



## CLINICAL RESEARCH ARTICLE

## International comparison of guidelines for managing neonates at the early phase of the SARS-CoV-2 pandemic

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**BACKGROUND:** The COVID-19 pandemic threatens global newborn health. We describe the current state of national and local protocols for managing neonates born to SARS-CoV-2-positive mothers.

**METHODS:** Care providers from neonatal intensive care units on six continents exchanged and compared protocols on the management of neonates born to SARS-CoV-2-positive mothers. Data collection was between March 14 and 21, 2020. We focused on central protocol components, including triaging, hygiene precautions, management at delivery, feeding protocols, and visiting policies.

**RESULTS:** Data from 20 countries were available. Disease burden varied between countries at the time of analysis. In most countries, asymptomatic infants were allowed to stay with the mother and breastfeed with hygiene precautions. We detected discrepancies between national guidance in particular regarding triaging, use of personal protection equipment, viral testing, and visitor policies. Local protocols deviated from national guidance.

**CONCLUSIONS:** At the start of the pandemic, lack of evidence-based guidance on the management of neonates born to SARS-CoV-2-positive mothers has led to ad hoc creation of national and local guidance. Compliance between collaborators to share and discuss protocols was excellent and may lead to more consensus on management, but future guidance should be built on high-level evidence, rather than expert consensus.

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**IMPACT:**

- At the rapid onset of the COVID19 pandemic, all countries presented protocols in place for managing infants at risk of COVID19, with a certain degree of variations among regions.
- A detailed review of ad hoc guidelines is presented, similarities and differences are highlighted.
- We provide a broad overview of currently applied recommendations highlighting the need for international context-relevant coordination.

**INTRODUCTION**

In December 2019, a new severe disease caused by coronavirus 2 (severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)) emerged in Wuhan, China, creating a global pandemic of unprecedented magnitude.<sup>1</sup> By April 2, 2020, >1,000,000 cases of coronavirus disease (COVID-19) have been reported in >200 countries, resulting in >52,000 deaths.<sup>2</sup> COVID-19 appears to have the greatest impact on seniors and those with significant co-morbidities.<sup>3</sup>

SARS-CoV-2 infection in children appears to be less common and less severe compared with adults.<sup>4–6</sup> Few cases of neonatal COVID-19 have been reported to date, and little is known

regarding route of infection, clinical presentation, management, and outcome.<sup>7,8</sup> Reassuringly, vertical transmission of SARS-CoV-2 appears rare, consistent with other coronavirus infections.<sup>7,9</sup> In the few reported infants with possible vertical transmission, the clinical course was mild.<sup>5,8,10</sup> Answers are missing to a number of pressing questions, including the significance of vertical and horizontal transmission for the newborn, route and timing of horizontal transmission, the role of breastfeeding, prediction of infant disease severity, and the effectiveness of preventive measures to protect infants and health care workers (HCW), as well as the potential side effects of such measures. Nonetheless,

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HCW must act to protect patients and families in the face of uncertainty. The aforementioned questions are of utmost importance for organizing an effective and efficient health system response for mothers and infants, while protecting HCW and limited resources. Yet, in the absence of high-quality evidence, pragmatic solutions need to be found.<sup>11</sup>

We compare the experiences and practical recommendations from international, national, and local guidelines on the management of newborn infants born to SARS-CoV-2-suspected or SARS-CoV-2-positive mothers. Common to all efforts are the lack of objective data and limited published reports on effective management at the time guidelines were devised. This report reflects possible management options at a specific point in time and future work will supercede the presented guidance. We aim to highlight the state of coordinated guideline-informed approaches to the pandemic while extracting lessons for future pandemic preparedness.

## METHODS

On March 10, 2020, a core group of experts in neonatal intensive care from Italy, Norway, the United States (US), Ireland, and the United Kingdom (UK), began to share local guidance on the management of babies born to mothers with COVID-19. Initially, protocols from Chinese units were requested from professional contacts, followed by further invitation of key professionals, in the following referred to as collaborators, who were identified via

societal databases (European Society for Paediatric Research, Society for Pediatric Research and American Academy of Pediatrics, and personal contacts). We aimed to secure global representation through a wide selection of national backgrounds, including low-and-middle-income countries. Collaborators shared national epidemiological data on disease prevalence and provided national and local guidelines on the management of neonates born to COVID-19-suspected or COVID-19-positive mothers. When local guidelines were provided, they reflected practice at the collaborators' institution but were not necessarily representative of national guidelines.

A convenience sample of 23 experts from 21 countries was approached via email with a structured questionnaire. Collaborators were surveyed between March 14 and 21, 2020. We focused on the following aspects of management: organization of hospital triaging and centralization of care (sequestering patients in designated hospitals or wards); hygiene management, including use of personal protective equipment (PPE) in the delivery room (DR) and the neonatal intensive care unit (NICU) with a specific focus on aerosol-generating procedures (AGP); clinical pathways for asymptomatic infants, those delivered vaginally or by cesarean section, and those inborn or outborn; approaches to breastfeeding; diagnostic testing; family access to the NICU; and psychological support for families and HCW.

Data were analyzed in Microsoft Excel (Microsoft Redmond, Washington, U.S.).

