Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Differences in strategies for prevention of COVID-19 transmission in hospitals: nationwide survey results from the Republic of Korea

W. Jang a,†, B. Kim b,†, E.S. Kim c, K-H. Song c, S.M. Moon c, M.J. Lee d, J.Y. Park e, J-Y. Kim f, M.J. Shin g, H. Lee h, H.B. Kim c,⁎

a School of Medicine, Hanyang University College of Medicine, Seoul, Republic of Korea
b Department of Internal Medicine, Hanyang University College of Medicine, Seoul, Republic of Korea
c Department of Internal Medicine, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam, Republic of Korea
d Division of Infectious Diseases, Department of Internal Medicine, Inje University Sanggye Paik Hospital, Seoul, Republic of Korea
e Department of Paediatrics, Chung-Ang University Hospital, Seoul, Republic of Korea
f Department of Infectious Diseases, Seongnam Citizens Medical Centre, Seongnam, Republic of Korea
g Infection Control Office, Seoul National University Bundang Hospital, Seongnam, Republic of Korea
h Department of Paediatrics, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam, Republic of Korea

ARTICLE INFO

Article history:
Received 23 April 2022
Accepted 31 July 2022
Available online 20 August 2022

Keywords:
Coronavirus disease 2019
Hospital
Infection control
Nationwide survey
South Korea

SUMMARY

Background: Hospital infection control measures against coronavirus disease 2019 (COVID-19) are often based on expert discretion due to the lack of detailed guidelines.
Aim: To survey the current strategies for preventing the transmission of COVID-19 in medical institutions.
Methods: Thirteen key issues related to the prevention of COVID-19 transmission within medical institutions were selected via discussion among infectious diseases specialists, and related critical questions were obtained following a review of national-level guidelines in government databases. Six hospitals had an open survey between 11th and 25th August 2020 to provide responses to these topics. An online questionnaire developed from these data was sent to infection control teams at 46 hospitals in South Korea between 31st January 2021 and 20th February 2021.
Findings: All 46 hospitals responded to the survey. All operated screening clinics, but 89.1% (41/46) allowed symptomatic patients without COVID-19-associated symptoms to visit general outpatient clinics. Most hospitals (87.2%, 34/39) conducted polymerase chain reaction (PCR) tests for all hospitalized patients. Of 35/46 (76.1%) hospitals with pre-emptive isolation policies for hospitalized patients, 31 (88.6%) released

⁎ Corresponding author. Address: Department of Internal Medicine, Seoul National University Bundang Hospital, Seoul National University College of Medicine, 82, Gumi-ro 173 Beon-gil, Bundang-gu, Seongnam-si, Gyeonggi-do 13620, Republic of Korea. Tel.: +82 31 787 7021; fax: +82 31 787 4052
E-mail address: hbkimmd@snu.ac.kr (H.B. Kim).
† W. Jang and B. Kim contributed equally to this article as first authors.

https://doi.org/10.1016/j.jhin.2022.07.032
0195-6701/© 2022 The Healthcare Infection Society. Published by Elsevier Ltd. All rights reserved.
patients from isolation after a single negative PCR test, while most (76.9%, 20/26) allowed shared-room accommodation for patients meeting the national criteria for release from isolation despite positive PCR results with above cycle threshold values (34.6%, 9/26), or after a certain period that satisfied the national criteria (26.9%, 7/26).

**Conclusion:** Individual hospitals in South Korea are currently relying on experience to frame relevant guidelines, and responded differently to some infection control issues on hospital settings during the COVID-19 pandemic.

© 2022 The Healthcare Infection Society. Published by Elsevier Ltd. All rights reserved.

**Introduction**

Coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), which emerged in December 2019 in Wuhan, China [1]. SARS-CoV-2 spread rapidly worldwide, and the World Health Organization (WHO) declared a global pandemic on 11th March 2020 [2]. COVID-19 outbreaks in medical institutions are important, and can be associated with high mortality rates, especially amongst the elderly [3–6]. Although strict infection control measures to prevent nosocomial COVID-19 are crucial, the development of these may need to be tailored locally because of the heterogeneity of hospitals and their patient populations [7]. Thus, COVID-19 infection control measures in hospitals often rely on the experience and opinion of in-house experts, and may be benchmarked against the strategies of other hospitals [8].

