Scientific Research Publishing

Open Journal of Preventive Medicine, 2023, 13, 11-21
https://www.scirp.org/journal/ojpm
ISSN Online: 2162-2485
ISSN Print: 2162-2477

Prevention of Nosocomial COVID-19 Infections in a Designated Hospital for Children in Guangzhou, China

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How to cite this paper: Sun, J., Shi, X., Qiu, Y.Z., Cai, X., Zhao, D.Y., Li, P.Q. and Shen, J. (2023) Prevention of Nosocomial COVID-19 Infections in a Designated Hospital for Children in Guangzhou, China. *Open Journal of Preventive Medicine*, **13**, 11-21.
https://doi.org/10.4236/ojpm.2023.131002

Received: December 30, 2022
Accepted: January 28, 2023
Published: January 31, 2023

Abstract

Background: Guangzhou Women and Children's Medical Center was chosen as the designated facility for screening, diagnosing, and treating children in Guangzhou with SARS-CoV-2 infection after the COVID-19 outbreak in China. From January 23 to March 20, 2020, the center opened new wards for screening and treatment, taking measures to prevent and control nosocomial infections. This article summarizes and evaluates measures for preventing and controlling nosocomial infections to provide reference information during the pandemic. **Methods:** The COVID-19 nosocomial infection prevention and control strategies were summarized and analyzed, including the formulation of the hospital partition, the improvement of the hospitalization process, environmental cleaning and disinfection, graded protection based on risk assessment, enhanced training on-site quality control inspection, data monitoring and evaluation, among others, and evaluating the effects by comparing before and after the intervention. **Results:** There were 159 patients admitted to the screening wards, including 98 males and 61 females, with a median age of 34 years (interquartile range (IQR): 15, 60) months. There were no abnormal findings in these patients and their families during follow-up. During the screening ward opening period, hand hygiene compliance was significantly improved. Fifty staff members in close contact with the contaminated area had tested for SARS-CoV-2 nucleic acid by polymerase chain reaction (PCR), which showed zero infections and no nosocomial infections occurred. **Conclusions:** For SARS-CoV-2 nosocomial infections, taking the "standard prevention & contact isolation & droplet isolation & air isolation" strategies can prevent patients and staff effectively.

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Keywords

COVID-19, Children, Screening, Prevention, Hospital

1. Background

In China, there have been new coronavirus infections since December 2019. With the approval of the State Council, COVID-19 has been included as a Class B infectious disease as stipulated in the Law of the People's Republic of China on the Prevention and Control of Infectious Diseases. Additionally, measures for preventing and controlling Class A infectious diseases have been adopted [1]. The World Health Organization declared the epidemic a public health emergency of the greatest international concern on January 30, 2020 (2). On March 11, a world pandemic was declared [2]. Subsequently, it involved more than 200 countries on six continents. Available data indicate that the population is generally susceptible to COVID-19, and infants and children can be affected [3]. During the epidemic, Guangzhou Women and Children's Medical Center was designated for the screening and treating children with COVID-19 in Guangzhou. Measures to control infection in the center include reducing the transmission of COVID-19, early identification and isolation of patients with suspected disease, using appropriate personal protective equipment when caring for patients with COVID-19, and environmental disinfection. The local population is successfully protected against infection by these procedures.

2. Methods

2.1. Deployment before Admission

Organization of Suspected Screening Wards

Suspected patients are at a high risk of spreading the disease, so screening wards are used for primary defense measures. Additionally, the center had designated a management department for COVID-19, clarified responsibilities, and set up a dedicated isolation building for suspected and confirmed patients. The isolation building includes one confirmed ward and two screening wards, the latter of which were described in this article. Nosocomial infection prevention strategies were standard prevention, contact, droplet, and air isolation.

