

## Coronavirus Pandemic

# Prevention and control strategies for the post-pandemic era: finding a balance between COVID-19 and reviving medical service

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### Abstract

**Introduction:** Public life in China is gradually returning to normal with strong measures in coronavirus 2019 (COVID-19) control. Because of the long-term effects of COVID-19, medical institutions had to make timely adjustments to control policies and priorities to balance between COVID-19 prevention and daily medical services.

**Methodology:** The framework for infection prevention and control in the inpatient department was effectively organized at both hospital and department levels. A series of prevention and control strategies was implemented under this leadership: application of rigorous risk assessment and triage before admission through a query list; classifying patients into three risk levels and providing corresponding medical treatment and emergency handling; establishing new ward visiting criteria for visitors; designing procedures for PPE and stockpile management; executing specialized disinfection and medical waste policies.

**Results:** Till June 2020, the bed occupancy had recovered from 20.0% to 88.1%. In total, 13045 patients were received in our hospital, of which 54 and 127 patients were identified as high-risk and medium-risk, respectively, and 2 patients in the high-risk group were eventually laboratory-confirmed with COVID-19. No hospital-acquired infection of COVID-19 has been observed since the emergency appeared.

**Conclusions:** The strategies ensured early detection and targeted prevention of COVID-19 following the COVID-19 pandemic, which improved the recovery of medical services after the pandemic.

**Key words:** COVID-19; hospital-acquired infection; inpatients; risk assessment; prevention and control.

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### Introduction

Since December 2019, an outbreak of coronavirus disease 2019 (COVID-19) in Wuhan has infected many people and resulted in many deaths in China [1]. On March 11, 2020, the World Health Organization (WHO) announced that the current epidemic could be characterized as a global pandemic according to the assessment [2]. As of March 28, 2021, nearly 130 million cases of COVID-19 had been recorded, and new cases continued to rise globally [3].

The hospital in this study is a 1500-bed tertiary general hospital specializing in orthopedics and burns in Beijing and undertakes numerous emergency rescue tasks. In fact, some of the patients came from epidemic areas or were still in the 14-day quarantine, which put immense pressure on the COVID-19 control. In response to the COVID-19 pandemic, the current hospital has implemented a rigorous risk assessment and a series of measures to minimize transmission in the hospital, such as reducing the bed occupancy, conducting differentiated control, prohibiting ward visits, strengthening ventilation and disinfection,

implementing flexible work arrangements, and providing takeout services only for working meals.

To date, the epidemic has been held under control in China with sporadic cases or small-scale local transmission. Work resumption is inevitable, and continued efforts are required to strike a dynamic balance between COVID-19 prevention and daily medical service. In consideration of the long-term existence of COVID-19 [4], our hospital made timely adjustments to ensure early detection, quick response, targeted prevention and control, and smooth restarting of medical treatments in the post-pandemic era. This paper details our normalized prevention and control strategies for patients and the corresponding problems encountered in practice, which will assist other medical institutions in making policies for COVID-19 prevention and control in the post-pandemic era.

### Methodology

*Ensure the adequate distance between different inpatients*

In our inpatient department, most rooms are designed as multiple-bed rooms. To prepare sufficiently

many single rooms and an appropriate distance between beds, the hospital had to dynamically limit the number of admissions and postpone some elective surgical cases to maintain the bed occupancy rate at a lower level.

*Risk assessment before admission*

Rigorous infection risk assessment and triage were conducted by a clinician to evaluate a patient in the emergency or outpatient department through a query list according to the clinical guidance for COVID-19 [5] (Table 1). A detailed epidemiological history can provide an important reference to identify high-risk patients [6,7]. Chest computed tomography (CT) is recommended as a valuable and fast tool to assist clinical diagnosis [8-10]. Although it was not a COVID-19 validation criterion, compared to the reverse-transcription polymerase chain reaction (RT-PCR), the high sensitivity and timeliness of chest CT make it an invaluable tool for early detection and diagnosis [11].

As of April 30, 2020, the requirement for a 14-day quarantine for people from low-risk areas was canceled in Beijing. The hospital was facing the pressure of high demand for hospitalization and tried to eliminate the massive backlog since February. Then, the assessment was adjusted accordingly, and nucleic acid testing (NAT) was added as a required item (Table 1). Although considered a specific test, a relatively high rate of false negatives for NAT continues to be reported [12]. False negative results may occur due to the influence of sample types [13], sampling time [14],

collection technique [15], and analytical sensitivity of the detection technology [16]. Hence, the clinical manifestations and epidemiological history continue to be integrated as complementary components.