In the light of these issues, this study aimed to evaluate the issues of infection control strategies for COVID-19, which were not dealt with appropriately in the guidelines, in the real-world setting in Korean hospitals during the early phase of the pandemic.

**Methods**

**Questionnaire design**

In the initial phase of questionnaire development, 13 issues related to the prevention of COVID-19 transmission within medical institutions were selected via discussion among four infectious diseases (ID) specialists (BK, ESK, KHS and HBK) (Supplement 1, see online supplementary material). To extract the critical questions related to these issues that are relevant in an actual hospital setting, governmental database review of the recommendations and guidelines issued by the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), European Centre for Disease Prevention and Control, and Korea Disease Control and Prevention Agency (KDCA) between 1st January 2020 and 30th September 2020 was conducted by two researchers (WJ and BK) (Supplement 2, see online supplementary material). In addition, information was obtained 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, see online supplementary material). Based on a review of the guidelines and information about real-world practices, a questionnaire consisting of 71 questions was developed through discussions among investigators in this study (Supplement 4, see online supplementary material). After conducting a pilot test, the developed questionnaire was refined on the SurveyMonkey platform (Figure S1, see online supplementary material).

**Conducting the survey**

The survey was conducted over a 21-day period (31st January–20th February 2021), targeting the six hospitals where information about real-world practices for controversial topics was gathered and 40 sample hospitals in South Korea that managed patients with COVID-19 at the time of the survey. The 40 hospitals were selected based on hospital type and regional distribution. Hospitals were assessed based on bed numbers and whether they had state-designated isolation beds and ID specialists, with four categories: those with >500 beds with or without state-designated isolation beds, those with <500 beds, and those without ID specialists. Ten hospitals were selected per category while maintaining uniform distributions across regions as much as possible.

A link to the online-based survey was forwarded via e-mail to physician or nurse members of the infection control team (ICT) of each hospital. Hospital ICTs in South Korea are comprised of infection control doctors and nurses dedicated to infection control and prevention in their hospital [9]. Given that the main practitioners related to the COVID-19 response vary depending on the hospital, a person in charge of practical affairs was asked to answer according to the circumstances of each hospital. To encourage participation, reminders were

| Table I<br>Basic information of medical institutions participating in the survey |
|---------------------------------|-----------------|-------------------|
| Hospital characteristics (N=46) |
| **Type of hospital**           | (N) (%)         |
| University-affiliated hospital: national or public | 6 (13.0) |
| University-affiliated hospital: private | 15 (32.6) |
| Non-university-affiliated hospital: national or public | 17 (37.0) |
| Non-university-affiliated hospital: private | 8 (17.4) |
| **Number of hospital beds**    |                 |
| <300                            | 10 (21.7) |
| 300–599                         | 15 (32.6) |
| 600–899                         | 11 (23.9) |
| 900–1199                        | 4 (8.7) |
| >1200                           | 6 (13.0) |
| **No infectious diseases specialists** | 10 (21.7) |
Results

Basic information on participating hospitals (Table I)

All 46 invited hospitals responded to the survey. Among them, 13.0% (6/46) were university-affiliated national or public hospitals, 32.6% (15/46) were university-affiliated private hospitals, 37.0% (17/46) were non-university-affiliated national or public hospitals, and 17.4% (8/46) were non-university-affiliated private hospitals. There were no ID specialists in 21.7% (10/46) of the participating hospitals.

Screening and selective treatment policies to prevent patients with COVID-19 from entering hospitals (Table II)

All 46 hospitals operated screening clinics, which treated patients with respiratory symptoms, fever of unknown cause, and epidemiological association with patients with COVID-19, and accepted people who wanted to undergo polymerase chain reaction (PCR) tests for COVID-19.

In total, 41/46 (89.1%) hospitals allowed patients with symptoms generally unrelated to COVID-19 to visit the general outpatient clinics. Thirty-eight (92.7%) of these 41 hospitals used a negative COVID-19 test result within a certain period to determine whether symptomatic patients could enter the general outpatient clinics.
Forty-two of 46 (91.3%) hospitals implemented measures to prevent the introduction of COVID-19 into the hospital by caregivers/visitors. Of these 42 hospitals, 38 (90.5%) only allowed general ward access to the patients’ essential caregivers, 24 (57.1%) monitored fever and respiratory symptoms of caregivers regularly, and 27 (64.3%) performed mandatory PCR tests for caregivers.