Staffing arrangements

Supervise: Confirmed and screening wards each have two directors, overall management, unified scheduling, ensure medical safety—rotation after 14 d to guarantee adequate rest. The quarantine area should have a chief nurse, an executive head nurse, and an assistant head nurse. The chief head nurse is responsible for total coordination and planning, developing and improving the process. Additionally, the executive head nurse will oversee the application of rules, procedures, norms, and guidelines and the daily data reporting. The assistant head nurse pays attention to various notifications and requirements, organizes the

required information, and pays attention to the work of front-line clinical personnel, physical conditions, and mood.

Nurse: According to the needs of the isolation ward, the nursing department set up a nursing staffing team and scientifically dispatched and organized the hospital's nursing staff to perform support registration activities. There should be no less than two people in each post, and the ratio of bed care should be 1:2. Furthermore, the nurse ratio to the patient should be no less than 1:4 for mild patients and no less than 1:2 for severe patients. Once confirmed patients were screened, they were transferred to the confirmed ward. All patients in the confirmed ward were unaccompanied, and nurses cared for them 24 h. overall, 207 nurses voluntarily registered to support the front-line work of epidemic prevention. Overall, 50 staff were deployed. After the training and assessment passed and adopting the APN work system, working 8 h per shift, nurses wearing protective clothing rotated once every 4 h.

Pediatrician: The screening area was equipped with three chief physicians, two second-line doctors, and sufficient first-line doctors.

Cleaner: Confirmed ward equipped with two cleaners and screening ward equipped with six cleaners.

Area division and protective materials

Screening wards are strictly divided into clean, semi-contaminated, and isolation areas. Each area has an independent toilet and shower room and does not use cleaning and disinfection items across the districts. Ground markings are in different zones, yellow landmarks are contaminated areas, blue landmarks are semi-pollutants, and green landmarks are clean. Buffer rooms are set up between different partitions, and corresponding protective materials are allocated to the buffer rooms (see Table 1). The personal protective equipment (PPE) for staff in different positions with corresponding protection levels and disinfection is presented in Table 2. Set up a temporary garbage storage area, and pack three layers of yellow garbage bags. Each layer is packed with gooseneck-knot; spray 2000 mg/L chlorine-containing disinfectant on the outer layer, paste a yellow biological label of COVID-19, and form a closed loop for registration and delivery.

2.2. Personnel Management System

Patient management

Evaluate children's age and self-care ability, set up a reasonable nursing staff for life and nursing management, life support nurses for unaccompanied children, and strengthened the guidance of life care for the caregivers of children. Furthermore, to prepare corresponding preschool children's toys and books and disinfection management of toys to strengthen psychological evaluation and support for children of school age and adolescence. Suspected children were strictly isolated in a single room, with two negative nucleic acid tests and an interval of no less than 24 h.

Escort management

Table 1. Area division and protective materials.

Area	Material settings
Polluted area	• Mobile care system; • Disinfection supplies: myris surface disinfection wipes, 75% alcohol, gamma cleaning towel, chlorine disinfectant and test paper; • Treatment vehicle: (relatively clean and pollution each; • Electronic equipment: special walkie-talkie for polluted area, PDA (personal digital assistant); • Patient Handling Supplies: specimen packing bag (small and medium size), yellow trash bins of various models (sealed and covered), and other common medical meterials.
Polluted area to semi-polluted area	• Protective Equipment (Protective clothing, gowns, N95 masks, disposable surgical masks, shoe covers, hats, gloves, goggles). • UV disinfection lamp, air circulation disinfection machine. • Yellow trash bins of various models (Sealed and covered). • Dedicated bedside X-ray machine. • Dedicated bedside ultrasound machine (special ultra-probe disinfection wipes, disinfectant), Rescue car and so on.
Semi-polluted area to clean area	• Protective equipment (protective clothing, gown, N95 mask, disposable surgical mask, shoe cover, hat, gloves, goggles). • Various types of work clothes. • Dirty clothes storage (closed with lid). • Common items in other wards such as yellow trash cans.

Table 2. Protection lever and personal protective equipment (PPE) for staff working in COVID-19 isolation area.

