

# Translating Neonatal Resuscitation Guidelines Into Practice in Brazil

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abstract

**BACKGROUND AND OBJECTIVES:** The Brazilian Neonatal Resuscitation Program releases guidelines based on local interpretation of international consensus on science and treatment recommendations. We aimed to analyze whether guidelines for preterm newborns were applied to practice in the 20 Brazilian Network on Neonatal Research centers of this middle-income country.

**METHODS:** Prospectively collected data from 2014 to 2020 were analyzed for 8514 infants born at 23<sup>0/7</sup> to 31<sup>6/7</sup> weeks' gestation. The frequency of procedures was evaluated by gestational age (GA) category, including use of a thermal care bundle, positive pressure ventilation (PPV), PPV with a T-piece resuscitator, maximum fraction of inspired oxygen (FiO<sub>2</sub>) concentration during PPV, tracheal intubation, chest compressions and medications, and use of continuous positive airway pressure in the delivery room. Logistic regression, adjusted by center and year, was used to estimate the probability of receiving recommended treatment.

**RESULTS:** For 3644 infants 23 to 27 weeks' GA and 4870 infants 28 to 31 weeks' GA, respectively, the probability of receiving care consistent with guidelines per year increased, including thermal care (odds ratio [OR], 1.52 [95% confidence interval (CI) 1.44–1.61] and 1.45 [1.38–1.52]) and PPV with a T-piece (OR, 1.45 [95% CI 1.37–1.55] and 1.41 [1.32–1.51]). The probability of receiving PPV with FiO<sub>2</sub> 1.00 decreased equally in both GA groups (OR, 0.89; 95% CI, 0.86–0.93).

**CONCLUSIONS:** Between 2014 and 2020, the resuscitation guidelines for newborns <32 weeks' GA on thermal care, PPV with a T-piece resuscitator, and decreased use of FiO<sub>2</sub> 1.00 were translated into clinical practice.

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**WHAT'S KNOWN ON THIS SUBJECT:** How the International Liaison Committee on Resuscitation (ILCOR) recommendations are translated into the care provided to preterm infants at birth in public hospitals of middle-income countries is unknown.

**WHAT THIS STUDY ADDS:** ILCOR recommendations on resuscitation of preterm newborns were successfully translated into practice in Brazilian public hospitals. Thermal care, use of T-piece resuscitator, and more judicious oxygen use were the main recommendations incorporated into the care of neonates <32 weeks' gestation.

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The science of transition and resuscitation at birth evolves continuously and is evaluated by the International Liaison Committee on Resuscitation (ILCOR).<sup>1</sup> The ILCOR Neonatal Life Support Task Force has published several consensus on science statements and treatment recommendations for newborn life support since 1999.<sup>2-6</sup> These summaries were designed for adaptation by member resuscitation councils that develop national or regional guidelines reflecting local resources and circumstances.<sup>7</sup> Although programs like Helping Babies Breathe are designed to bring practical, short, and approachable resuscitation education programs to low- and middle-income countries, their focus is largely on the care of term newborns with birth asphyxia resuscitated by birth attendants with limited resources.<sup>8</sup> It is unclear how more-complex treatment guidelines for preterm newborns in the ILCOR consensus statements are translated into care in hospitals of low- and middle-income countries.

Brazil is a middle-income country with nearly 300 000 preterm births per year. Births occur predominantly in hospitals (98%).<sup>9</sup> There is an established neonatal research network and a resuscitation education program. The Neonatal Resuscitation Program of the Brazilian Society of Pediatrics (BNRP) began in 1994, and its guidelines have been released every 5 years after reviewing the ILCOR treatment recommendations with the 54 BNRP state coordinators and the members of the national steering committee.<sup>10-13</sup> Since 1994, >120 000 providers have been trained in resuscitation by the BNRP.<sup>14</sup> The program includes ~1200 pediatrician instructors who teach providers in the local hospitals where they work.