All medical institutions provided education concerning the use of masks for patients and caregivers, while 35/46 (76.1%) hospitals made regular public address announcements guiding patients and caregivers to wear masks. Only 10 (21.7%) hospitals had designated staff to monitor and provide guidance to patients and visitors about mask-wearing. PCR tests were performed even for patients without suspected COVID-19 in 39/46 (84.8%) hospitals, and 34 (77.2%) of these 39 hospitals tested all patients requiring hospitalization. Additional screening and selective treatment policies for patients with suspected COVID-19 are provided in Table S1 (see online supplementary material).

### Table III
Isolation practices for patients with symptoms suggestive of coronavirus disease 2019 (COVID-19) but without a confirmed diagnosis

| Healthcare workers who determine pre-emptive isolation | N (%) (N=35) |
|-------------------------------------------------------|-------------|
| Pre-emptive isolation for all patients or patients who meet specific conditions | 7 (20.0) |
| Doctor who treated the patient directly | 26 (74.3) |
| Healthcare workers belonging to specific departments | 22 (62.9) |

| Type of isolation room | N (%) |
|-----------------------|-------|
| Single isolation room | 31 (88.6) |
| Cohort isolation room | 6 (17.1) |
| Partially operated as cohort isolation room, and other single rooms | 8 (22.9) |

| Criteria for removing patients from pre-emptive isolation | N (%) |
|----------------------------------------------------------|-------|
| COVID-19 PCR test confirmed negative once | 31 (88.6) |
| COVID-19 PCR test confirmed negative twice | 3 (8.6) |
| Determined on a case-by-case basis | 1 (2.9) |

| Range of patients isolated before PCR results were confirmed | N (%) |
|----------------------------------------------------------|-------|
| All patients admitted to hospital | 23 (65.7) |
| Existence of suspected symptoms of COVID-19 | 12 (34.3) |
| Existence of results of imaging tests that are suspected to be pneumonia | 12 (34.3) |
| Existence of epidemiological association with a patient with COVID-19 | 12 (34.3) |
| Patients admitted to high-risk wards | 3 (8.6) |
| Patients came from a nursing home or transferred from a different institution | 3 (8.6) |

PCR, polymerase chain reaction.
Only hospitals with policies on pre-emptive isolation were included.

---

### Table IV
Policies for patients with coronavirus disease 2019 (COVID-19) whose polymerase chain reaction (PCR) results remained positive but whose symptoms improved, allowing release from isolation

| Personal protective equipment for the treatment of patients | N (%) (N=27, unless otherwise stated) |
|----------------------------------------------------------|--------------------------------------|
| Coveralls with PAPR | 0 (0) |
| Coveralls with N95/KF94 mask | 0 (0) |
| N95/KF94 mask + disposable gown + gloves + goggles/face shield + hair cover + shoe covers | 2 (7.4) |
| N95/KF94 mask + disposable gown + gloves + goggles/face shield + hair cover | 3 (11.1) |
| N95/KF94 mask + disposable gown + gloves | 4 (14.8) |
| N95/KF94 mask + gloves | 4 (14.8) |
| N95/KF94 mask | 17 (63.0) |
| Surgical mask | 11 (40.7) |

| Allocation of hospital room | N (%) |
|-----------------------------|-------|
| Shared room in a general ward | 20/26 (76.9) |
| Regardless of PCR test results (Ct value) or time of release from isolation | 5/26 (19.2) |
| If PCR test results (Ct value) meet certain criteria | 9/26 (34.6) |
| After a certain period from time of release from isolation, regardless of PCR test results (Ct value) | 7/26 (26.9) |
| Single room for isolation, without negative pressure | 4/26 (15.4) |
| Regardless of PCR test results (Ct value) or time of release from isolation | 1/26 (3.8) |
| If PCR test results (Ct value) meet certain criteria | 3/26 (11.5) |
| After a certain period from time of release from isolation, regardless of PCR test results (Ct value) | 1/26 (3.8) |
| Single room for isolation with negative pressure | 2/26 (7.7) |
| Cohort room for isolation with negative pressure | 0/26 (0) |

Ct, cycle threshold.

