# Changes Adopted in Asian Pediatric Hospitals during the COVID-19 Pandemic: A Report from the Pediatric Acute and Critical Care COVID-19 Registry of Asia

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## Abstract

There is wide variation in the overall clinical impact of novel coronavirus disease 2019 (COVID-19) across countries worldwide. Changes adopted pertaining to the management of pediatric patients, in particular, the provision of respiratory support during the COVID-19 pandemic is poorly described in Asia. We performed a multicenter survey of 20 Asian pediatric hospitals to determine workflow changes adopted during the pandemic. Data from centers of high-income (HIC), upper middle income (UMIC), and lower middle income (LMIC) countries were compared. All 20 sites over nine countries (HIC: Japan [4] and Singapore [2]; UMIC: China [3], Malaysia [3] and Thailand [2]; and LMIC: India [1], Indonesia [2], Pakistan [1], and Philippines [2]) responded to this survey. This survey demonstrated substantial outbreak adaptability. The major differences between the three income categories were that HICs were (1) more able/willing to minimize use of noninvasive

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- novel coronavirus disease 2019
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- noninvasive ventilation
- mechanical ventilation
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ventilation or high-flow nasal cannula therapy in favor of early intubation, and (2) had greater availability of negative-pressure rooms and powered air-purifying respirators. Further research into the best practices for respiratory support are warranted. In particular, innovation on cost-effective measures in infection control and respiratory support in the LMIC setting should be considered in preparation for future waves of COVID-19 infection.

## Introduction

There is wide variation in the overall clinical impact of novel coronavirus disease 2019 (COVID-19) across countries worldwide.[1,2] While this phenomenon is more obvious in the adult population, it may also be true in the pediatric population.[3–6] The varying clinical impact is influenced by patient factors (e.g., age, diabetes, and heart disease),[7,8] treatment factors (e.g., supportive care and direct therapies),[9] and medical resources (e.g., frequency of viral testing, bed capacity, and infection control measures).[10] Limitations in medical resources may not only increase the risk of transmission to other patients and health care staff but also lead to an overwhelmed health care system and poor overall outcome in patients.[2,10]

Since the beginning of the COVID-19 pandemic, a substantial number of nosocomial infections have been reported, especially among health care workers (6–20%).[11,12] As such, hospital-wide infection control measures aimed at mitigating the transmission risk of the virus are of vital importance. Reports have emerged on the preparedness response of pediatric emergency departments,[13–15] the creation of dedicated triage areas for hospital attendees,[16] regular surveillance of health care workers for symptoms and nasopharyngeal swabs,[16] workflows for centralized control room reporting of new/exposed cases,[17] and rigorous surface decontamination protocols.[18] Nevertheless, there remains a paucity of description on infection control measures adopted in pediatric hospitals and the changes pertaining specifically to the provision of respiratory support during the COVID-19 pandemic.

## Methods

As resources vary across countries, we sought to determine the extent of change adopted for infection control and respiratory support by pediatric Asian hospitals for COVID-19 suspected/confirmed cases. This was achieved by conducting an online site survey of all hospitals involved in the Pediatric Acute and Critical Care COVID-19 Registry of Asia (PACCOVRA) over April 20 to May 24, 2020. In brief, PACCOVRA aims to (1) pool the number of pediatric COVID-19 cases within the Pediatric Acute and Critical Care Asian Network (PACCMAN); (2) characterize demographic, clinical, and laboratory features; (3) determine the proportion of confirmed pediatric COVID-19 cases who develop pneumonia, pediatric acute respiratory distress syndrome (PARDS), multisystem inflammatory in children (MIS-C); and (4) provide a platform for continued surveillance for unanticipated clinical complications (clinicaltrial.gov registration NCT04395781).

The survey, developed by the study team, included hospital-level characteristics, infection control practices, and respiratory support practices (►**Supplementary Table S1** [available in the online version]) and was administered by e-mail invitation only. Each site completed a single, representative, and nonanonymous survey. Any ambiguity of the questionnaire was discussed and resolved, and all questions were mandatory. The Checklist for Reporting Results of Internet E-Surveys (CHERRIES) was used.[19] We compared data from centers of high-income (HIC), upper middle income (UMIC), and lower middle income (LMIC) countries using the Fisher's exact test. HIC, UMIC, and LMIC were classified according to the World Bank's classification.[20] Exemption from ethics review was obtained for this study.