Staff	**Workplace**	**Medical activity**	Hand hygiene	Work clothes	Work hat	Surgical mask	Medical protective mask	Protective goggles/ mask	Compre-hensive protective mask	Latex gloves	Waterproof isolation gown	Protection suit	Shoe cover	Long sleeve thick rubber gloves
														
Medical staff	Hospital-wide treatment area	Generalmedical activities: Triage/Inquiry/Physical examination etc.	√	√	√	√								
	Pre-test triage/ Second triage	Triage	√	√	√	√		√		direct contace √	√ or fabric isolation gown		√ or Work shoes	
	Triage Stations or First Contact Locations	Escort people for screening cases	√	√	√	√		√		√	√ or fabric isolation gown		√ or Work shoes	
	Fever Clinics	General medical activities for non-body fluid exposure risks, such as Inquiry Station, Physical examination etc.	√	√	√		√	√		direct contace √	√ or fabric isolation gown		√ or Work shoes	
		Collection of respiratory samples, tracheal intuba-tion and other body fluid spraying actives	√	√	√		√ or Power-to-air filter respirator	√		Double √	√		√ or Work shoes	
	Suspected/ Screening Wards (Protected persons who have been released from quarantine please use risk assessment)	General medical activities without contacting the patients, non-body fluid exposure risks, such as Inquiry Station, Ward round, Physical Examination etc.	√	√	√		√	√		√	√ or fabric isolation gown		√ or Work shoes	
		Collection of respiratory samples, venipuncture, handling body fluids and other body fluid spraying actives.	√	√	√		√ or Power-to-air filter respirator	√		Double √	√		√ or Work shoes	

Continued

	Confirmed Ward/ Negative Pressure Ward of ICU (Protected persons who have been released from quarantine please use risk assessment)	General medical activities for non-body fluid exposure risks, such as Inquiry Station, Physical examination etc.	√	√	√		√ or Power-to-air filter respirator	√		Double √		√	√ or Work shoes	
		1. Collection of respiratory samples, venipuncture, handling body fluids and other body fluid spraying actives. 2. Activities that produce aerosols, such as tracheal intubation, Fiber bronchoscopy examination, spitting, CPR etc.	√	√	√		√ or Power-to-air filter respirator	√ or Full protective mask		Double √	√ If necessary	√	√ or Work shoes	
	Transit Group	Transport patients	√	√	√		√ or Power-to-air filter respirator	√		√	√ If necessary	√	√ or Work shoes	
Medical technicians	Fever Clinics, Obstetric Isolation Clinic etc.	Bedside X-ray, electrocardiogram, ultrasound examination etc.	1. According to the requirements of the lever of protection in the clinical department, do a good job of protection. 2. After examination, use 2000 mg/L chlorine-containing disinfectant to do a good job of final disinfection of the instrument. Valuable instruments can be wiped and disinfected with 75% alcohol or surface disinfection wipes /sterilizing liquid.										
	Isolation Wards	Bedside X-ray, electrocardiogram, ultrasound examination, etc.												
	Negative Pressure Ward of ICU	Bedside X-ray, electrocardiogram, ultrasound examination, etc.												
	Medical and Technical Related Departments	CT, MR, X-ray, electrocadiogram, ultrasound examination, etc.	√	√	√	√				√	√ or fabric isolation gown		√ or Work shoes	
Cleaning staff	Pre-test Triage/ Second triage/ General Outpatient Clinic/Emergency	Cleaning, medical waste disposer	√	√	√	√				√	√ or fabric isolation gown		√ or Work shoes, rubber boots	√
	Fever Clinics	Cleaning, medical waste disposer	√	√	√		√	√		√	√ or fabric isolation gown		√ or Work shoes, rubber boots	√
	Suspected/ Screening Wads (Protected persons who have been released from quarantine please use risk assessment)	Cleaning, medical waste disposer	√	√	√		√	√		√	√ or fabric isolation gown (need to add waterproof apron when there is splashing operation)		√ or Work shoes, rubber boots	√
	Confirmed Ward/ Negative Pressure Ward of ICU (Protected persons who have been released from quarantine please use risk assessment)	Cleaning, medical waste disposer	√	√	√		√ or Power-to-air filter respirator	√		√	√	√	√ or Work shoes, rubber boots	√
	Elevator Cleaning	Cleaning and disinfecting elevators (after use of confirmed cases, suspected cases, screening cases).	√	√	√	√		√		√	√ or fabric isolation gown (need to add waterproof apron when there is splashing operation)		√ or Work shoes, rubber boots	√
	Ambulance Cleaning	Cleaning and disinfecting ambulances (after use of confirmed cases, suspected cases, screening cases)	√	√	√	√		√		√	√ or fabric isolation gown (need to add waterproof apron when there is splashing operation)		√ or Work shoes, rubber boots	√
Waste transshipment staff	Collecting and Carrying Garbage	Fever clinics, Isolation Wards, Negative Pressure Ward of ICU	√	√	√	√				Double √	√ or fabric isolation gown		√ or Work shoes, rubber boots	√