---

Pre-emptive isolation policies for patients admitted with symptoms suggestive of COVID-19 (Table III)

Pre-emptive isolation of patients with symptoms suggestive of COVID-19 was used in 35/46 (76.1%) hospitals. The majority (65.7%) of hospitals had a policy of universal isolation of admitted patients. Thirty-one (88.6%) of these 35 hospitals de-
isolated patients after the first negative PCR test after hospitalization, and three (8.6%) hospitals required two negative swabs. The remaining hospital released patients on a case-by-case basis. Additional information on isolation policies for patients with suspected or confirmed COVID-19 is provided in Table S1 (see online supplementary material).

### Management of patients with COVID-19 whose PCR results remained positive but whose symptoms improved, allowing release from isolation (Table IV)

During the study period, according to national guidelines, patients with COVID-19 who were at least 10 days post symptom onset could be released from isolation if their symptoms were improved and they were afebrile [7]. Twenty-seven (58.7%) hospitals followed this recommendation. Most (76.9%) hospitals allowed de-isolated patients to occupy shared rooms, but often required additional criteria to be met [e.g. cycle threshold (Ct) value thresholds].

### Procedures and operations for patients with suspected or confirmed COVID-19 (Table V)

Most (76.1%) hospitals performed emergency procedures or operations for patients with suspected COVID-19, but 85.3% of hospitals postponed elective procedures or operations on patients with suspected COVID-19 until they were de-isolated, and 78.8% postponed elective procedures or operations on patients with confirmed COVID-19 until they were de-isolated. Some centres required additional criteria to be met [e.g. Ct value thresholds or time period after release from isolation].
Hospital work restriction policies for healthcare workers

| Conditions for returning to work among healthcare workers with COVID-19 after national isolation release criteria have been met | N (%) |
|---|---|
| Immediately after meeting national isolation release criteria | 12 (26.1) |
| After a certain period following release from isolation, regardless of PCR test results | 9 (19.6) |
| When PCR test results (Ct value) meet certain criteria | 11 (23.9) |
| After confirming negative PCR results | 14 (30.4) |

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

Values are presented as N (%).

\(^a\) Two hospitals that did not have a work restriction policy for healthcare workers who had visited high-risk areas were excluded. Two hospitals wrote non-categorical answers for the question. One hospital monitored healthcare workers after performing PCR tests without work restriction, and another hospital decided in the infection control office.

\(^b\) This question asked the respondent to select multiple items.

Personal protective equipment for healthcare workers providing care for patients with coronavirus disease 2019 (COVID-19)

| Personal protective equipment for the treatment of patients with confirmed COVID-19: asymptomatic or mild-to-moderate symptoms\(^a,b\) | N (%) |
|---|---|
| Coveralls with PAPR | 17/39 (43.6) |
| Coveralls with N95/KF94 mask | 37/39 (94.9) |
| N95/KF94 mask + disposable gown + gloves + goggles/face shield + hair cover + shoe covers | 5/39 (12.8) |
| N95/KF94 mask + disposable gown + gloves + goggles/face shield | 5/39 (12.8) |
| N95/KF94 mask + disposable gown + gloves | 1/39 (2.6) |
| N95/KF94 mask + gloves | 0/39 (0) |
| N95/KF94 mask | 0/39 (0) |
| Surgical mask | 0/39 (0) |

Personal protective equipment for the treatment of patients with confirmed COVID-19: severe symptoms\(^a,c\)

| Personal protective equipment for the treatment of patients with confirmed COVID-19: aerosol-producing procedures\(^a,b\) | N (%) |
|---|---|
| Coveralls with PAPR | 36/39 (92.3) |
| Coveralls with N95/KF94 mask | 22/39 (56.4) |
| N95/KF94 mask + disposable gown + gloves + goggles/face shield + hair cover + shoe covers | 2/39 (5.1) |
| N95/KF94 mask + disposable gown + gloves + goggles/face shield + hair cover | 2/39 (5.1) |
| N95/KF94 mask + disposable gown + gloves | 3/39 (7.7) |
| N95/KF94 mask | 0/39 (0) |