**Table 1.** Patient triage, care centralization, and national collaborations.

Country	Obstetrical emergency triaging and isolation	Organization of separate services for outpatient clinic	Centralization of care to identified tertiary centers: pregnant women	Centralization of care to identified tertiary centers: infants	National neonatal networking for COVID-19 pandemic
Argentina	Yes	Yes	Yes	Yes	Yes
Australia (WA)	Yes	Yes	No	No	No
Belgium	Yes	Yes	Preferred	Yes	Yes
Brazil	Yes	Yes	Yes	Yes	No
Canada	Yes	Yes	No	No	No/work in progress
China	Yes	Yes	Yes	Yes	Yes
Germany	Yes	Yes	No (under discussion)	No (under discussion)	Yes
Ireland	Yes	Yes	No	No	Yes
Israel	Yes	Yes	Yes	No	Yes
Italy	Yes	Yes	Yes	Yes	Yes
Kenya	No	No	No	No	No
Mexico	No countrywide Yes locally	No countrywide Yes locally	No countrywide Yes locally	No countrywide Yes locally	No
The Netherlands	No <sup>a</sup>	No <sup>b</sup>	No	No	Yes
Norway	No <sup>a</sup>	No <sup>b</sup>	No	No	Yes
Poland	Yes	Yes	Yes	Yes	Yes
Spain	Yes	Yes	Preferred	Preferred	Yes
Sweden	No	Yes	No	No	Yes
Switzerland	Yes	Yes	Yes <sup>c</sup>	Yes <sup>c</sup>	Yes
UK	Yes	Yes <sup>b</sup>	No	Yes <sup>c</sup>	Yes
US—CDC	Yes	Not specified	Not specified	Not specified	No
US—Boston	Yes	Yes	Yes	Yes	No
US—Palo Alto	Yes	Yes	No	No	No <sup>d</sup>
Total (%) <sup>e</sup>	17 (77%)	17 (77%)	10 (45%)	10 (45%)	14 (64%)

WA Western Australia.

<sup>a</sup>Special rooms for (suspected) COVID-19-positive pregnant women.

<sup>b</sup>Outpatient clinics by telephone if possible for all patients.

<sup>c</sup>Standard regionalization of care.

<sup>d</sup>Neonatal networking webinar, initiated by the California Maternal and Perinatal Quality Care Collaboratives.

<sup>e</sup>Total based on 20 countries.

**Table 2.** Delivery room and NICU management.

Country	Resuscitation in the delivery room	Infants in need of immediate intensive care—vaginal delivery (VD)	Infants in need of immediate intensive care—cesarean delivery (CS)	Infants in NICU treated with aerosol-generating procedure (AGP) (e.g., CPAP, nHFT)
Argentina	Wearing PPE. COVID-19 dedicated rooms. DCC	Wearing PPE. Transport in dedicated incubators	Wearing PPE. Transport in dedicated incubators	Closed incubator, isolation room expiratory filters. Avoid AGP if possible. PPE
Australia (WA)	Wearing PPE. Same room as mother	Wearing PPE	Wearing PPE	Closed incubator, isolation room; negative pressure if available
Belgium	Wearing PPE. Dedicated rooms	Wearing PPE. Transport in dedicated incubators	Wearing PPE. Transport in dedicated incubators	Closed incubator, isolation room (if suspected), cohortation (if positive), negative pressure if available (rarely)
Brazil	Wearing PPE. Minimum number of care providers involved. Dedicated rooms (suspected or confirmed). Resuscitation in the delivery suite. No DCC	Wearing PPE. Transport in dedicated incubators	Wearing PPE. Transport in dedicated incubators	Closed incubator, isolation room. Respiratory support: avoid PPV (balloon self-inflated or T-piece), if needed, the mask must be firmly sealed. Non-invasive ventilation must not be used. Mechanical ventilation: respiratory filters, closed tracheal suctioning systems. PPE
Canada	Wearing PPE. Suggested no DCC. One physician. SSC immediately after birth—allowed if parents insist	Wearing PPE	Wearing PPE	Closed incubator. Isolation room, negative pressure if available, expiratory filters between the expiratory valve and the expiratory circuit. PPE
China	Wearing PPE. No DCC. Preferably in negative pressure rooms	Wearing PPE	Wearing PPE. Inform neonatal team 30 min before emergency CS	Isolated in a single room or negative pressure rooms. Minimal number of staff. PPE
Germany	Wearing PPE	Wearing PPE	Wearing PPE	Closed incubator, isolation room, negative pressure expiratory filters between the expiratory valve and the expiratory circuit
Ireland	Wearing PPE	Wearing PPE	Wearing PPE	Closed incubator, isolation room
Israel	Wearing PPE, COVID-19 dedicated rooms	Wearing PPE, PPE	Wearing PPE	Closed incubator, isolation room, minimal oxygen flow, closed-loop suctioning, PPE
Italy	Wearing PPE. Same room as mother, COVID-19 dedicated rooms. Suggested no DCC. No SCC after birth	Wearing PPE. Transport in dedicated incubators	Wearing PPE. Transport in dedicated incubators	Closed incubator. Isolation room, negative pressure if available. Expiratory filters between the expiratory valve and the expiratory circuit. No restriction to non-invasive respiratory support. Preferring CPAP provided by mechanical ventilator. PPE
Kenya	Wearing PPE	Wearing PPE	Wearing PPE	Isolation room. PPE
Mexico	Limited hygiene precautions—possibly contagious (low risk)	Wearing PPE	Wearing PPE	Closed incubator. Isolation room, respiratory isolation. Individualized respiratory care. PPE
The Netherlands	Wearing PPE. COVID-19 dedicated rooms	Wearing PPE	Wearing PPE	Closed incubator. Isolation room, if possible dedicated (open bay) room for COVID-19-positive patients. Consider intubation with cuffed tube if infants need more than low flow oxygen. PPE
Norway	Wearing PPE	Limited hygiene precaution—possibly contagious (low risk)	No precautions. Considered not contagious	Closed incubator. Isolation room. PPE
Poland	Wearing PPE	Wearing PPE	Wearing PPE	Closed incubator. Isolation room. PPE
Spain	Wearing PPE	Wearing PPE	Wearing PPE	Closed incubator. Isolation room. PPE. Individualized respiratory support
Sweden	Resuscitation outside delivery. Standard hygiene if resuscitation outside the delivery room	Standard hygiene. Single room if possible. Initially considered not contagious	Standard hygiene. Single room if possible. Considered not contagious	PPE for aerosol. Isolation room if available. Single room