Continued

Security staff	Clinic Room	On-site order maintenance	√	√
	Lobby	On-site order maintenance, guidance	√	√
	Gate	Guidance etc.	√	√
	Monitoring Room	Monitoring		
	Transport	On-site order maintenance	√	√

During the diagnosis and screening of wards, visits are strictly forbidden. During escort: 1) only one escort should be left, the escort is relatively fixed, and family members do not leave the room. However, nurses accompanied the diagnosed children for 24 h without family members. 2) No fever, respiratory tract, digestive tract, and other symptoms; monitor body temperature twice a day (morning and evening) and close observation for related symptoms, and the department should make a registration. After admission, accompany the family members to perform two tests of throat swab specimens, and the interval between the two tests should not be less than 24 h. Distribute medical surgical masks to family members of children every day, guide family members to cough etiquette, and wash hands properly. If the accompanying family members develop symptoms such as fever (above 37.3˚C), cough, etc., follow the standard procedure and replace the accompanying family members.

Staff management

Employees should monitor body temperature twice a day, wear masks when contacting people; conduct self-evaluation, and report on health daily. When the risk level of employee changes, they can refer to the "Exposure Risk Assessment Form" (see Table 3). Employees must complete the training and assessment of "Nosocomial Infection Prevention and Control for COVID-19" before going to work, and the pass rate was 100%. Additionally, using WeChat training and assessment to synchronize with the updated diagnosis and treatment guidelines of the National Health and Health Commission. Overall, five related WeChat assessments were conducted, with a pass rate of 100%.

Cleaner management

The cleaning staff are trained before they take up their posts. They should master the use of protective equipment, the process of putting on and taking off, become familiar with the principles of disinfection, and clean and disinfect the quarantine area. Furthermore, there should be a supervisor in the department to supervise and guide and jointly manage with the cleaning supervisor.

2.3. Management of Hospitalization Institutions and Processes

Our hospital created a new manual for the diagnosis and emergency treatment of new coronary pneumonia based on the state's system. It has now been updated to the 20th edition. It includes guidelines for pertinent domestic policy, different work procedures, a pediatric expert formula, a consultation system, nosocomial infection control, and different work procedures.

Table 3. Assessment form of employee exposure risk to SARS-CoV-2.