(continued on next Column)
Table VII (continued)                      

| Personal protective equipment for the treatment of patients with suspected COVID-19 | N (%) |
|---------------------------------------------------------------------------------|-------|
| N95/KF94 mask + gloves                              | 0/39 (0) |
| N95/KF94 mask                                      | 0/39 (0) |
| Surgical mask                                      | 0/39 (0) |

PAPR, powered air-purifying respirator.

a This question asked the respondent to select multiple items.

b Seven hospitals that did not have an isolation policy for patients with confirmed or suspected COVID-19 were excluded.

c Seven hospitals that did not have an isolation policy for patients with confirmed COVID-19, and two hospitals that did not perform aerosol-producing procedures were excluded.

d Seven hospitals that did not have an isolation policy for patients with suspected COVID-19, and one hospital that did not operate a screening clinic were excluded.

Hospital work-restriction policy for healthcare workers (Table VI)

Healthcare workers who had visited areas at high risk for COVID-19 and who were asymptomatic were excluded from work and PCR tested if they became symptomatic in 43.2% of hospitals. All hospitals excluded healthcare workers with fever or respiratory symptoms from work and conducted PCR tests. However, only 29/46 (63.0%) hospitals placed restrictions on the activities of healthcare workers outside the hospital. Fourteen (30.4%) hospitals required staff to have a negative PCR test result before returning to work, and only 12 (26.1%) hospitals allowed healthcare workers to return to work immediately after meeting the national isolation release criteria. Additional data for decision-making systems for COVID-19-related issues are provided in Table S3 (see online supplementary material).

Personal protective equipment for healthcare workers providing care for patients with COVID-19 (Table VII)

The majority of hospitals provided coveralls with a powered air-purifying respirator (PAPR) and coveralls with an N95/KF94 mask for the treatment of patients with COVID-19. While 43.6% of hospitals provided coveralls with PAPR for the treatment of asymptomatic or mild-to-moderate patients, 86.5% and 92.3% of hospitals provided coveralls with PAPR for the treatment of severe patients and patients who needed aerosol-producing procedures, respectively. The proportion of hospitals that provided coveralls with an N95/KF94 mask for the management of suspected cases of COVID-19 was 39.5%, which was lower than that for hospitals that provided N95/KF94 masks, disposable gowns, gloves and goggles/face shields (57.9%). Additional information about personal protective equipment for healthcare workers is provided in Table S2 (see online supplementary material).

Discussion

This study investigated the measures taken by medical institutions to prevent the spread of COVID-19 in South Korea. This enabled identification of real-world strategies, especially in areas where no detailed guidelines have been established.

All hospitals operated screening clinics, and approximately 90% allowed patients with symptoms that are not considered to be associated with COVID-19 to enter their general outpatient clinics. As screening clinics have minimal facilities and a workforce that can only provide minimal examinations [7], most hospitals managed patients with fever and respiratory symptoms but unlikely to have COVID-19 in general outpatient clinics (where careful evaluation and management could be provided). Unfortunately, there were no clear criteria for the entry of symptomatic patients into general outpatient clinics, which could lead to confusion among frontline medical professionals [7]. At the time of writing, unlike when the study was conducted, unrestricted general outpatient clinic entry has been allowed in almost all South Korean hospitals since the emergence of the Omicron variant. As countermeasures to the surge of the highly transmissible but less serious Omicron variant, hospitals in South Korea have been encouraged to perform COVID-19 diagnostic testing and to manage low-risk patients at their outpatient clinics since 3rd February 2022 [11].

Due to concerns regarding the transmission of COVID-19 by asymptomatic patients, CDC recommended universal PCR testing of hospitalized patients, including asymptomatic patients [12]. Nevertheless, approximately 15% of the hospitals in this study did not test asymptomatic patients. According to the Infectious Diseases Society of America, screening asymptomatic patients is expected to be effective when the prevalence rate is at least 2%, taking account of the consequences of missed diagnoses and the accuracy of PCR tests [13]. Although they may be less accurate, rapid antigen tests may be considered as an alternative screening option, especially where access to PCR testing is constrained [14].