Following the decision rules, patients evaluated as low-risk were eligible for hospitalization. For medium-high risk patients, admission will be delayed until their symptoms disappear or the 14-day quarantine ends unless there is a need for emergency treatment. For emergency cases, lives should be saved in a designated room first, and assessment should be finished when the patients are clinically stable.

*Administrative controls and capacity building*

A management framework for infection prevention and control was organized at both hospital and department levels. The administrative management group took an overall charge of intervention measures, involving developing policies, recruiting consultants, supervising, ensuring sufficient supplies, conducting staff health surveillance, and performing training for nonmedical staff (such as cleaners, security guards, specimen deliveryman, and medical waste collectors). The training schedule included proper handling of personal protective equipment (PPE), hand hygiene, preparation of disinfectants, disinfection procedures, and other updated protocols. NAT was performed at regular intervals for early detection to cover medical staff and employees of outsourcing service companies [17]. A rigorous contact tracing and risk assessment will be conducted in the event of occupational

**Table 1.** Risk assessment before admission in different periods of COVID-19 pandemic.

Category	Item	Pandemic period			Post-Pandemic period								
		Low	Medium	High	Low	Medium	High						
Epidemiological History*	1. History of travel/residence in a high-risk area#												
	2. Exposure to confirmed case												
	3. Previous exposure to patient with fever or respiratory symptoms from high-risk area#	×	√	×	√	×	√	×	×	√	√	×	√/×
	4. Clustered cases around▲												
	5. A 14-day quarantine is not ended yet▼												
Symptoms and signs	6. Had a fever in the last 24 hours												
	7. Had respiratory symptoms	×	×	√	√	×	×	√	×	√	×	√	√/×
	8. CT imaging can not rule out COVID-19												
Nucleic acid testing**	9. Result: (+)/(-)/(Not available, NA)	/	/	/	/	(-)	(-)	(-)	NA	(-)/NA	NA	NA	(+)

√ At least one positive answer was present; × All items were negative answers; / Not applicable. \* Cover 14 days prior to symptom onset. # Wuhan and surroundings, abroad, or communities with confirmed cases were designated as high risk areas, which were dynamically updated according to the health department. ▲ Two or more cases of fever and/or respiratory symptoms in a small area, such as family, office and class. ▼ A self-quarantine for people who arrives in Beijing from other regions of China. Only applicable during the pandemic period. \*\* Only applicable during the post-pandemic period.

exposure, and health care workers (HCWs) will be kept in quarantine for 14 days [18].

A leading team of infection control composed of a director, head nurse, and infection supervisor was formed in every ward. An emergency plan regarding COVID-19 developed by this team involved quarantine measures, partitioning of clean and contaminated zones, optimizing routes for inspection and urgent transfer, PPE management, disinfection, medical waste disposal, etc. Subsequently, there was an emergency drill at regular intervals to unblock the actual process.

#### *Isolation room preparation*

In the post-pandemic context, a “ready for use” unit containing 1-2 isolation rooms was reserved to receive medium-high risk patients in each ward. The room should be relatively independent and convenient for patient transport. If there is no need for isolation, the room can be used as an ordinary room.

#### *Precise and differentiated control*

Admission education about respiratory and hand hygiene was available for all patients and visitors to ensure that everyone behaved properly. Application for leaving was forbidden during one’s hospitalization. In the isolation room, a warning sign of contact and droplet precautions was posted on an appealing position. If possible, these patients should be managed by a group of designated HCWs. Moreover, the corresponding ward round or medical care should be placed at the final stage with a minimum number of staff. Equipment such as stethoscopes and thermometers was recommended for dedicated use. If an urgent transfer was required, the predetermined routes should be used. We provided the patient with a mask during transportation and notified the reception department before arriving.

It was recommended to prohibit visits in the pandemic period, and video visitation was encouraged.

In the post-pandemic period, maintaining a record and setting a limit to the number of visitors are necessary. Visitors entering the ward were asked to wear masks and undergo temperature monitoring. NAT and isolation measures were additionally required for the accompanying family member if a patient required one in a particular condition.

#### *PPE and stockpile*

HCWs chose appropriate PPE according to the exposure risk during medical procedures and operations (Table 2). Stock check of PPE was regularly updated. For quick access in urgent need, it was recommended to package PPE as an emergency kit. Meanwhile, it was best to place a specification and procedure nearby for the convenience of HCWs who were unfamiliar with PPE.