Despite the large number of trained providers, the implementation of the Brazilian guidelines on preterm neonatal resuscitation into clinical practice has not been systematically evaluated. As BNRP instructors continue to teach updated resuscitation guidelines, we sought to confirm that the knowledge and skills taught in the course are consistently applied during actual clinical practice. In this study, we aimed to analyze whether the BNRP guidelines on thermal and respiratory care were applied by resuscitation teams in public university hospitals.

## METHODS

In this prospective cohort study, we used information obtained from the database registry of the Brazilian Network on Neonatal Research, which comprises 20 academic public hospitals. The research ethics committee of the coordinating institution approved the project without requiring individual informed consent (#3691375).

From January 2014 to December 2020, all inborn infants 23<sup>0/7</sup> to 31<sup>6/7</sup> weeks' gestational age (GA) with a birth weight of 400 to 1499 g and without major congenital anomalies diagnosed before or after birth<sup>15</sup> were included in the study.

The 20 participating hospitals are high-risk pregnancy referral centers located in 12 cities of 7 Brazilian states.<sup>16</sup> All centers had the required equipment and material for neonatal resuscitation in the delivery room, and their neonatal resuscitation teams received BNRP training. Updated BNRP guidelines for care of preterm newborns were published in 2011<sup>10,11</sup> and 2016,<sup>12,13</sup> and both were adapted from ILCOR recommendations.<sup>4,5</sup> In 2011, guidelines for newborns <34 weeks' GA included the following:

1. Thermal care: The delivery room temperature is  $\geq 26^{\circ}\text{C}$ , and a radiant warmer, plastic bag, single cotton cap, and prewarmed transport incubator are used.
2. Monitoring: A pulse oximeter sensor is placed as soon as the patient is placed under the radiant warmer.
3. Positive pressure ventilation (PPV): PPV is started with a face mask and T-piece resuscitator followed by specified corrective steps and endotracheal intubation if face mask ventilation fails.
4. Supplemental oxygen: The use of free-flow oxygen was withdrawn from the guidelines. If a blender is available in the delivery room, PPV is started with fraction of inspired oxygen ( $\text{FiO}_2$ ) 0.40 and increased by 0.20 every 15 seconds if the heart rate is <100 beats per minute and/or preductal pulse oxygen saturation ( $\text{SpO}_2$ ) <70%. In the absence of a blender, room air is started and  $\text{FiO}_2$  increased to 1.00 if needed.
5. Continuous positive airway pressure (CPAP): CPAP is applied in spontaneously breathing infants if respiratory distress and/or  $\text{SpO}_2$  are below the target.

In 2016, the following additions or changes were made:

1. Thermal care: The delivery room temperature should be  $23^{\circ}\text{C}$  to  $26^{\circ}\text{C}$  and a double cap (plastic and cotton) and thermal mattress for infants weighing <1000 g used.
2. PPV: Recommendations stressed that endotracheal intubation should be done only after failure of face mask ventilation with adequate technique.

- Supplemental oxygen: A blender should be available in the delivery room.  $\text{FiO}_2$  0.30 is started and increased by 0.20 every 30 seconds if the heart rate  $<100$  beats per minute and/or preductal  $\text{SpO}_2 < 70\%$ .

Maternal and neonatal characteristics were analyzed. GA was determined by the best obstetric estimate, and patients were divided into extremely preterm ( $23^{0/7}$ – $27^{6/7}$  weeks' GA) and very preterm ( $28^{0/7}$ – $31^{6/7}$  weeks GA) groups. Small for GA was defined by INTERGROWTH-21st.<sup>17</sup> The following clinical data were recorded: 5-minute Apgar score, hypothermia (axillary temperature  $<36.0^\circ\text{C}$ ) at admission to the NICU,<sup>18</sup> death in the delivery room, and early neonatal death (0 to 6 days after birth).