Three-quarters of the hospitals in this study implemented pre-emptive isolation for patients with suspected COVID-19, and most required at least one negative COVID-19 PCR test for de-isolation. WHO and CDC recommend different criteria for de-isolation; the WHO criteria relate to symptom disappearance, whilst the CDC criteria require a single negative PCR test [7]. In a single-centre study in South Korea, 350 symptomatic patients with epidemiological associations with patients with COVID-19 were pre-emptively isolated, and none of these patients were confirmed to have COVID-19 [15]. This may suggest that universal pre-emptive isolation of symptomatic inpatients with no clear epidemiological association with COVID-19 may not be required. Where PCR tests are performed, it needs to be borne in
mind that a single negative test may not provide assurance that a patient does not have COVID-19, as the mean incubation period for COVID-19 is 5.2 days; a single negative PCR test result should be considered, especially for patients with a recent history of contact with COVID-19 [16–19].

Although the probability of infectious SARS-CoV-2 is usually very low >10 days after symptom onset, severely ill or immunocompromised patients can remain infectious for longer [18,20–23], and the possibility of continuing infectivity of hospitalized patients, especially those undergoing aerosol-generating procedures, is hotly debated [22,24–26]. This explains why only 19% of the hospitals in this study de-isolated patients with COVID-19 into shared rooms regardless of the PCR test result. Despite concerns about the transmission of COVID-19 in hospitals, even after 10 days of isolation, many countries including South Korea advise that isolation can be discontinued after 10 days. To do otherwise would be costly in terms of healthcare resources, and of questionable clinical effectiveness [27].

This study found that most hospitals provided coveralls as personal protective equipment for healthcare workers managing patients with confirmed COVID-19. A Korean study showed that although most healthcare workers knew that the KDCA guidelines allowed healthcare workers to choose either coveralls or long-sleeved gowns, many healthcare workers did not use long-sleeved gowns [28]. This may be attributable to confusion among healthcare workers about the transmission of COVID-19 due to the initial KDCA recommendation about personal protective equipment; at the beginning of the pandemic, KDCA recommended using coveralls when managing patients with COVID-19 [29]. A recent study found that coverall contamination occurred rarely, even while managing patients with severe COVID-19 at the early stage of the illness, and coveralls are not recommended in the April 2021 guideline update [30,31].

As healthcare workers can also spread COVID-19 in hospitals, many have applied stricter return-to-work criteria than are defined in national guidelines. This study found that more than one-third of hospitals required a negative PCR test result from asymptomatic healthcare workers who visited high-risk areas. However, such stringency can result in the lack of a sufficient workforce [32]. Internationally, return-to-work criteria for healthcare workers are now being eased. For example, CDC updated its criteria in January 2022, such that asymptomatic healthcare workers who have had SARS-CoV-2 infection in the preceding 90 days do not require work restrictions following further exposure [33].

This study has limitations. First, it was conducted in February 2021, and will not necessarily reflect current practice. Second, selection bias may arise from most of the surveyed hospitals, as most selected hospitals were public hospitals with ID specialists; selection of participants was not randomized. Third, the survey was performed in South Korea alone, and may not be representative of other countries [34,35]. Nevertheless, the findings remain important as 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.

In conclusion, individual hospitals in South Korea relied on experience to frame relevant guidelines, and responded differently to some infection control issues in hospital settings during the COVID-19 pandemic.

Acknowledgements

The authors wish to thank the ICTs for their participation, and Kurt B. Stevenson, Julia Ah-Reum An and June-Ho Kim for their inestimable and generous contributions. In addition, the authors wish to thank the Centre for Public Healthcare Policy of the National Medical Centre for providing the contact information for the ICTs.

Conflict of interest statement

None declared.

Funding sources

This work was supported under the framework of the international cooperation programme managed by the National Research Foundation of Korea (2020K2A9A1A0109507911). The funders had no role in the study design, data collection and analysis, preparation of the manuscript or the decision to publish.

Ethical approval

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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2022.07.032.