Country	Resuscitation in the delivery room	Infants in need of immediate intensive care—vaginal delivery (VD)	Infants in need of immediate intensive care—cesarean delivery (CS)	Infants in NICU treated with aerosol-generating procedure (AGP) (e.g., CPAP, nHFT)
Switzerland	Wearing PPE	Wearing PPE	Wearing PPE	Incubator care, single isolation room if available, negative pressure if available. PPE
UK	Stabilization/resuscitation outside the delivery suite. Level-1 PPE (partial) for infant handling immediately after delivery, full PPE when potential for aerosol exposure	Level-1 PPE	Level-1 PPE	Isolation room. Closed incubator, non-invasive respiratory support (nasal high flow in incubator). When mechanically ventilated: expiratory filters
US—CDC	Wearing PPE	Wearing PPE	Wearing PPE	Wearing PPE
US—Boston	Wearing PPE. Transport in specified incubators	Wearing PPE. Transport in dedicated incubators	Wearing PPE. Transport in dedicated incubators	If no respiratory support: PPE and single room. If respiratory support: PPE+negative pressure isolation room or single room with HEPA filter
US—Palo Alto	Wearing PPE (airborne+mask); filter used for PPV equipment	Incubators; those not requiring respiratory support in droplet +eyewear precautions	Incubators; those not requiring respiratory support in droplet +eyewear precautions	Closed incubators. Negative pressure rooms. Ventilatory filters

AGP aerosol-generating procedures = non-invasive respiratory support (e.g., nasal high-flow therapy and continuous positive airway pressure), DCC delayed cord clamping, nHFT nasal high-flow therapy, PPE personal protective equipment, PPV positive pressure ventilation, SSC skin-to-skin contact, WA Western Australia.

**RESULTS**

The epidemiological burden of COVID-19 differs markedly between countries. By March 21, 2020, Italy and China were the 2 most severely affected countries, while 8 countries reported <10 deaths (for more detail, see Supplementary Table S1). The availability of local and national guidelines for neonatal management varied considerably among collaborators. Half of the institutions adopted national guidelines, and the remainder relied on local guidelines. Reasons for not adopting national guidelines included: unavailable at the time of the survey, difficult application or disagreement with national guidelines, and lack of granularity of national guidelines. Means for triaging actively laboring SARS-CoV-2-positive mothers were considered in all guidelines. Interventions included transfer to specific hospitals or hospital sites, for example, designated isolation rooms on delivery suites. Guidelines regarding centralization of care for symptomatic and/or SARS-CoV-2-positive infants varied widely (Table 1). More consistency was observed with regard to PPE, which was universally recommended during neonatal management in the DR (Table 2). Isolation procedures in the NICU varied, with the majority of respondents suggesting isolation for infants in single rooms. When conducting AGP such as non-invasive respiratory support, most guidelines recommended isolation in closed incubators. However, only a few institutions had an explicit respiratory support plan for infected and/or symptomatic patients. Most national or local guidelines suggested that an asymptomatic infant could stay with the mother to breastfeed, with the exception of China, and, in part, Ireland and the US. Breastfeeding COVID-19-positive mothers were to be supplied with material clearly explaining hygienic precautions. Most guidelines recommend viral testing of all infants born to COVID-19-positive mothers but a few countries restricted testing to symptomatic infants (Table 3). For viral testing, nasopharyngeal swabs (NPSs) were most commonly advised. In Table 4, we present data on infant feeding, visitation arrangements, and considerations for psychological care for parents/caregivers. Guidelines from several countries included detailed descriptions of recommended psychological care; however, the content varied. Very few guidelines mentioned psychological care for parents or HCW affected by COVID-19.

**DISCUSSION**

We performed an analysis of the early, quasi ad hoc process of national and local guidelines developed for managing neonates born to SARS-CoV-2-positive mothers during the month of March 2020. Our pragmatic international survey includes guidance from 20 countries on 6 continents. Many similarities, but also striking differences, became apparent. At the early stage of the pandemic, guidelines from the World Health Organization (WHO) or national authorities may have been difficult to implement in different local contexts or had left several, relevant aspects of newborn care undefined, necessitating the formulation of pragmatic local recommendations. We have observed the constant growth in the evidence base for managing infants born to COVID-19-positive mothers alongside the changing interpretation of the available data. Thus already existing guidelines are being adapted in a non-predictable pattern. Common to all is the likelihood that guidelines will continue to evolve over the coming weeks according to the best available evidence. Until sufficiently evidence-based guidelines are in place, international recommendations and national protocols need to be adapted to the local settings.

The progression of international and national guidance since the writing of this paper illustrates how knowledge gained and shared by reputable institutions worldwide has entered guidelines. On March 13, the WHO published an interim guidance on clinical management of COVID-19, "Caring for infants and mothers."<sup>12</sup> At that time, available evidence suggested no vertical