## Results

This registry currently involves 20 sites over 9 countries (HIC: Japan [4] and Singapore [2]; UMIC: China [3], Malaysia [3], and Thailand [2]; LMIC: India [1], Indonesia [2], Pakistan [1], and Philippines [2]) and all responded to this survey. All participating hospitals were national referral centers for COVID-19 cases (►**Supplementary Table S2** [available in the online version]). Aside from 2 of 20 (10.0%) centers which performed universal COVID-19 screening for all patients, screening was mostly done selectively (►**Table 1**). Mandatory hospital admission was implemented differently in HIC, UMIC, and LMIC countries [5/6 (83.3%) and 8/8 (100.0%) vs. 3/6 (50.0%); $p = 0.070$], although this was not statistically significant. Isolation facilities built into the main hospital building [5 (83.3%), 6 (75.0%) vs. 1 (16.7%); $p = 0.053$] and negative pressure rooms [6/6 (100.0%), 2/8 (25.0%) vs. 3/6 (50.0%); $p = 0.020$] were also more common in HIC versus UMIC and LMIC countries, respectively.

Changes in practices for the use of noninvasive ventilation (NIV), high-flow nasal cannula (HFNC), intubation, and care of the mechanically ventilated patient were observed in all sites (►**Table 2**). NIV (3/20 [15.0%]) and HFNC (2/10 [10.0%]) therapies were completely withheld in several centers. All these centers were from HIC countries. Instead, early intubation seemed to be adopted more often in centers from higher income status (6/6 [100.0%] and 7/8 [87.5%] vs. 3/6 [50.0%]; $p = 0.136$), though this was not statistically significant. The use of a of powered air-purifying respirators (PAPR) for care of patients on NIV [2/3 (66.7%), 0/8 (0.0%) vs 1/6 (16.7%); $p = 0.028$] and HFNC [2/4 (50.0%), 0/8 (0.0%) vs. 1/5 (20.0%); $p = 0.065$] therapy were also more common in HIC versus UMIC and LMIC. Personal protective equipment (PPE) was also used universally for NIV, HFNC, intubation, and resuscitation; however, PAPR use was higher in centers from HIC than UMIC and LMIC for these procedures.

 

**Table 1** COVID-19 control measures observed at Asian centers

| COVID-19 control measures | All $n = 20$ (%) | HIC $n = 6$ (%) | UMIC $n = 8$ (%) | LMIC $n = 6$ (%) | *p*-Value |
|---|---|---|---|---|---|
| Screening criteria | | | | | |
| All patients | 2 (10.0) | 0 (0.0) | 2 (25.0) | 0 (0.0) | 0.305 |
| Travel history | 10 (50.0) | 0 (0.0) | 5 (62.5) | 5 (83.3) | 0.012 |
| Close contacts | 19 (95.0) | 5 (83.3) | 8 (100.0) | 6 (100.0) | 0.600 |
| Respiratory symptoms | 18 (90.0) | 5 (83.3) | 7 (87.5) | 6 (100.0) | 1.000 |
| Pneumonia | 19 (95.0) | 6 (100.0) | 7 (87.5) | 6 (100.0) | 1.000 |
| Rescreening criteria | | | | | |
| Never rescreened | 2 (10.0) | 1 (16.7) | 1 (12.5) | 0 (0.0) | 1.000 |
| At intervals | 5 (25.0) | 1 (16.7) | 4 (50.0) | 0 (0.0) | 0.124 |
| New respiratory symptoms | 15 (75.0) | 5 (83.3) | 5 (62.5) | 5 (83.3) | 0.675 |
| New pneumonia | 8 (40.0) | 1 (16.7) | 3 (37.5) | 4 (66.7) | 0.286 |
| Clinical deterioration | 16 (80.0) | 4 (66.7) | 7 (87.5) | 5 (83.3) | 0.792 |
| Admission policy | | | | | |
| Mandatory admission | 16 (80.0) | 5 (83.3) | 8 (100.0) | 3 (50.0) | 0.070 |
| Quarantine elsewhere | 8 (40.0) | 2 (33.3) | 2 (25.0) | 4 (66.7) | 0.386 |
| Isolation features | | | | | |
| Isolation building | 6 (30.0) | 0 (0.0) | 2 (25.0) | 4 (66.7) | 0.066 |
| Isolation ward | 12 (60.0) | 5 (83.3) | 6 (75.0) | 1 (16.7) | 0.053 |
| Isolation cubicle | 9 (45.0) | 1 (16.7) | 3 (37.5) | 5 (83.3) | 0.076 |
| Isolation room | 11 (55.0) | 4 (66.7) | 6 (75.0) | 2 (33.3) | 0.386 |
| Negative pressure | 11 (55.0) | 6 (100.0) | 2 (25.0) | 3 (50.0) | 0.020 |
| Anteroom | 4 (20.0) | 2 (33.3) | 1 (12.5) | 1 (16.7) | 0.792 |
| Number of visitors allowed | | | | | 1.000 |
| One | 17 (85.0) | 5 (83.3) | 7 (87.5) | 5 (83.3) | |
| Two | 3 (15.0) | 1 (16.7) | 1 (12.5) | 1 (16.7) | |