To describe resuscitation practices, we calculated the frequency per year of the following procedures: use of a thermal care bundle (recommended delivery room temperature and use of plastic bag and cap), use of free-flow supplemental oxygen, any PPV during initial resuscitation, face mask PPV without endotracheal intubation, endotracheal intubation without a trial of face mask PPV, PPV using only a T-piece resuscitator, PPV with maximum  $\text{FiO}_2 < 0.40$ , PPV with maximum  $\text{FiO}_2 1.00$ , use of a PPV bundle (face mask PPV with a T-piece resuscitator and maximum  $\text{FiO}_2 < 0.60$ ), advanced resuscitation (PPV by endotracheal tube with chest compressions and/or medications), and use of CPAP in the delivery room.

The  $\chi^2$  test for trend was applied to compare the use of the resuscitation procedures per year. A logistic regression model, adjusted by year and center, was used to estimate the probability of incorporating recommended guidelines into

clinical practice. Results are expressed as odds ratios (ORs) and 95% confidence intervals (CIs). Analyses were performed using SPSS for Windows version 21.0 software (IBM Corporation, Armonk, NY).

## RESULTS

In the 20 participating centers, 12 669 very low birth weight infants were born between 2014 and 2020. Of these, 8514 inborn infants without congenital anomalies between  $23^{0/7}$  and  $31^{6/7}$  weeks' GA and with a birth weight of 400 to 1499 g comprised the study population (Fig 1). Maternal and neonatal characteristics of both groups are shown in Table 1.

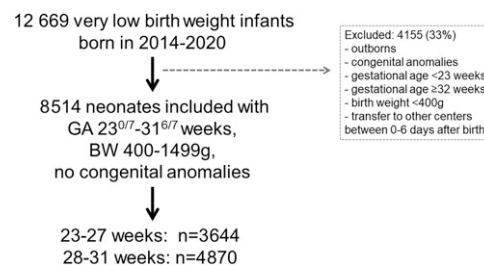
Among both extremely preterm and very preterm newborns, BNRP thermal guidelines were increasingly followed during study period (Table 2). The use of free-flow supplemental oxygen significantly decreased in the very preterm group. Although this use did not change in the extremely preterm group throughout the study period, no extremely preterm newborn received free-flow supplemental oxygen in the final study year (Table 2).

Most extremely preterm newborns (83%) received PPV in the delivery room. During the study period, the use of the T-piece resuscitator as the only device to deliver PPV in this group increased from 63% to

90% ( $P < .001$ ; Fig 2A). Among the extremely preterm newborns requiring PPV, only 26% received face mask PPV without tracheal intubation across the full study period (Fig 2B). However, initiation of PPV with an endotracheal tube without an initial trial of face mask PPV decreased from 10% in 2014 to 6% in 2020 ( $P = .002$ ; Fig 2B). As recommended, the use of  $\text{FiO}_2 1.00$  decreased from 77% to 64% ( $P < .001$ ), and the use of a maximum  $\text{FiO}_2 < 0.40$  increased from 2% to 12% ( $P < .001$ ; Fig 2C). The use of the PPV bundle increased from 7% in 2014 to 11% in 2020 ( $P = .011$ ; Fig 2D). There was no change in the frequency of advanced resuscitation or the use of CPAP in the delivery room (Table 2).

Adjusted by center, there was a significant annual increase in the probability of adopting recommended practices in the extremely preterm group, including the thermal care bundle, attempting face mask ventilation before tracheal intubation, PPV with a T-piece, maximum  $\text{FiO}_2 < 0.40$ , avoidance of  $\text{FiO}_2 1.00$ , and use of the PPV bundle (Table 3). During the study period, hypothermia at NICU admission ( $P < .001$ ) and early neonatal deaths ( $P = .026$ ) among extremely preterm newborns significantly decreased (Table 4).

Among very preterm newborns, 59% received PPV in the delivery room. Of those receiving PPV, use of



**FIGURE 1**

Flow diagram of the study population. BW, birth weight.

