 19; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; WHO, World Health Organization; ID, infectious diseases; CDC, Centers for Disease Control and Prevention; ECDC, European Centre for Disease Prevention and Control; KDCA, Korea Disease Control and Prevention Agency; PCR, polymerase chain reaction; PPE, personal protective equipment; Ct, cycle threshold; IDSA, Infectious Diseases Society of America; mRNA, messenger ribonucleic acid; RT-PCR, real-time polymerase chain reaction

Declarations

Ethics approval and consent to participate:

The study protocol was approved by the Institutional Review Board of the Seoul National University Bundang Hospital (B-2101/660-303). Online written informed consent was obtained from the participants.

Consent for publication:

Not applicable.

Availability of data and materials:

All data generated or analysed during this study are included in this published article and its supplementary information files.

Competing interests:

The authors declare that they have no competing interests.

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Conceptualization: Kim B, Kim ES, Song KH, Kim HB. Data curation: Jang W, Kim B. Formal analysis: Jang W, Kim B. Funding acquisition: Kim HB. Investigation: Jang W, Kim B. Methodology: Jang W, Kim B, Kim ES, Song KH, Kim HB. Project administration: Kim B, Kim ES, Song KH, Kim HB. Resources: Kim B, Kim ES, Song KH, Moon SM, Lee MJ, Park JY, Kim JY, Shin MJ, Lee H, Kim HB. Software: Jang W, Kim B. Supervision: Kim HB. Validation: Kim B, Kim ES, Song KH, Kim HB. Visualization: Jang W, Kim B. Writing - original draft: Jang W. Writing - review & editing: Kim B.

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