#### *Disinfection and waste management*

Cleaning and disinfection procedures for the environmental surface should be conducted at least twice a day with commonly used disinfectants such as sodium hypochlorite at 500 mg/L or 70% ethyl alcohol in a general room [19]. For the isolation room, disinfection should be strengthened to 4 times a day with sodium hypochlorite at 1,000 mg/L [19]. Air disinfection was conducted through natural ventilation at least 4 times a day for more than 30 minutes each time. If the circumstances allow, an air sterilizer can provide continuous disinfection in a closed environment. Ultraviolet (UV) light disinfection for at least 30 min at a time is a choice when the space is empty. If the room area exceeds the UV exposure range, the number of UV lamps should be supplemented.

All kinds of waste generated by patients who are suspected or confirmed to have COVID-19 should be disposed of as medical waste. A double-layer packaging bag and outer surface disinfection were required when the medical waste was removed from an isolation room.

**Table 2.** PPE in the differentiated infection prevention strategies during the post-pandemic era.

Operation type	Risk Level	PPE										
		Hand hygiene	Cap	Surgical mask	N95 respirator	Working clothes	Protective suit	Gloves	Long-sleeved gown	Goggles / face shield	Shoe cover	Surgical mask (Patient)
Ward round, routine care, contact with patients but no spray and body fluid splashing	Low	●	○	●		●						○
	Medium	●	●	●	○	●			●	○	○	●
	High	●	●		●	●	○	●	●	●	●	●
Operations that may produce aerosols, droplets or splashes of body fluids	Low	●	●	●	○	●		●	●	●	○	/
	Medium	●	●		●	●	○	●	●	●	●	/
	High	●	●		●	●	●	●	●	●	●	/

● Mandatory; ○ Optional; / Not applicable.

## Results

In the COVID-19 pandemic (from January to early March 2020), the bed occupancy rate was maintained at a low level (approximately 20.0%) to ensure the adequacy of single-room supplies. With the remission of COVID-19 and effective implementation of prevention and control strategies, the bed occupancy rate gradually increased after mid-March and reached 88.1% in early June. From January 20 to April 29, 7393 patients in total were admitted to the hospital for treatment through risk assessment before hospitalization; 54 (0.7%) were classified as high-risk, 59 (0.8%) as medium-risk, and 7280 (98.5%) as low-risk. Of the 54 high-risk patients, 2 with a history of epidemiology within 14 days and clinical symptoms of fever and pneumonia were ultimately laboratory-confirmed. They were admitted and treated in an isolation room following the classification and transported to a designated hospital following their diagnosis. Since the 14-day quarantine was no longer mandatory in Beijing after April 30, the adjusted query list went into effect. Between April 30 and June 7, 68 (1.2%) patients were assessed as medium-risk of 5,652 cases in total, and no one was reported as high-risk during this period. A total of 3989 HCWs, including outsourcing service workers, received NAT for COVID-19 via throat swabs before June 24, 2020, and all of them tested negative.

## Discussion

Following the outbreak of COVID-19, the hospital set up a leading group to ensure a quick response to the epidemic. Despite achieving remarkable results in disease prevention and control, many questions about intervention measures and workflows have emerged. Identification of suspected COVID-19 cases at admission is essential for applying isolation measures and avoiding nosocomial infections [20]. During the early stages of the pandemic, admission questionnaires with chest CT were used to screen infectious sources to prevent the spread of infection, which proved feasible and effective in distinguishing patients at risk of infection. However, this process may have limitations, since the questionnaire relies on honest answers [21,22]. In addition, this approach may be questioned when screening among asymptomatic patients [23]. As hospital services return to a new normal, NAT and a mini-program using multi-source big data [24] were included to increase the accuracy and efficiency of admission assessment.

Early and effective isolation is one of the most important control measures to face emergent infectious

disease events. In principle, in addition to the rational partition (clean zone, semi-contaminated zone, buffer zone, and contaminated zone), the ideal hardware facility for isolation may include but is not limited to the following: separated ventilation, separated bathroom, toilet, and dedicated entrances for patients and HCWs. Several hospitals worldwide have documented their experience of repurposing hospital inpatient units, including the redesigning of isolation partition, dedicated pathway, and buffer zone, which resulted in substantial improvements in layout and reduced the risk of transmission [25-27]. The current hospital faces a similar challenge. The temporary isolation unit has some deficiencies in emergencies, such as a shared entry, toilet and the lack of a buffer zone. Therefore, careful replanning of the auxiliary space is of immense importance. In actual practice, one toilet was used for the designated use, while another was converted into a gender-neutral toilet for low-risk patients. In case of a patient's need for an auxiliary space, we maintained good ventilation and followed a procedure of cleaning and disinfection after the space was occupied by a patient in quarantine, e.g., cleaning the doorknob, urinals, floors, and other surfaces.