**Table 3.** Clinical pathway for asymptomatic infants, inborn/outborn, testing, and follow-up.

Country	Asymptomatic infants	Baby admitted after contact with mother/parent or outborn	Testing	Culture specimens and other diagnostic	Discharge/follow-up (FU)
Argentina	Stay with mother. Breastfeeding allowed. Strict hygiene precautions	Contact isolation only if mother positive or highly suspicious	Only symptomatic infants	NPS	Discharge: clinical stability and two NPS negative, 24 h apart. FU at 1 month
Australia (WA)	Stay with mother. Breastfeeding allowed. Strict hygiene precautions	Dependant on clinical status. Mild symptoms, isolated in a single room, close monitoring. Once well, discharge and 14 days' isolation. If baby unwell, isolated in negative pressure room (if available) or single room (if available), otherwise consider cohorting. Closed incubator, with droplet precautions. Wearing PPE	All	NPS	Discharge home early—if mother COVID-19 positive. FU not specified
Belgium	Stay with mother. Breastfeeding allowed. Strict hygiene precautions. Keep distance (1.5 m) between crib and mother	If mother moderately/severely ill: infant hospitalized in step down unit or NICU. Isolation until tested; continued for 14 days if negative; cohorting possible if positive	All	NPS × 2. If respiratory symptoms: CXR, CBC	Early discharge recommended 24 h from birth. Care by midwives with PPE; contact precautions for 21 days. FU to be defined
Brazil	Stay with mother. Breastfeeding allowed. Hygiene precautions. Keep distance (2 m) between crib and mother	Same as asymptomatic babies	Only symptomatic infants	Both inborn and outborn NPS	FU at University Hospital at 1 month and 6 months, including respiratory function testing
Canada	Stay with mother. Breastfeeding allowed. Hygiene precautions	Parents positive or suspected—follow same as considered positive (closed incubators, isolation rooms, PPE). Parents negative—routine care. Until results come back—same precaution as positive	All	Delivery: placenta, cord blood. Newborn: NPS × 2. If respiratory symptoms: sepsis work-up, NPS for SARS-CoV-2 and other respiratory viruses. CXR	Early discharge. FU at 48–72 h with a pediatrician
China	Isolation room	Negative pressure rooms, isolation in single rooms	All	NPS or other respiratory tract specimens; blood, stools	Criteria for discharge: normal temperature for > 3 days, respiratory symptoms and chest XT improved dramatically, negative NP swab (2 tests, at 24-h interval). FU in 2–3 weeks
Germany	Stays with mother. Breastfeeding allowed. Hygiene advice	Wearing PPE and isolation until discharge. Mother allowed for breastfeeding	All	Both inborn/outborn: NPS × 2	FU to be defined
Ireland	Separation recommended and give EBM but can room with mother if separation is refused, in which case baby is placed in an incubator and all handling breastfeed with PPE donned. Remove baby temporarily if AGP	Separation recommended and give EBM but can room with mother if separation is refused, in which case baby is placed in incubator and all handling breastfeed with PPE donned. Remove baby temporarily if AGP	All	NPS	14 days' FU at home or hospital with public health FU of close contacts
Israel	Stay with mother if both positive and well. If negative to positive mother—separation or rooming-in according to mother's request	If asymptomatic, can stay with mother in the dedicated room. If unwell, will stay at the dedicated room in NICU	All	NPS × 3 and stool × 3, 24 h apart	2 negative tests before discharge. Community FU to be defined
Italy			All		

**Table 3.** continued

Country	Asymptomatic infants	Baby admitted after contact with mother/parent or outborn	Testing	Culture specimens and other diagnostic	Discharge/follow-up (FU)
Kenya	Stay with mother. Breastfeeding allowed. Hygiene precautions	Wearing PPE until the baby is tested negative, closed incubator, isolation room (negative pressure room if available)	All	Delivery: placenta, cord, amniotic fluid; Newborn: NPS × 2; Outborn: NPS × 2; CXR if respiratory symptoms	At 14 and 28 days (testing only for research protocols). National registry
Mexico	Stay with mother. Breastfeeding allowed. Strict hygiene precautions	Isolation room, PPE	All	NPS	FU not specified
The Netherlands	Stay with mother. Breastfeeding allowed. Hygiene precautions	Wearing PPE. Mother and infant tested for virus. Incubator, isolation. Breastfeeding withheld until negative results	All	NPS CXR if respiratory symptoms	FU not specified
Norway	Stay with mother after delivery (at home or in hospital) unless needing other care. Breastfeeding allowed. Hygiene precautions	Consider positive for COVID-19 until tested negative. PPE	Only symptomatic infants	NPS	FU not defined yet, unless indicated for other problems
Poland	Stay with mother. Breastfeeding allowed. Hygiene precautions	Strict hygiene precaution—considered contagious. PPE	Only symptomatic infants	NPS	Open readmission first 3 postnatal weeks if needed
Spain	Newborn isolated from the mother during hospitalization, expressed breast milk provided	Incubator, isolation room. PPE	All	NPS	FU to be defined
Sweden	Stay with mother. Breastfeeding allowed. Hygiene precautions	Incubator. Isolation room. PPE	All	NPS. Sepsis workout is symptomatic infants and CXR	FU to be defined
Switzerland	Stay with mother. Breastfeeding allowed. Hygiene precautions	Strict hygiene precaution—considered contagious. PPE	All	NPS	A Covid-19 protocol in the Swedish neonatal quality register. At present, routine FU
UK	Stay with mother. Breastfeeding allowed. Hygiene precautions	PPE until the baby is tested negative. Incubator. Isolation room	All	Delivery: swab from placenta, cord, amniotic fluid	FU to be defined
US—CDC	Stay with mother. Breastfeeding allowed. Hygiene precautions	PPE until the baby is tested negative. Incubator. Isolation room	Only symptomatic infants on admission to unit	Only for symptomatic neonates	FU to be defined
US—Boston	PPE for caregivers. Consider temporary separation. Rooming in is an option, with separate caregiver and physical barrier such as curtains if possible. Continue while mother on transmission precautions	Not specified	Maternal NPS × 2	Not specified	FU not specified
US—Palo Alto	Same as CDC	If no respiratory support: PPE including surgical mask, eye protection, gown, gloves	Case-by-case in consultation with IDS, based on symptoms and maternal status	Case-by-case in consultation IDS, based on symptomatology and maternal status	Routine pediatric well-baby monitoring
	Same as CDC	PICU or pediatric acute care COVID cohort unit in single room; negative pressure if on respiratory support, closed door with droplet+eyewear if acute care	Case-by-case in consultation with IDS, based on symptoms and maternal status	NPS	No change in FU indications

AGP aerosol-generating procedures, CBC complete blood count, CDC Center for Disease Control, CXR chest X-ray, EBM expressed breast milk, FU follow-up, MPS nasopharyngeal swab, IDS Infectious Disease Service, PPE personal protective equipment, WA Western Australia.