**TABLE 1** Maternal and Neonatal Characteristics According to GA Group

	GA Group	
	23–27 wk (n = 3644)	28–31 wk (n = 4870)
Maternal age, y	27 ± 7	28 ± 7
Schooling <8 y	24	22
Prenatal care <sup>a</sup>	93	95
Hypertension <sup>b</sup>	28	46
Diabetes <sup>c</sup>	6	10
Chorioamnionitis <sup>d</sup>	20	9
Placental abruption	12	8
Multiple gestation	23	23
Antenatal steroids <sup>e</sup>	77	85
Cesarean section	50	74
Birth weight, g	779 ± 198	1138 ± 227
Small for GA <sup>f</sup>	17	28
Male	51	50
Apgar first-minute score	4 ± 3	6 ± 2
Apgar first-minute score 0–2	35	11

Data are shown as % or mean ± SD.

<sup>a</sup> Any prenatal obstetrical care before the admission during which birth occurred.

<sup>b</sup> Chronic or pregnancy-induced hypertension recorded in the maternal or infant medical record.

<sup>c</sup> Any type or severity of diabetes recorded in the maternal or infant medical record.

<sup>d</sup> Whether the diagnosis of chorioamnionitis was recorded in the maternal or infant medical record.

<sup>e</sup> Any dose of betamethasone, dexamethasone, and hydrocortisone administered intramuscularly or intravenously to the mother during pregnancy at any time before delivery.

<sup>f</sup> According to INTERGROWTH-21st.

the T-piece resuscitator as the only device to deliver PPV increased from 71% in 2014 to 91% in 2020 ( $P < .001$ ; Fig 2A). Across the full study period, 55% of the ventilated newborns between 28<sup>0/7</sup> and 31<sup>6/7</sup> weeks' GA received only face mask PPV without tracheal intubation

(Fig 2B). When receiving PPV, the use of a maximum  $FiO_2$  of 1.00 decreased from 55% to 38% ( $P < .001$ ), and the use of a maximum  $FiO_2 < 0.40$  increased from 5% to 24% ( $P < .001$ ; Fig 2C). During the study period, use of the PPV bundle increased from 19% to

34% ( $P = .001$ ; Fig 2D). In the very preterm group, use of CPAP in the delivery room increased from 62% in 2014 to 73% in 2020 (Table 2).

Adjusted by center, there was a significant annual increase in the probability of adopting recommended practices in the very preterm group, including use of the thermal care bundle, avoidance of supplemental free-flow oxygen, use of the T-piece resuscitator for PPV, avoidance of PPV with  $FiO_2 1.00$ , provision of PPV with a maximum  $FiO_2 < 0.40$ , use of the PPV bundle, and use of CPAP in the delivery room (Table 3). During the study period, hypothermia at NICU admission ( $P < .001$ ) and early neonatal deaths ( $P = .002$ ) among very preterm newborns also significantly decreased (Table 4).

## DISCUSSION

In this prospective cohort study, we show that among newborns <32 weeks' GA, there was a gradual implementation of the BNRP guidelines on neonatal resuscitation in the centers affiliated with the Brazilian Network on Neonatal