In comparison, several medical institutions have introduced the “transition ward” to help in the triage process [28,29]. This is a temporary segregation ward where a series of screening services is conducted. Patients without risk of infection are finally transferred to a general ward for follow-up treatment. This solution requires a greater degree of coordination between departments, a sufficient workforce, and major layout changes. Furthermore, if a reported case is not effectively detected and isolated, the virus is likely to spread further, which necessitates a higher infection management requirement for the “transition ward”.

Additionally, efficient information exchange and communication among departments and colleagues is a challenge for us in our practice, especially for admission in emergency circumstances and transport for medical purposes. The failure of communication or handover of high-risk patients will cause a prolonged stay in public or waiting areas. Therefore, it is of special importance to enhance the training in multi-sector cooperation to decrease the risk to a minimum.

## Conclusions

In summary, this article suggests that regular comprehensive strategies are of significance to epidemic prevention and control in a medical institution. In particular, it is imperative to maintain the sensitivity of surveillance systems and emergency

response mechanisms to the outbreak. We offer practical evidence for a general hospital on how to achieve early detection, targeted prevention, and quick isolation of COVID-19 in the work resumption process. We also discuss difficult problems to develop more effective measures against COVID-19 in the present background.

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### Authors' contributions

Study conception and design: Hui Chen, Shuang Liu and Yan Ren. Data acquisition: Lihong Chen, Shuang Liu, Yue Liu, Yan Ren, Jiao Shan and Lin Yang. Data analysis and interpretation: Shuang Liu and Hong Li. Draft revision: Hui Chen, Shuang Liu and Yan Ren. All the authors approved the final version for submission.

### References

- Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T, Xia J, Wei Y, Wu W, Xie X, Yin W, Li H, Liu M, Xiao Y, Gao H, Guo L, Xie J, Wang G, Jiang R, Gao Z, Jin Q, Wang J, Cao B (2020) Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 395: 497-506.
- World Health Organization (WHO) (2020) WHO Director-General's opening remarks at the media briefing on COVID-19-11 March 2020. Available: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>. Accessed: 2 April 2021.
- World Health Organization (WHO) (2021) Weekly epidemiological update on COVID-19- 30 March 2021. Available: <https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19---31-march-2021>. Accessed: 2 April 2021.
- World Health Organization (WHO) (2020) WHO Director-General's opening remarks at the media briefing on COVID-19-22 April 2020. Available: <https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19--22-april-2020>. Accessed: 2 April 2021.
- General office of the national health commission (2020) Guidelines for the diagnosis and treatment of pneumonia associated with the COVID-19 (Versions 7). Available: <http://www.nhc.gov.cn/yzygj/s7653p/202003/46c9294a7dfe4cef80dc7f5912eb1989.shtml>. Accessed: 2 April 2021.
- Zheng Y, Xiong C, Liu Y, Qian X, Tang Y, Liu L, Leung EL, Wang M (2020) Epidemiological and clinical characteristics analysis of COVID-19 in the surrounding areas of Wuhan, Hubei Province in 2020. *Pharmacol Res* 157: 104821.
- Nie X, Fan L, Mu G, Tan Q, Wang M, Xie Y, Cao L, Zhou M, Zhang Z, Chen W (2020) Epidemiological characteristics and incubation era of 7015 confirmed cases with coronavirus disease 2019 outside Hubei Province in China. *J Infect Dis* 222: 26-33.
- Zhu J, Zhong Z, Li H, Ji P, Pang J, Li B, Zhang J (2020) CT imaging features of 4121 patients with COVID-19: a meta-analysis. *J Med Virol* 92: 891-902.
- Hu S, Li Z, Chen X, Liang CH (2021) Computed tomography manifestations in super early stage 2019 novel coronavirus pneumonia. *Acta Radiol* 62: 360-367.
- Yang WJ, Sirajuddin A, Zhang XC, Liu GS, Teng ZZ, Zhao SH, Lu MJ (2020) The role of imaging in 2019 novel coronavirus pneumonia (COVID-19). *Eur Radiol* 30: 4874-4882.
- Ai T, Yang ZL, Hou HY, Zhan CN, Chen C, Lv WZ, Tao Q, Sun ZY, Xia LM (2020) Correlation of chest CT and RT-PCR testing for Coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. *Radiology* 296: E32-E40.
- Woloshin S, Patel N, Kesselheim AS (2020) False negative tests for SARS-CoV-2 infection. Challenges and implications. *New Engl J Med* 383: e38.
- Pan Y, Zhang DT, Yang P, Poon LLM, Wang QY (2020) Viral load of SARS-CoV-2 in clinical samples. *Lancet Infect Dis* 20: 411-412.
- Zou LR, Ruan F, Huang MX, Liang LJ, Huang HT, Hong ZS, Yu JX, Kang M, Song YC, Xia JY, Guo QF, Song T, He JF, Yen HL, Peiris M, Wu J (2020) SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *New Engl J Med* 382: 1177-1179.
- Liu M, Li QY, Zhou J, Ai W, Zheng XL, Zeng JJ, Liu YW, Xiang XY, Guo R, Li XY, Wu XD, Xu HY, Jiang L, Zhang HQ, Chen J, Tian LL, Luo J, Luo CH (2020) Value of swab types and collection time on SARS-COV-2 detection using RT-PCR assay. *J Virol Methods* 286: 113974.
- Lippi G, Simundic AM, Plebani M (2020) Potential preanalytical and analytical vulnerabilities in the laboratory diagnosis of coronavirus disease 2019 (COVID-19). *Clin Chem Lab Med* 58: 1070-1076.
- Lai X, Wang M, Qin C, Tan L, Ran L, Chen D, Zhang H, Shang K, Xia C, Wang S, Xu S, Wang W (2020) Coronavirus disease 2019 (COVID-2019) infection among health care workers and implications for prevention measures in a tertiary hospital in Wuhan, China. *JAMA Netw Open* 3: e209666.
- Maltezou HC, Dedoukou X, Tseroni M, Tsonou P, Raftopoulos V, Papadima K, Mouratidou E, Poufta S, Panagiotakopoulos G, Hatzigeorgiou D, Sipsas N (2020) SARS-CoV-2 infection in healthcare personnel with high-risk occupational exposure: evaluation of 7-day exclusion from work policy. *Clin Infect Dis* 71: 3182-3187.
- World Health Organization (WHO) (2020) Water, sanitation, hygiene, and waste management for SARS-CoV-2, the virus that causes COVID-19. Available: <https://www.who.int/publications/i/item/WHO-2019-nCoV-IPC-WASH-2020.4>. Accessed: 2 April 2021.
- Wang QX, Wang XP, Lin HP (2020) The role of triage in the prevention and control of COVID-19. *Infect Control Hosp Epidemiol* 41: 772-776.
- Teo AKJ, Tan RKJ, Prem K (2020) Concealment of potential exposure to COVID-19 and its impact on outbreak control: lessons from the HIV response. *Am J Trop Med Hyg* 103: 35-37.
- Zolkefli Y (2020) Be honest: individuals' moral responsibility within the COVID-19 context. *Malays J Med Sci* 27: 144-147.
- Ornaghi S, Callegari C, Milazzo R, La Milia L, Brunetti F, Lubrano C, Tasca C, Livio S, Savasi VM, Cetin I, Vergani P