**Table 4.** Breastfeeding, family access restrictions in NICU, and psychological support.

Country	Breast milk/feeding regimen	Family access restrictions	Psychological needs for parents/caregivers
Argentina	Direct breastfeeding with hygiene precautions for asymptomatic mother with suspected infection; mother's milk by bottle for confirmed cases	Strict contact/respiratory isolation and use of PPE for confirmed and symptomatic cases. Restricted access to the NICU only to parents, one at a time, all day long. Hygiene precautions. Access forbidden to anybody positive or presenting COVID-19 symptoms. Transport incubator for transfers. No restriction to skin-to-skin if parents are asymptomatic	Continue offering psychological support, with adequate use of PPE
Australia (WA)	Hygiene precautions. Face mask, wash hands and breast	No restriction to parental access visiting, except for infants with COVID-19 (only parents)	Not defined
Belgium	Hygiene precautions. Face mask, wash hands. Promote breastfeeding even in case of mother–infant separation. Fresh expressed breast milk. Container disinfection and separated refrigerator for NICU storage; no specific testing or storage procedure	A separate circuit for COVID-19 patients (resources may vary across centers). Restricted access to NICU: 1 relative allowed. COVID-19-positive mother or relative not allowed. Father admitted if tested negative and after 14-day quarantine (may vary across centers). Visitors with COVID-19 symptoms require negative testing before admission	No specific recommendation
Brazil	Hygiene precautions. Face mask, wash hands and breast. Promote breastfeeding even in case of mother–infant separation. Fresh EBM, no recommended pasteurization	Visits restricted to only one parent at a time, with limit of stay (2 h), hygiene measures, and education. Temperature checked for all health care workers; they should bathe in the hospital locker room when they leave the unit. The number of health professionals at NICU will be limited; for examinations and consultations, only one professional	Psychological support planned
Canada	Hygiene precautions. Face mask, wash hands. EBM	One parent allowed per day can stay as long as they want. Handover via teleconference. Social distancing, all healthcare workers to wear a surgical mask. No new recruitment in research projects (avoid research personnel entering the NICU). Access is forbidden to anybody positive or presenting COVID-19 symptoms. No restriction to SSC if parents are asymptomatic	Urgent mental health support available
China	Formula milk, breastfeeding discouraged	Neonatal department strictly stratified into transitional, quarantine, living, and work areas	Psychological support considered (not specified)
Germany	Breastfeeding allowed, hygiene precautions	Restricted access to NICU for positive parents (mother up to 3 times for several hours, the father only once per day). Intercenter variability for SSC. Most research activities are interrupted	Intercenter variability (suspended or provided with PPE)
Ireland	Mother has dedicated pump, asked to sanitize parts after each use; clean breasts before pumping and wear PPE while pumping; bottles wiped down by mother and again upon transfer to NICU	Incubator. Single room	Routine parent support
Israel	Hygiene precautions. Face mask, wash hands. Pumping allowed with private pump and tube cleaning instructions	Not specified	Routine parent support
Italy	Hygiene precautions. Face mask, wash hands. Promote breastfeeding even in case of mother–infant separation. Fresh EBM, no recommended pasteurization. Consider drugs administered to the mother before deciding on breastfeeding	Only one relative (beside mothers) can access the nursery during predefined opening hours. Restricted access to the NICU only to parents, one at a time, all day long, wearing surgical mask. Hygiene precautions. Access is forbidden to anybody positive or presenting COVID-19 symptoms. No	Parents: psychological support suspended, unless urgent, for restrictive measures to contain the infection. COVID-19 operators: online tools available