**TABLE 2** Procedures in the Delivery Room According to GA Group and Year

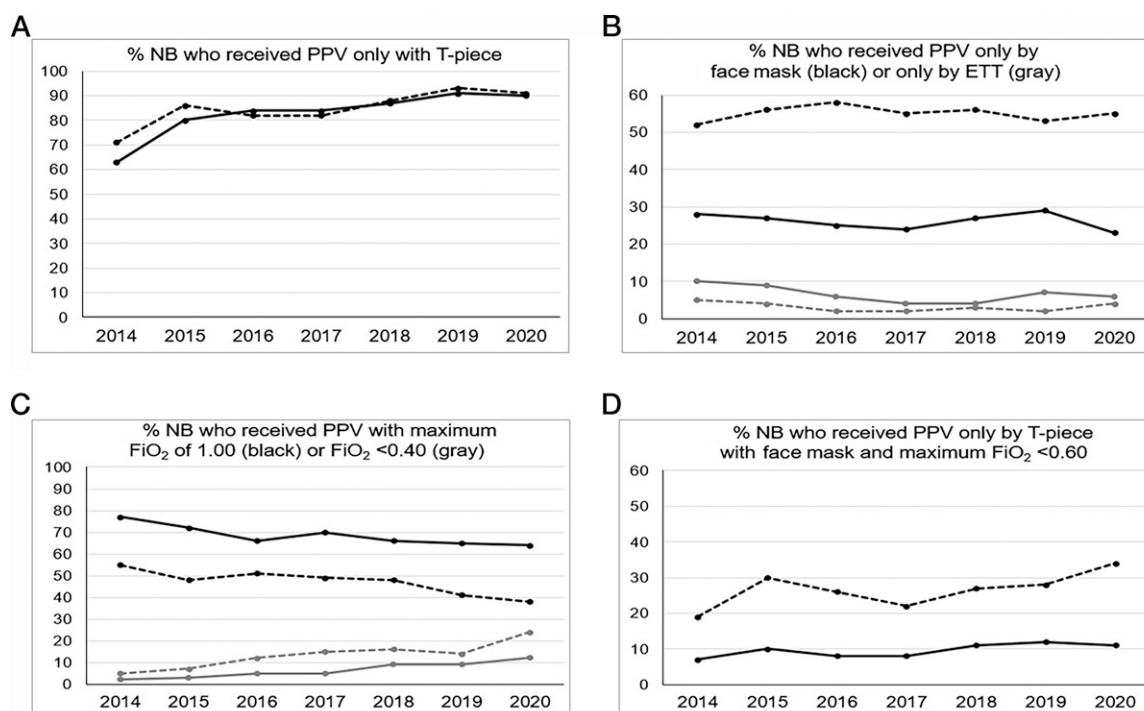
	2014	2015	2016	2017	2018	2019	2020	<i>P</i> *
No. infants								
23–27 wk	584	576	532	531	512	486	423	—
28–31 wk	742	694	774	710	702	678	570	—
Thermal care, <sup>a</sup> %								
23–27 wk	49	90	89	94	93	83	88	<.001
28–31 wk	51	92	93	93	90	87	87	<.001
Only free-flow oxygen, %								
23–27 wk	1.2	0.7	1.1	0.6	1.4	0.8	0	.195
28–31 wk	3.2	3.3	3.1	3.2	2.0	1.3	0.2	<.001
Any PPV, %								
23–27 wk	82	81	81	86	82	85	87	.018
28–31 wk	62	58	60	58	54	55	59	.020
Advanced resuscitation, <sup>b</sup> %								
23–27 wk	12	9	11	12	10	9	12	.830
28–31 wk	2	3	4	3	2	2	3	.918
CPAP in delivery room, %								
23–27 wk	39	38	40	35	42	38	36	.610
28–31 wk	62	68	71	68	75	74	73	<.001

GA groups were 23–27 wk (n = 3644) and 28–31 wk (n = 4870). —, p-value not applicable.

<sup>a</sup> Delivery room temperature  $\geq 23^\circ\text{C}$  plus radiant warmer, plastic bag, cap.

<sup>b</sup> PPV by endotracheal tube plus chest compression and/or medications.

\* Significance trend by  $\chi^2$  test.



**FIGURE 2**

Annual percentage of newborn infants (NB) who received PPV. A, PPV with only a T-piece. B, PPV only by face mask (black) or only by endotracheal tube (ETT; gray). C, PPV with a maximum  $FiO_2$  of 1.00 (black) or  $FiO_2 < 0.40$  (gray). D, PPV with only a T-piece by face mask and maximum  $FiO_2 < 0.60$ . Solid lines represent 23–27 weeks' GA (3036 NBs who received PPV), and dashed lines represent 28–31 weeks' GA (2863 NBs who received PPV).

Research. Thermal care, PPV with the T-piece resuscitator, and more judicious use of oxygen during PPV were the main recommendations incorporated into practice. Among extremely preterm newborns (23–27 weeks' GA), initiating PPV with an endotracheal tube decreased over the study period. In very preterm newborns

(28–31 weeks' GA), the use of CPAP in the delivery room increased. In both GA groups, changes were accompanied by a reduction in hypothermia at NICU admission and in early neonatal deaths.