- (2020) Performance of an extended triage questionnaire to detect suspected cases of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection in obstetric patients: experience from two large teaching hospitals in Lombardy, Northern Italy. *PLoS One* 15: e0239173.
24. The People's Government of Beijing Municipality (2020) User guide to the Health Kit (Jiankang Bao) for foreign nationals. Available: <http://english.beijing.gov.cn/specials/healthkit/index.html>. Accessed: 2 April 2021.
  25. Careno L, Costantini E, Greco M, Barra FL, Rendiniello V, Mainetti M, Bui R, Zanella A, Grasselli G, Lagioia M, Protti A, Cecconi M (2020) Hospital surge capacity in a tertiary emergency referral centre during the COVID-19 outbreak in Italy. *Anaesthesia* 75: 928-934.
  26. Fadaak R, Davies JM, Blaak MJ, Conly J, Haslock J, Kenny A, Pinto N, Leslie M (2021) Rapid conversion of an in-patient hospital unit to accommodate COVID-19: an interdisciplinary human factors, ethnography, and infection prevention and control approach. *PLoS One* 16: e0245212.
  27. Tosoni A, Rizzatti G, Nicolotti N, Di Giambenedetto S, Addolorato G, Franceschi F, Zileri Dal Verme L (2020) Hospital reengineering against COVID-19 outbreak: 1-month experience of an Italian tertiary care center. *Eur Rev Med Pharmacol Sci* 24: 8202-8209.
  28. Wee LE, Hsieh JYC, Phua GC, Tan Y, Conceicao EP, Wijaya L, Tan TT, Tan BH (2020) Respiratory surveillance wards as a strategy to reduce nosocomial transmission of COVID-19 through early detection: the experience of a tertiary-care hospital in Singapore. *Infect Control Hosp Epidemiol* 41: 820-825.
  29. Ng PC (2020) Infection control measures for COVID-19 in the labour suite and neonatal unit. *Neonatology* 117: 141-143.

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