References

[1] Centers for Disease Control and Prevention. Basics of COVID-19. Atlanta, GA: CDC; 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/your-health/about-covid-19/basics-covid-19.html [last accessed August 2022].
[2] World Health Organization. Coronavirus disease. 2019 (COVID-19): situation report. Geneva: WHO; 2020. Available at: https://www.who.int/publications/m/item/situation-report---51 [last accessed August 2022].
[3] Abbas M, Robalo Nunes T, Martischang R, Zingg W, Iten A, Pittet D, et al. Nosocomial transmission and outbreaks of coronavirus disease 2019: the need to protect both patients and healthcare workers. Antimicrob Resist Infect Control 2021;10:7.
[4] Mas-Ubillus G, Ortiz PJ, Huaringa-Marcelo J, Sarzo-Miranda P, Muñoz-Aguiire P, Diaz-Ramos A, et al. High mortality among hospitalized adult patients with COVID-19 pneumonia in Peru; a single centre retrospective cohort study. PLoS One 2022;17. e0265089.
[5] de Oliveira Lima H, da Silva LM, de Campos Vieira Abib A, Tavares LR, Santos DWCL, de Araújo ACLF, et al. Coronavirus disease-related in-hospital mortality: a cohort study in a private healthcare network in Brazil. Sci Rep 2022;12:6371.
[6] Hobohm L, Sagschen I, Barco S, Schmidtmann I, Espinola-Klein C, Konstantinides S, et al. Trends and risk factors of in-hospital mortality of patients with COVID-19 in Germany: results of a large nationwide inpatient sample. Viruses 2022;14:275.
[7] Jang W, Kim B, Kim ES, Song KH, Moon SM, Lee MJ, et al. Are the current guidelines sufficient to establish infection control strategies for COVID-19 related issues in hospitals? J Korean Med Sci 2021;36:e343.
8. An JA, Song KH, Kim ES, Kwak R, Jung J, Park JY, et al. Pandemic preparedness of an academic medical centre in the Republic of Korea. Clin Microbiol Infect 2020;26:1595–9.

9. Korean Medical Service Act, Article 47: Preventive measures against hospital infection. Sejong-si: Korea Legislation Research Institute; 2008. Available at: https://elaw.kiri.re.kr/eng_service/lawView.do?seq=5591&lang=ENG&joseq=J00047000&searchText=MEDICAL%2520SERVICE%2520ACT%252047.

10. Kim JE, Lee JH, Lee H, Moon SJ, Nam EW. COVID-19 screening centre models in South Korea. J Public Health Policy 2021;42:15–26.

11. Korea Centres for Disease Control & Prevention Division of Risk Assessment and International Cooperation. Press release: Preparing for the Omicron epidemic, from February 3 (Thu), a gradual transition to a test and treatment system in which local hospitals and clinics participate. Cheongju: KCDC; 2022. Available at: http://ncov.mohw.go.kr/tcmBoardView.do?contSeq=370004 [last accessed August 2022].

12. Centers for Disease Control and Prevention. Testing strategies for SARS-CoV-2. Atlanta, GA: CDC; 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/lab/resources/sars-cov2-testing-strategies.html [last accessed August 2022].

13. Hanson KE, Caliendo AM, Arias CA, Hayden MK, Englund JA, Lee MJ, et al. Infectious Diseases Society of America guidelines on the diagnosis of COVID-19: molecular diagnostic testing. Artiling, VA: IDSA; 2020. Available at: https://www.idsociety.org/practice-guideline/covid-19-guideline-diagnotics/ [last accessed August 2022].

14. Centers for Disease Control and Prevention. Guidance for antigen testing for SARS-CoV-2 for healthcare providers testing individuals in the community. Atlanta, GA: CDC; 2022. Available at: https://www.cdc.gov/coronavirus/2019-ncov/lab/resources/antigen-tests-guidelines.html [last accessed August 2022].

15. Shi HJ, Lee JB, Choi MK, Jang YR, Cho YK, Eom JS. Protection and response of a tertiary hospital in South Korea to the COVID-19 outbreak. Disaster Med Public Health Prep 2021;15:e1–5.

16. Jung J, Kim J, Lim JS, Kim EQ, Kim MN, Kim SH. Pitfall of universal pre-admission screening for SARS-CoV-2 in a low prevalence country. Viruses 2021;13:804.

17. World Health Organization. Criteria for releasing COVID-19 patients from isolation: scientific brief. Geneva: WHO; 2020. Available at: https://apps.who.int/iris/handle/10665/332451 [last accessed August 2022].

18. Centers for Disease Control and Prevention. Ending isolation and precautions for people with COVID-19: interim guidance. Geneva: WHO; 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/duration-isolation.html [last accessed August 2022].