	No mask was worn in direct contact with the confirmed case	No mask was worn in direct contact with the suspected case	Relatives have been exposed to confirmed cases	Have been exposed to fever and cough cases and didn't wear a mask	Worn a mask in direct contact with the confirmed case	Worn a mask in direct contact with the suspected case or fever and cough case	Had contact with asymptomatic people in Hubei
Travel or residence of Wuhan and surrounding areas within 14 days	High	High	High	High	High	High	Medium
Residence of Hubei within 14 days	High	High	High	High	High	Medium	Medium
Public transport through Wuhan and surrounding areas	High	High	High	Medium	Medium	Medium	Medium
Public transport through Hubei (Non-Wuhan)	High	High	Medium	Medium	Medium	Medium	Low
Passing through Wuhan but didn't stop	High	High	Medium	Medium	Medium	Low	Low
To other regions outside Wuhan	High	High	Medium	Medium	Medium	Low	Low
To other communities with confirmed case reports	High	High	Medium	Low	Low	Low	Low
Never went out	High	High	Medium	Low	Low	Low	Low
High-risk measures	1. Four pharyngea samples viral nucleic acid RT-PCT test on days 1, 4, 7 and 14. 2. Home isolation for 14 days; 2. Test body temperature 2 times a day for 14 days; 3. Please see a doctor in time for discomfort during isolation.						
Medium-risk measures	1. Two pharyngea samples viral nucleic acid RT-PCT test, 24 h apart; 2. Home isolation for 7 days; 3. Test body temperature 2 times a day for 14 days; 4. Wear a mask when touching people.						
Low-risk measures	1. Reworkable; 2. Test body temperature 2 times a day for 14 days; 3. Wear a mask when touching people.						

2.4. Management of Medical Equipment and Prevention Materials

Management of medical equipment

In the isolation area, bedside monitors, thermometers, stethoscopes, pens, hot water bottles, and other items are equipped according to the beds. Additionally, bedside X-ray machines and B-ultrasound are available in semi-contaminated areas.

Prevention material overall planning

Daily consumption statistics and reporting, scan the code and use the paper version to register the user.

Prevention material Supply

Review and determine the protective equipment base and report, including N95 masks, protective clothing, goggles, KN95 masks, disposable gowns, disposable surgical masks, and protective face screens, among others, are uniformly distributed by the nursing department based on clinical usage.

Prevention material inventory

Including PPE, the limited materials are coordinated by the nursing department, and the department sets the base according to the quantity used and supplements it daily.

2.5. Evaluation of Nosocomial Infection Control

Hand hygiene compliance (%) is the percentage of hand hygiene measures taken (= number of hand hygiene completed during the observation period/Total hand hygiene index during the observation period). The observation was divided into department and hospital evaluation, the observation time was not less than 20 min, and the subjects were not informed. Members of the hospital sense team perform spot checks every day in the department and complete the evaluation of doctors, nurses, and cleaning staff monthly. The hospital sense team of the department is composed of the director, the head nurse, the hospital sense nurse, and the hospital sense doctor. Hospital evaluations are conducted monthly by the joint supervision group of the hospital sense of the Ministry of Health.

Passing rate of sense of hospital training and assessment. Assessment of COVID-19 theory: the department shall conduct assessment weekly, the department monthly, and the nursing/medical department quarterly, and supervise and report the qualified rate of assessment. Operation assessment, including protective equipment wearing and taking off, nasopharyngeal swab collection, was performed weekly by the hospital sense team of the department and monthly spot check by the hospital sense joint supervision group.

The daily report rate of the employee's physical condition by WeChat.

SARS-CoV-2 real-time fluorescence (RT-PCR) test for employees.

2.6. Participants' Admission Criteria and Distribution

1) Age < 18 years old.

2) Meet the screening and suspected case diagnostic criteria according to the Consensus of Experts in the Diagnosis and Treatment of Children with SARS-CoV-2 Infection in Guangdong Province[3]. The suspected case diagnostic criteria include epidemiological history and/or clinical manifestations.

3) Non-confirmed cases on etiological evidence.

4) Meet the clinical non-severe and non-critical cases criteria[3].

5) Confirmed cases transferred to the confirmed ward.

2.7. Statistical Analysis

Descriptive statistics were used to interpret the patterns of the clinical characteristics. The count data results are expressed in frequency (percentage), among others; statistical analyses were performed using SPSS 22.0 (IBM, Armonk, NY, USA). Two-sided *P*-values < 0.05 were considered significant.