In 2010, emphasis on thermal care for newborns <28 weeks' GA during transition after birth was

highlighted when ILCOR recommended covering their bodies with a polythene bag or wrap, without drying, and placing them under a radiant heater in a delivery room with temperature  $\geq 26^\circ C$ .<sup>4</sup> In 2011, the BNRP adopted these recommendations and introduced the use of a cotton cap for very low birth weight newborns. The importance of adopting these measures was demonstrated by a Brazilian multicenter cohort study showing that hypothermia  $< 36.0^\circ C$  was present upon NICU admission in 55% of infants born at 23 to 33 weeks' GA and increased the chance of early neonatal death 1.64-fold (95% CI, 1.03–2.61).<sup>19</sup> In 2014, data forms for the Brazilian Network on Neonatal Research were revised to include information on the use of plastic bag, cap, and delivery room temperature, encouraging centers to pay attention to thermal care after birth. These actions likely had a role

**TABLE 3** Chance of Performing the Procedure at Birth per Year Adjusted by Center According to GA Group

	GA Group, Adjusted OR (95% CI)	
	23–27 wk	28–31 wk
Thermal care	1.52 (1.44–1.61)	1.45 (1.38–1.52)
Only free-flow oxygen	0.90 (0.75–1.09)	0.77 (0.69–0.85)
Any PPV	1.03 (0.99–1.08)	0.98 (0.95–1.01)
PPV only by face mask	1.02 (0.98–1.06)	1.01 (0.98–1.05)
PPV only by endotracheal tube	0.87 (0.81–0.94)	0.94 (0.84–1.05)
PPV only by T-piece	1.45 (1.37–1.55)	1.41 (1.32–1.51)
PPV with $FiO_2 < 0.40$	1.39 (1.28–1.52)	1.29 (1.22–1.37)
PPV with $FiO_2 1.00$	0.89 (0.86–0.93)	0.89 (0.86–0.93)
PPV with T-piece by face mask with $FiO_2 < 0.60$	1.10 (1.03–1.17)	1.10 (1.05–1.15)
Advanced resuscitation	0.97 (0.92–1.03)	0.99 (0.90–1.09)
CPAP in the delivery room	1.02 (0.98–1.05)	1.11 (1.08–1.15)

GA groups were 23–27 wk ( $n = 3644$ ) and 28–31 wk ( $n = 4870$ ).



**TABLE 4** Clinical Outcomes According to GA Group and Year

	2014	2015	2016	2017	2018	2019	2020	<i>P</i> *
Apgar fifth-minute score 7–10, %								
23–27 wk	63	67	66	63	66	65	63	.857
28–31 wk	88	90	90	91	92	90	90	.262
Hypothermia at admission, <sup>a</sup> %								
23–27 wk	66	53	56	55	47	49	53	<.001
28–31 wk	49	47	39	38	35	33	36	<.001
Death in delivery room, %								
23–27 wk	10	7	7	8	6	7	6	.070
28–31 wk	0.8	0.6	0.4	0.3	0.6	0.4	0.4	.299
Early neonatal death, <sup>b</sup> %								
23–27 wk	35	27	30	30	28	28	27	.026
28–31 wk	8	7	7	5	6	8	4	.002

GA groups were 23–27 wk (*n* = 3644) and 28–31 wk (*n* = 4870).

<sup>a</sup> Newborn temperature <36.0°C at NICU admission.

<sup>b</sup> Death between 0 and 6 d after birth.