Abbreviations: COVID-19, novel coronavirus disease 2019; HIC, high income country; LMIC, lower middle income country; UMIC, upper middle income country.

## Discussion

This site survey showed differences in the adoption of COVID-19 control measures for infection control and respiratory support in pediatric hospitals across Asia. Early recommendations to minimize/avoid aerosol-generating procedures, such as NIV and/or HFNC, resulting in earlier than usual intubation,[21–23] has likely made an impact in pediatric centers. The observation that this change was only adopted by centers from HIC may imply that this policy is only viable to centers with sufficient invasive mechanical ventilators to accommodate a surge in use. It is important, however, to note that these recommendations have been challenged and noninvasive respiratory support is believed to be useful in COVID-19 patients provided that health care staff have adequate provision of PPE.[24,25] Thus far, the role of NIV and HFNC in COVID-19 remains unclear with poor evidence of its benefits or risks. This has resulted in the publication of varying recommendations from national health care authorities (e.g., the National Health System [NHS], United Kingdom recommends against the use of HFNC,[22] whereas the Australia New Zealand Intensive Care Society [ANZIC] recommends against the use of NIV[23]). However, at a global level, the World Health Organization (WHO) recommends that NIV (including bubble continuous positive airway pressure) and HFNC may be used in mild adult/pediatric acute respiratory distress syndrome caused by COVID-19.[26]

The availability of negative-pressure rooms (or airborne-infection isolation rooms) and certain protective equipment (e.g., PAPR) is also evidently discrepant between centers from HICs and UMIC/LMICs. If admission is warranted, patient placement is conducted ideally in a single room with closed doors, negative-pressure rooms may only be necessary for aerosol generating procedures.[27] In our survey, centers from lower income countries have considered cohorting patients in isolation cubicles or stand-alone isolation units. The indication for PAPR use was also found to be different between countries; with centers from HIC adopting its use more frequently than UMIC and LMIC. This is not surprising, considering the cost of PAPRs, need for adequate training, time consumed for staff to don and doff this complex

 