3. Results

3.1. Epidemiology, Clinical Characteristics, and Follow-Up

From January 23 to March 20, 2020, 159 patients were admitted into the suspected screening wards, including 98 males and 61 females; the median age was 34 (IQR: 15, 60). All of them with the first pharyngeal or/and anal swab RT-PCR test for SARS-CoV-2 nucleic acids within 12 h of admission and second RT-PCR

test was separated from the first test by 24 h. The mean hospitalization days in screening wards were 1.61 d. Fever was the most common symptom (n = 125), followed by respiratory and gastrointestinal symptoms. However, the confirmed patient was asymptomatic, but ground-glass opacities were present in the anterior basal segment of his right lung on CT. Early throat swab RT-PCR tests were negative. Additionally, his anus swab did not turn negative until 19 days after hospitalization. The top three diagnoses of these patients were pneumonia (n = 57), bronchitis (n = 49), and acute upper respiratory tract infection (n = 22). Follow-up from one to four weeks of the patients and their families, no abnormalities were seen after 21 days.

3.2. Evaluation of Nosocomial Infection Control

Hand hygiene compliance (%): post-epidemic hand hygiene adherence was 92.50% (74/80%) in January, 87.50% (98/112) in February, and 86.67% (104/120) in March, all significantly higher than the 2019 annual hand hygiene compliance of 81.34% before the epidemic.

The daily report rate of the employee's physical condition by WeChat was 100%, with no morbidity.

The nucleic acid detection frequency is set according to the job risk. Overall, 50 employees in the screening ward underwent SARS-CoV-2 nucleic acid RT-PCR daily, no staff with SARS-CoV-2 infected, and no nosocomial infection.

4. Discussion

We have known that some pediatric patients confirmed with COVID-19 are asymptomatic [4] [5]. Furthermore, the basic reproduction number (R0) of COVID-19 is affected by many factors [6] [7]. Additionally, the family members are required to accompany the screening patient during hospitalization. These factors increase the difficulty of epidemic prevention in the pediatric screening ward [8]. Infection prevention and control in screening wards are conducted from three aspects: strengthened management of infectious sources, cutoff of transmission channels, comparative assessment, and protection of people at higher risk. This study discovered that by taking the following measures: 1) Designated management department for COVID-19 and clarified responsibilities. 2) Set up a special department to manage epidemic prevention materials and register inventory online in real time. 3) Set up special isolation routes and areas. 4) Formulate the procedures for patient screening, treatment and referral, and implement them effectively; each auxiliary department provided necessary guarantees. 5) Allocated employees' working positions with clear responsibilities and working hours. 6) Standardize the education and evaluation content of patients and escorts. 7) Nursing care and patient evaluation in the ward. 8) Screening wards set up polluted areas, polluted-semi-polluted areas, and semi-polluted-clean areas. 9) Provide level-I defense materials for high-risk areas such as contaminated areas. 10) Employees in the quarantine area conduct daily SARS-CoV-2 exposure risk assessments, and daily WeChat report. 11) Determine the hospital

monitoring indicators and monitor them daily, in addition to hand hygiene compliance monitoring, it also includes employee physical status assessment and SARS-CoV-2 nucleic acid RT-PCR test. The effective prevention and control of nosocomial infection made no one infected in the screening wards.

5. Conclusion

For pediatric screening wards of SARS-CoV-2 infections, taking the "standard prevention, contact, droplet, and air isolation" strategy can prevent patients and staff from being infected.

Declarations

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Guangzhou Women and Children's Medical Center ([2020]25001). Written informed consent was obtained from participants.

Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no competing interests.

Funding

This work was supported by Fundamental Research Project of Guangzhou Municipal Science and Technology Bureau (Dengfeng Hospital) [grant number 202102010514]. The funding only gave financial support.

Authors' Contributions

JS contributed to drafting of the manuscript. XS and YQ contributed to data collection and statistical analysis. XC and DZ contributed to study design and drafting of the manuscript. PL contributed to operation of the clinical trials. JS contributed to study design and revising of the manuscript. All authors have read and approved the final manuscript.

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List of Abbreviations

PCR = polymerase chain reaction

PPE = personal protective equipment

RT-PCR = real-time fluorescence

IQR = interquartile range