19. Xin H, Li Y, Wu P, Li Z, Lau EHY, Qin Y, et al. Estimating the latent period of coronavirus disease 2019 (COVID-19). Clin Infect Dis 2022;74:1678–81.

20. Cheng HY, Jian SW, Liu DP, Nq TC, Huang WT, Lin HH, et al. Contact tracing assessment of COVID-19 transmission dynamics in Taiwan and risk at different exposure periods before and after symptom onset. JAMA Intern Med 2020;180:1156–63.

21. Wölfel R, Corman VM, Guggemos W, Seilmaier M, Zange S, Müller MA, et al. Virological assessment of hospitalized patients with COVID-2019. Nature 2020;581:465–9.

22. Bullard J, Dust K, Funk D, Strong JE, Alexander D, Garnett L, et al. Predicting infectious severe acute respiratory syndrome coronavirus 2 from diagnostic samples. Clin Infect Dis 2020;71:2663–6.

23. Arons MM, Hatfield KM, Reddy SC, Kimball A, Jacobs JR, et al. Presymptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. N Engl J Med 2020;382:2081–90.

24. Liu WD, Chang SY, Wang JT, Tsai MJ, Hung CC, Hsu CL, et al. Prolonged virus shedding even after seroconversion in a patient with COVID-19. J Infect 2020;81:318–56.

25. Korea Centres for Disease Control & Prevention Division of Risk Assessment and International Cooperation. Findings from investigation and analysis of re-positive cases. Cheongju: KCDC; 2020. Available at: https://www.kdca.go.kr/board/board.es?mid=a30402000000&bid=0030 [last accessed August 2022].

26. National Centre for Infectious Diseases and Chapter of Infectious Disease Physicians. Period of infectivity to inform strategies for de-isolation for COVID-19 patients. Singapore: Academy of Medicine of Singapore; 2020. Available at: https://www.ams.edu.sg/view-pdf.aspx?file=media%5c5556_fi_331.pdf&ofile=Period-of-infectivity-Position-Statement-(final)-23-5-20-(logos).pdf [last accessed August 2022].

27. European Centre for Disease Prevention and Control. Guidance on ending the isolation period for people with COVID-19. Stockholm: ECDC; 2022. Available at: https://www.ecdc.europa.eu/sites/default/files/documents/Guidance-for-discharge-and-ending-of-isolation-of-people-with-COVID-19-third-update.pdf [last accessed August 2022].

28. Min HS, Moon S, Jang Y, Cho I, Jeon J, Sung HK. The use of personal protective equipment among frontline nurses in a nationally designated COVID-19 hospital during the pandemic. Infect Chemother 2021;53:705–17.

29. Park SH. Personal protective equipment for healthcare workers during the COVID-19 pandemic. Infect Chemother 2020;52:165–82.

30. Jung J, Song KH, Jeong H, Ham SY, Kim ES, Kim HB. Are coveralls required as personal protective equipment during the management of COVID-19 patients? Antimicrob Resist Infect Control 2021;10:164.

31. Korea Disease Control and Prevention Agency. Coronavirus infections-19 prevention and control of infections in medical institutions (for hospital-level medical institutions). Cheongju: KCDC; 2021. Available at: https://www.kdca.go.kr/board/board.es?mid=a2050702000000&bid=0019 [last accessed August 2022].

32. Jo HJ, Kim JS, Cheo PG, Lee HY, Chang E, Jung H, et al. Work restrictions for healthcare personnel with potential in-hospital exposure to SARS-CoV-2: experience at a tertiary hospital. J Korean Med Sci 2021;36:e274.

33. Centers for Disease Control and Prevention. Interim guidance for managing healthcare personnel with SARS-CoV-2 infection or exposure to SARS-CoV-2. Atlanta, GA: CDC; 2022. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-risk-assessment-hcp.html [last accessed August 2022].

34. World Health Organization. WHO coronavirus (COVID-19) dashboard. Geneva: WHO; 2020. Available at: https://covid19.who.int/ [last accessed August 2022].

35. Milani F. COVID-19 outbreak, social response, and early economic effects: a global VAR analysis of cross-country inter-dependencies. J Popul Econ 2021;34:223–52.