**Table 4.** continued

Country	Breast milk/feeding regimen	Family access restrictions	Psychological needs for parents/caregivers
Kenya	Breastfeeding allowed. Hygiene precautions	restriction to SSC if parents are asymptomatic. No restriction to research activities if they do not increase the risk of infection Restricted access for parents (only level 1). Only mothers allowed for breastfeeding and SSC (level 2). Strict hygiene precautions	Not specified
The Netherlands	Breastfeeding allowed. Hygiene precautions. EBM as an option, with strict hygiene measures applied	Only parents allowed to visit if no symptoms and not tested positive. No time restriction. No other family/friends allowed. If parents have (suspected) COVID-19, they are not allowed to visit the unit	Support by psychologists, social worker
Norway	Hygiene precautions. Face mask, wash hands and breast	Both parents restricted to visit the NICU if the mother is COVID-19 positive (assume partner also positive). Parents allowed to visit after testing negative at 14 days. If possible, try to keep baby with mother in a separate room outside NICU. In general, only 1 visitor/parent allowed to stay with the baby in NICU (all infants)	Routine parent support. Consider electronic media for interaction between separated infant and parent
Mexico	Breastfeeding withheld until mother tests negative	Access to the NICU restricted only to parents, one at a time, all day long, wearing surgical mask. Supervised hygiene precautions. Access is forbidden to anybody positive or with COVID-19 symptoms	To be defined
Poland	Mother under investigation—EBM. Mother positive—infant formula may be administered due to organizational issues	Restrict access to all neonatal units: even mothers do not have access, staff send photos of infants by email daily; mothers can supply expressed breast milk; hospitalized mothers only allowed to access for the time of breastfeeding; if they do not breastfeed, they can be present in the NICU for 15 min	Not defined
Spain	Hygiene precautions. Face mask, wash hands and breast	Not specified	Not defined
Sweden	Hygiene precautions. Promote breastfeeding even in case of mother–infant separation: fresh EBM, no recommended pasteurization	Restricted access to the NICU only to parents, rooming-in. Hygiene precautions. Access is forbidden to anybody positive or presenting COVID-19 symptoms. No restriction to SSC if parents are asymptomatic. Temporal restriction to inclusion of new patients in non-Covid-related research activities	Routine parental support
Switzerland	Hygiene precautions, face mask, wash hands	Restricted access to the NICU only to parents, one parent at a time, all day long, social distancing of parents within NICU, hygiene precautions. Access is forbidden to anybody positive or presenting COVID-19-like symptoms. No restriction to SSC if parents are asymptomatic	Unchanged
UK	Breastfeeding and formula feeding by the mother permitted. Strict hygiene precautions, mothers wearing a mask while handling baby	One relative only (beside mothers) to come to the hospital during predefined opening hours. Restricted access to the NICU; only one parent. Strict hygiene precautions. No access for anybody testing positive or presenting COVID-19-like symptoms. No SSC in babies on respiratory support. Restrict in-hospital transfer/surgery on the NICU/pausing of all non-COVID-19-related research	Continue offering psychological support, with adequate use of PPE
US—CDC		Not specified	Not specified

**Table 4.** continued

Country	Breast milk/feeding regimen	Family access restrictions	Psychological needs for parents/caregivers
US—Boston	Preferred: EBM, fed by healthy caregiver with PPE. If mother wishes to breastfeed, hand hygiene and face mask Same as CDC	Visitors restricted to healthy parent or caregiver, with PPE including gown, glove, face mask, and eye protection	Social work service remains involved remotely
US—Palo Alto	Same as CDC	Labor support person/father cannot accompany the infant to NICU. Mother can access NICU once ruled out for COVID-19. Hospital access limited to parents only (or another caregiver) and must be healthy. If outborn patient admitted, one parent may stay with the infant and not leave isolation room. Not currently recommending masks for asymptomatic visitors	Unchanged

AGP aerosol-generating procedures, CBC complete blood count, CDC Center for Disease Control, CXR chest X-ray, EBM expressed breast milk, FU follow-up, NPS nasopharyngeal swab, IDS Infectious Disease Service, PPE personal protective equipment, SSC skin-to-skin contact, WA Western Australia.

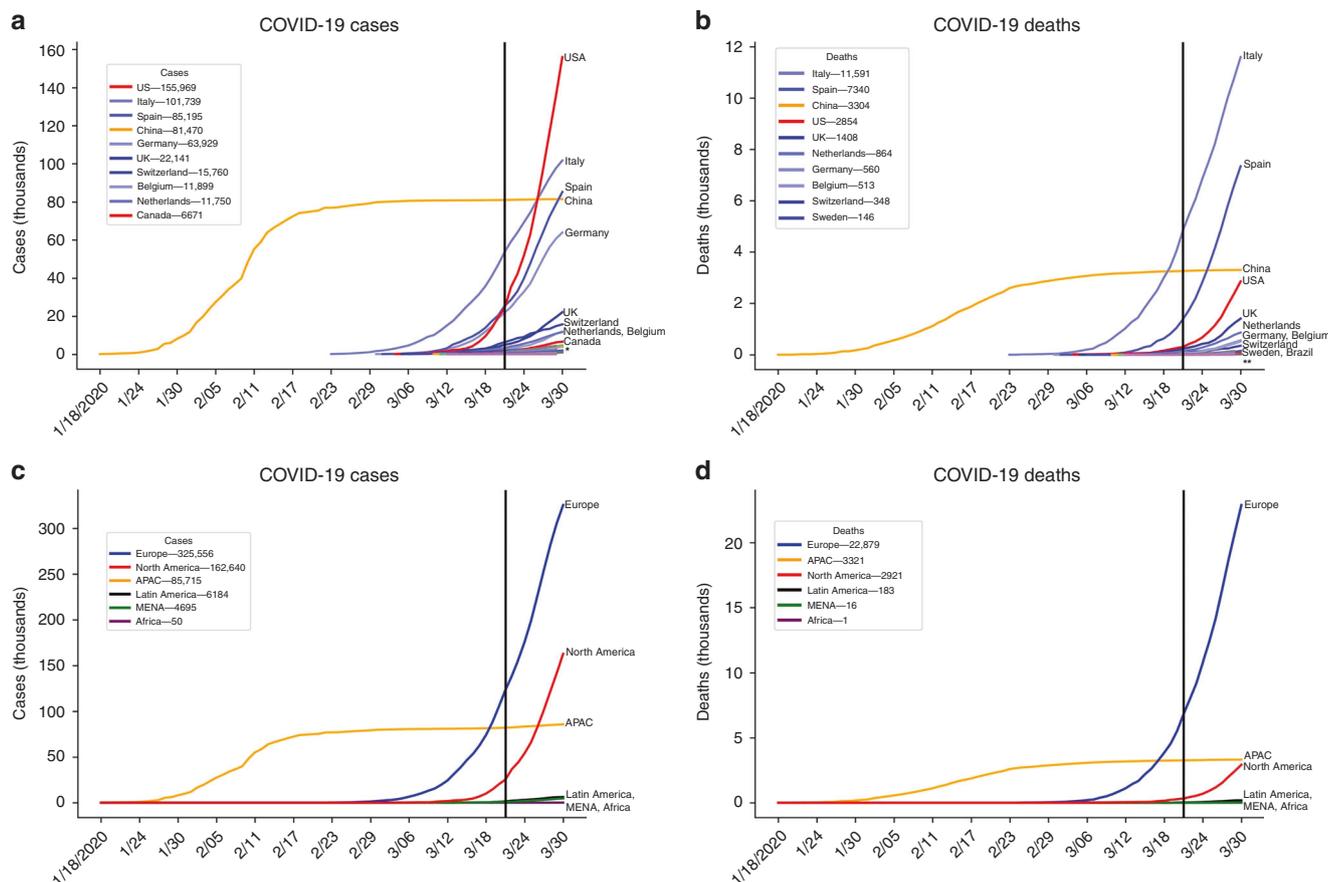
transmission, and in small case series from China, samples from amniotic fluid, genital tract, cord blood, and breast milk from COVID-19-infected mothers were negative for SARS-CoV-2.<sup>9,13–15</sup> The Royal College of Obstetricians and Gynaecologists (RCOG) in the UK published their first guidance “Coronavirus (COVID-19) infection and pregnancy” even before the WHO on March 9. Since then, there have been regular updates, and the fifth version appeared on the 28th of March, reflecting the rapidly evolving knowledge in this area.<sup>16</sup>