\* Significance trend by  $\chi^2$  test.

in the significant increase in the use of recommended thermal care measures noted in 2015 and maintained through 2020. Despite widespread adoption of these guidelines, hypothermia at NICU admission continues to be an important problem, occurring in 43% of all included preterm newborns at the study conclusion. Additional collaborative quality improvement initiatives are needed to further decrease hypothermia at admission.<sup>20</sup>

In 2010, ILCOR recommended that ventilation of the newborn could be performed effectively with a self-inflating bag or a pressure-limited T-piece resuscitator but highlighted that in mechanical models, delivery of target inflation pressures and maintenance of positive end-expiratory pressure (PEEP) were more consistent when using a T-piece resuscitator.<sup>4</sup> In 2015, ILCOR suggested the use of PEEP if the facilities and equipment were available and cautioned that PEEP could not be reliably administered with a self-inflating bag.<sup>5</sup> In this context, in 2012, the BNRP started teaching the use of the T-piece resuscitator as an option for PPV among infants <34 weeks' GA, and in 2016, the T-piece resuscitator was recommended as the first choice for PPV in this group of

infants,<sup>10,12</sup> explaining the high frequency of T-piece use in 2014 and its sustained use throughout the study period. It is encouraging to note that the adoption of the T-piece for PPV at the participating centers was associated with an increased chance of survival to discharge from the hospital without either bronchopulmonary dysplasia or intraventricular hemorrhage.<sup>21</sup>

Controversy has persisted over the initial concentration of oxygen during PPV in the delivery room. In 2010, ILCOR suggested that blended oxygen and air should be used judiciously among newborns <32 weeks' GA and ideally guided by pulse oximetry.<sup>4</sup> In 2015, ILCOR recommended against initiating resuscitation of preterm newborns with high *F*<sub>IO<sub>2</sub></sub> (0.65–1.00).<sup>5</sup> On the basis of these recommendations, in 2010, the BNRP first suggested the use of gas blenders in the delivery room,<sup>10</sup> which was strongly reinforced in 2015.<sup>12</sup> Indeed, since 2015, all 20 participating Brazilian centers reported the presence of gas blenders, pulse oximeters, and *S*<sub>PO<sub>2</sub></sub> targets clearly posted in the delivery room. Despite the widespread presence of adequate equipment and increase in the use of *F*<sub>IO<sub>2</sub></sub> 0.40 during the study period, most extremely preterm (88%) and very

preterm (76%) infants receiving PPV were still exposed to a maximum *F*<sub>IO<sub>2</sub></sub> 1.00. Increasing access to appropriate interfaces for providing noninvasive PPV to the smallest preterm newborns, additional training to improve PPV technique, and guidance on adjusting *F*<sub>IO<sub>2</sub></sub> during the first minutes of life may help Brazilian neonatologists to achieve a more judicious use of supplementary oxygen.

Among neonatologists, there is a consensus that tracheal intubation is difficult and associated with potential risks, including bradycardia and severe oxygen desaturations.<sup>22,23</sup> Therefore, at birth, emphasis has been placed on improving face mask PPV technique and optimizing the use of CPAP. In 2010, ILCOR stated that spontaneously breathing preterm infants who have respiratory distress may be supported with CPAP or intubation and mechanical ventilation.<sup>4</sup> In 2015, ILCOR suggested the initial use of CPAP for spontaneously breathing preterm newborns with respiratory distress in the delivery room.<sup>5</sup> Beginning in 2013, the BNRP stated that use of CPAP was feasible and might be beneficial in preterm newborns with respiratory distress and/or *S*<sub>PO<sub>2</sub></sub> lower than expected at birth.<sup>10</sup> In 2016, the wording was strengthened with recommendations for initial use of CPAP in newborns <34 weeks' GA with respiratory distress.<sup>12</sup> During the study period, tracheal intubation as the first option to ventilate extremely preterm newborns decreased 13% per year, and CPAP use in very preterm newborns at birth increased 11% per year. However, there are still opportunities for improvement. Research on new interfaces and modes to deliver CPAP to extremely and very preterm newly born infants may decrease the intubation rate and increase the success of CPAP in these newborns.<sup>24</sup>

It is interesting to consider whether some interventions could compete with others in our study. Appropriate thermal care (use of plastic bag and cap and delivery room temperature  $\geq 23^{\circ}\text{C}$ ) and appropriate respiratory care (PPV only by face mask with T-piece resuscitator and  $\text{FiO}_2 < 0.60$ ) were provided simultaneously to 847 (15.3%) infants (53 [5.6%] in 2014 and 133 [19.9%] in 2020;  $P < .001$ ). This finding reveals that improvements were across the board, and that one group of interventions did not compete with the others.