**Table 2** Changes adopted for provision of respiratory support

| Respiratory support | All $n = 20$ (%) | HIC $n = 6$ (%) | UMIC $n = 8$ (%) | LMIC $n = 6$ (%) | *p*-Value |
|---|---|---|---|---|---|
| Change in NIV[a] practice | | | | | |
| NIV use withheld | 3 (15.0) | 3 (50.0) | 0 (0.0) | 0 (0.0) | 0.035 |
| Single room | 14 (82.4) | 2 (66.7) | 7 (87.5) | 5 (83.3) | 0.753 |
| Cohort | 2 (11.8) | 1 (33.3) | 0 (0.0) | 1 (16.7) | 0.265 |
| HEPA filter | 13 (76.5)) | 0 (0.0) | 1 (12.5) | 3 (50.0) | 0.249 |
| Oronasal mask | 3 (17.7) | 1 (33.3) | 2 (25.0) | 0 (0.0) | 0.365 |
| PAPR worn by staff | 3 (17.7) | 2 (66.7) | 0 (0.0) | 1 (16.7) | 0.028 |
| Change in HFNC[a] practice | | | | | |
| HFNC use withheld | 2 (10.0) | 2 (33.3) | 0 (0.0) | 0 (0.0) | 0.146 |
| Single room | 16 (94.1) | 4 (100.0) | 8 (100.0) | 4 (80.0) | 0.529 |
| Cohort | 3 (17.7) | 0 (0.0) | 1 (12.5) | 2 (40.0) | 0.394 |
| Face mask (over HFNC) | 9 (52.9) | 1 (25.0) | 6 (75.0) | 2 (40.0) | 0.263 |
| PAPR worn by staff | 3 (17.7) | 2 (50.0) | 0 (0.0) | 1 (20.0) | 0.065 |
| Change in intubation practice | | | | | |
| Early intubation | 16 (80.0) | 6 (100.0) | 7 (87.5) | 3 (50.0) | 0.136 |
| Minimize BVM | 18 (90.0) | 6 (100.0) | 7 (87.5) | 5 (83.3) | 1.000 |
| HEPA on BVM | 18 (90.0) | 6 (100.0) | 7 (87.5) | 5 (83.3) | 1.000 |
| Preference for LMA | 2 (10.0) | 0 (0.0) | 0 (0.0) | 2 (33.3) | 0.158 |
| Cuffed ETT | 16 (80.0) | 5 (83.3) | 6 (75.0) | 5 (83.3) | 1.000 |
| Video laryngoscopy | 16 (80.0) | 4 (66.7) | 7 (87.5) | 5 (83.3) | 0.792 |
| Intubation team | 10 (50.0) | 2 (33.3) | 5 (62.5) | 3 (50.0) | 0.848 |
| Intubation box | 3 (15.0) | 0 (0.0) | 2 (25.0) | 1 (16.7) | 0.747 |
| PAPR by staff | 8 (40.0) | 2 (33.3) | 4 (50.0) | 2 (33.3) | 0.733 |
| Change in care of the mechanically ventilated patient | | | | | |
| Minimize heated humidification | 11 (55.0) | 4 (66.7) | 4 (50.0) | 3 (30.0) | 0.867 |
| HEPA filter on circuit | 19 (95.0) | 6 (100.0) | 7 (87.5) | 6 (100.0) | 1.000 |
| In-line suction | 18 (90.0) | 6 (100.0) | 6 (100.0) | 4 (66.7) | 0.158 |
| PPE by staff | 18 (94.7) | 6 (100.0) | 6 (85.7) | 6 (100.0) | 1.000 |
| HFOV | 12 (60.0) | 4 (66.7) | 5 (62.5) | 3 (50.0) | 1.000 |

Abbreviations: BVM, bag-valve mask; ETT, endotracheal tube; HEPA, high-efficiency particulate air; HFNC, high-flow nasal cannula; HFOV, high-frequency oscillatory ventilation; HIC, high-income country; LMA, laryngeal mask airway; LMIC, lower middle income country; NIV, noninvasive ventilation; PAPR, powered air-purifying respirators; PPE, personal protective equipment; UMIC, upper middle income country.
[a]Only 17 centers offered NIV and HFNC during the novel coronavirus disease 2019 pandemic.

equipment, and there is no definitive evidence that PAPR reduces viral transmission.[27,28]

## Limitations and Strengths

This report has several limitations. First, all sites responding to this survey are national COVID-19 referral centers, as well as, tertiary pediatric hospitals with a dedicated pediatric intensive care unit. Additionally, the number of sites was few, and many Asian countries were not represented in this survey. Second, data were not exhaustive of all changes adopted during the COVID-19 pandemic. Lastly, this survey was conducted during the peak of the COVID-19 pandemic without longitudinal follow-up to capture changes over time. These factors result in limited generalizability to other pediatric centers in Asia or in other continents of the world within the same income category. Nevertheless, this survey demonstrated substantial outbreak adaptability, outlining major differences between the three income categories where HICs (1) were more able/willing to minimize use of NIV or HFNC therapy in favor of early intubation, and (2) had greater availability of negative-pressure rooms and PAPRs.

## Conclusion

Given the results of this survey, innovation on cost-effective measures in infection control and respiratory support in the LMIC setting should be considered in preparation for future

 

waves of COVID-19 infection. Though there were differences in the adoption of COVID-19 control measures for respiratory support, this site survey showed that pediatric hospitals across Asia have undergone significant change, regardless of economic status. Many of these preparedness measures were aligned with the Centers for Disease Control and Prevention (CDC) recommendations as standard and transmission-based precautions.[27] These measures require further evaluation on the clinical impact to patients and the nosocomial risk to health care staff. We anticipate reports from the PACCOVRA registry to emerge soon regarding the number and characterization of infected pediatric cases in Asia. The incidence of nosocomial COVID-19 infections will also be evaluated from these centers.

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Conflict of Interest
None declared.

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