An issue of primary interest for neonatologists is the DR management of infants born to mothers with suspected or confirmed SARS-CoV-2 infection. The limited literature concerning the risk of vertical transmission of SARS-CoV-2 as well as for related viruses causing severe respiratory illness, SARS-CoV and Middle East respiratory syndrome-CoV, indicates a low risk.<sup>6,7</sup> The first reports on postnatal COVID-19 disease in newborns from China have also been reassuring.<sup>5,8</sup> Many experts suggest that the contagious potential of the newborn infants themselves immediately after birth is very low. Nevertheless, an anxiety persists as the DR setting represents a contagious area due to maternal COVID-19 disease and due to possible contact with maternal fecal flora containing virus and transmitted to the baby at delivery. Therefore, all international, national, and local guidelines presented in our current report recommended caution during deliveries, including isolation room and the need for PPE, and have made no distinction in managing cesarean and vaginal deliveries.

One of our most pertinent findings concerned the guidance on the controversial topic of mother–infant separation, i.e., whether a COVID-19-positive mother and her asymptomatic infant should be separated right after birth in order to prevent postnatal horizontal disease transmission, through contact or respiratory droplets. In China, this seems to be routine practice and infants are usually fed formula.<sup>17</sup> In contrast, both WHO and RCOG recommend that babies may stay with the mother if she is able to care for the infant, and breastfeeding is recommended.<sup>12,16</sup> The interim guidance from the Center of Disease Control (CDC) in the US takes an intermediate standpoint on this topic and suggests that “whether and how to start or continue breastfeeding should be determined by the mother in coordination with her family and healthcare providers. A mother with confirmed or suspected COVID-19 should take all possible precautions to avoid spreading the virus to her infant, including washing her hands before touching the infant and wearing a face mask, if possible, while feeding at the breast.”<sup>18</sup> In our study, the majority of national or

local guidelines allowed the mother to stay with her asymptomatic infant after birth, and supported breastfeeding with hygiene precautions. These countries/hospitals most likely considered that the benefits of breastfeeding and early infant bonding outweigh the potential risks of postnatal transmission and in most cases mild respiratory disease in infants. The exceptions were China where separation was recommended, Ireland where separation was suggested but maternal decision to room-in with precautions was also available, the US where the CDC suggests “consider temporary separation”, and Israel where a COVID-19-positive mother and her COVID-19-negative child should be separated.

Isolation and personal protection practices were quite consistent across countries. Although neonates are not typically considered capable of generating infectious airborne particles, airborne precautions are recommended for AGPs for infants with SARS-CoV-2 infection.<sup>19</sup> NICUs from most countries reported the use of PPE for neonatal resuscitation for newborns of mothers who are suspected or confirmed COVID-19 positive. This is to protect HCW from maternal aerosolization in the second stage of labor or from the potential contamination and aerosolization that may occur during neonatal resuscitation. Recommendations for protection did not differ for infants in need of immediate intensive care after vaginal or cesarean delivery. The notable exceptions were Norway and Sweden, who consider infants after vaginal or cesarean delivery not likely or very unlikely to be contagious if immediately separated from the mother, for example, due to preterm delivery or acute asphyxia, owing to the lack of demonstrated vertical transmission. For potentially contagious infants in the NICU, countries were also quite consistent in attempting to care for infants in incubators, in isolation, or, if available, in negative pressure rooms (particularly in those with aerosolizing respiratory support), and HCW wearing PPE. One NICU from Brazil limits non-invasive respiratory support, favoring intubation instead, which is aligned with recommendations for adult management of COVID-19-associated acute respiratory syndrome. Several countries use filters in their equipment to minimize aerosolization. Given the shortage of PPE, equipment, and physical space to isolate infants, many countries employ efforts to limit their use, such as cohorting of patients, limiting staff access, and ending isolation as soon as feasible based on testing. A careful balance must be achieved between protecting HCW and other patients from infection while minimizing PPE wastage in low-risk patients. Continued data collection will reveal the true risk posed by newborns to transmit SARS-CoV-2 infection.



**Fig. 1 COVID-19 cases and deaths by country and region.** **a** Cases by country, **b** deaths by country, **c** cases by region, **d** deaths by region. From Financial Times COVID-19 case and death data, accessed 31 March, 2020. Regions only represent the countries included in this study. \*Countries with <5000 total detected cases in descending order—Israel (4695), Norway (4445), Brazil (4371), Australia (4245), Sweden (4028), Ireland (2615), Poland (2055), Mexico (993), Argentina (820), Kenya (50); \*\*countries with <100 deaths in descending order—Canada (67), Ireland (46), Norway (32), Poland (31), Argentina (23), Mexico (20), Australia (18), Israel (16), Kenya (1).