The adoption of the practices recommended by the BNRP were not associated with changes in frequency of advanced resuscitation. Throughout the study period, 10% to 12% of extremely preterm and 2% to 4% of very preterm newborns received chest compressions and/or medications. Frequency of advanced resuscitation at birth in preterm infants  $< 32$  weeks' GA varied from 6.2% to 11.8% in cohort studies in California,<sup>25</sup> Italy,<sup>26</sup> and China.<sup>27</sup> The fact that the 20 study centers are referral units for high-risk pregnancies may be an explanation for the results. However, it is possible that improvements in PPV technique, first-attempt success with tracheal intubation, and use of electronic cardiac monitoring may lead to decreases in the rate of advanced resuscitation.

The reduction of early neonatal mortality during the study period is likely multifactorial. During the past 20 years, Brazil has focused special attention on maternal and neonatal care, introducing a sequence of initiatives, such as the National Program for the Humanization of Pregnancy and Childbirth (2000), the Pact for the Reduction of Maternal and Newborn Mortality (2004), the creation of local committees for the prevention of infant mortality (2005), the Pact for

Life (2006), the Stork Network (2011),<sup>28</sup> and the Qualification of Care to Newborns at Risk–Qualineo initiative (2017).<sup>29</sup> These strategies included training in resuscitation at birth and may have contributed to improving the quality of neonatal care and decreasing early mortality.

The study is limited by using a database that was not specifically designed to answer questions related to the indication, time of initiation after birth, duration, and sequence of performed resuscitation procedures. In addition, some variables of interest were not available, such as cord-clamping strategies, initial  $\text{FiO}_2$  for PPV, reasons why providers decided to use a self-inflating bag instead of a T-piece resuscitator, and the indication for tracheal intubation after face mask ventilation. Patient/case mix profile change over time was not assessed. Because the main outcomes of the study were related to the technical aspects of the resuscitation procedures, this limitation does not compromise the internal validity of the results. There are also some limitations on the external validity of the study that enrolled a selected group of Brazilian public university hospitals.

Despite these limitations, this is one of the few studies that evaluates actual delivery room practices in a large population of extremely and very preterm infants instead of surveying centers about their policies and intended practices. Moreover, the data were collected in a prospective and systematic way with strict definitions for each event and continuous input into an electronic database wherein consistency is verified by an independent data committee. Therefore, information on all outcomes was available for  $> 99\%$  of the studied infants, except for delivery room temperature, which was available for 93%. The fact that

the study was completed in a middle-income country adds information about the translation of ILCOR recommendations outside the highest income countries and may inform future studies in less developed settings.

In conclusion, we show in this study that ILCOR recommendations on resuscitation of preterm newborns were successfully translated through BNRP guidelines and training into clinical practice in public hospitals in Brazil from 2014 to 2020. We suggest that the reproducibility of the Brazilian experience in other contexts depends on the presence of national programs capable of discussing and adapting ILCOR treatment recommendations into their local realities.

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#### ABBREVIATIONS

BNRP: Neonatal Resuscitation Program of the Brazilian Society of Pediatrics  
CI: confidence interval  
CPAP: continuous positive airway pressure  
 $\text{FiO}_2$ : fraction of inspired oxygen  
GA: gestational age  
ILCOR: International Liaison Committee on Resuscitation  
OR: odds ratio  
PEEP: positive end-expiratory pressure  
PPV: positive pressure ventilation  
 $\text{SpO}_2$ : pulse oxygen saturation

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The authors show that it is possible to translate updated International Liaison Committee on Resuscitation recommendations on neonatal resuscitation into clinical practice in a middle-income country.

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