Guidelines in most countries suggest performing viral testing of all neonates born to COVID-19-positive mothers, regardless of symptoms. A few countries recommend testing only symptomatic infants. The purpose of testing may be to explain symptoms in infants with respiratory pathology and to end isolation measures in asymptomatic infants tested negative on two separate occasions. Obtaining NPS on asymptomatic infants may result in false negatives, and the optimal timing of testing is unclear,<sup>20</sup> a potential argument for not testing asymptomatic infants. In contrast, it has been suggested that all infants presenting with possible COVID-19 respiratory symptoms should be tested after 72 h of age to avoid potential false-negative results and tested again on day 5 before declaring non-infected.<sup>20</sup> However, the timing of testing is still controversial.<sup>8</sup>

In response to the pandemic, all countries reported a restricted regimen for family access to the NICU.<sup>21</sup> The majority of hospitals limited access to the NICU to only one parent at a time, wearing a surgical mask and under strict hygiene precautions. All strictly prohibited the entrance of symptomatic visitors. At the time of the survey, only Australia had not yet limited parental NICU access, possibly reflecting a different disease burden at the time (Fig. 1). In China and Poland, by contrast, the restriction to parental access also extended to mothers. Limitations in parent–infant contact may have significant adverse consequences on infants’ neurobehavioral development and family psychological well-being. Nevertheless, the dire risk of contracting SARS-CoV-2 led to unanimous agreement for prioritizing patients and HCW safety over family-centered care. All countries though recognized the need for

psychological support for families. The medical uncertainties related to COVID-19 are amplified in pediatric patients due to the lower rate and severity of cases compared with adult patients and lack of follow-up data. To date, neither the WHO nor other international organizations recommended a specific follow-up for infants developing COVID-19.<sup>12</sup> Only a few countries have already put in place a structured follow-up, highlighting the need for more information about the disease course in infancy.

It is heartening that this sample of guidelines agreed in several domains, but we also found multiple areas in which recommendations diverged between local and national guidance or between countries. The reasons for such inconsistency in practice can generally be grouped into two categories, both of which are more pronounced during the COVID-19 pandemic. First, the interpretation of evidence may differ between organizations conducting literature review. This will be particularly evident when evidence is lacking, of poor quality, or only indirectly applicable, as is the case with a novel viral disease. Standardization of care is still likely to improve outcomes even in such a situation, but the choice of which potentially better practices to implement is much more arbitrary in the absence of high-quality data. Second, countries and institutions develop guidelines with close consideration of the context in which they will be applied. The same intervention may be highly effective in one setting but of less use in another. Relevant context in the case of COVID-19 might include the feasibility of implementation given supply chain disruptions and personnel availability, the background prevalence of disease, and the degree of central control and regionalization of a health care

system, which facilitates the dissemination and adoption of recommendations at the frontline.

The scenario of a global viral (influenza) pandemic had been predicted for decades,<sup>22</sup> but when it happened with this new coronavirus, the neonatal health care community was relatively unprepared. However, rarely was the need for robust guidelines on disease management so immediately needed as in these times. Likewise, to date, concerted efforts to combat global pandemics have rarely been put to the test at such intensity. Specific efforts are ramping up to better understand this specific pandemic, but the need for a systematic effort to create an international structure for disaster preparedness is evident. Such a structure could provide important epidemiologic and quality of care information, including, for example, disease incidence, and diagnostic and therapeutic approaches. It could also serve as a rapidly mobilized trial network. Existing quality improvement networks, such as the Vermont Oxford Network, have started organizing an audit platform (VON SONPM Covid-19 Impact Audit) to assess and track the impact of COVID-19 in neonatal units around the world (Jeffrey Horbar, April 1, 2020, personal communication).

This study should be viewed in light of its design. We managed to collect granular data on guidelines from 20 countries in 6 continents early in the pandemic. However, not all respondents had available or applied national guidelines, and their responses thus reflected local rather than national practice. COVID-19 guidelines reported in this study reflect a single timepoint early in the pandemic with countries at different stages as illustrated in Fig. 1. Thus variation in response may not reflect different practice but simply different timing, and it is possible that responses centered by pandemic stage would further converge. However, given socio-political, cultural, health system, and resource capacity differences across countries, we think that convergence would remain incomplete. Finally, we did not inquire regarding each institution's volume of suspected or known COVID-19-positive mothers or infants, which may influence local response readiness. However, given the early pandemic stage in most countries, few respondents had significant patient volume.

## CONCLUSIONS

This paper establishes both similarities and differences in the management of newborns at the early stage of this pandemic. Guidelines and evidence are rapidly evolving with rapid generation of new knowledge.<sup>23</sup> However, many aspects of COVID-19 still lack clarifying evidence, particularly for the population of newborn infants. Generous and high-level international collaboration across the specialty of neonatology will promote best practice guidelines for the care of infants and offers a path forward beyond the immediate needs during this pandemic.

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## AUTHOR CONTRIBUTIONS

A.L., C.K., J.P., J.A.F.Z., and C.C.R. developed the initial research question. All authors contributed in identifying knowledge resources and completing information on local and national guidance. A.L., together with C.K., J.P., J.A.F.Z., E.J.M., and C.C.R., produced the first draft of the manuscript. A.S.D. and F.M. contributed to concluding the analysis and manuscript. All collaborators were included on the completion of the manuscript.

## ADDITIONAL INFORMATION

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**THE INTERNATIONAL NEONATAL COVID-19 CONSORTIUM**

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