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Survey of Preterm Neuro-Centric Care Practices in California Neonatal Intensive Care Units

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Abstract

Objective: Examine the adoption and presence of preterm, neuro-centric care practices across Neonatal Intensive Care Units (NICUs).

Study Design: Statewide, cross-sectional survey of California NICUs. Data were collected surrounding the timing of adoption and presence of delivery room practices, nursing protocols, provider management practices and quality improvement initiatives.

Result: Among the 95 NICUs completing the survey (65%), adoption of all surveyed practices increased between 2005 and 2016, though rates of uptake changed over time and varied by practice. Adoption of indomethacin prophylaxis increased 1.8-fold whereas delayed cord clamping increased 78-fold. Adoption of premedication for intubation and a patent ductus arteriosus management algorithm differed by unit level. Additionally, two underlying practice domains were identified; adoption of delivery room practices and adoption of any preterm practice.

Conclusion: Adoption of preterm, neuro-centric care practices across California NICUs has increased, though uptake patterns vary by practice and level.

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Introduction:

Adoption and implementation of neuro-centric care practices has increased in neonatal intensive care units (NICUs). Neuro-centric, or potentially neuroprotective, interventions and strategies have been studied in both preterm and term infants; however, the pathophysiology of injury and vulnerability differs between these two groups.(1) Studies with strong evidence to support one specific intervention strategy are few. However, there are a variety of potential interventions with varying degrees of evidence to support their use. Most focus on minimizing preterm brain injury, specifically intraventricular hemorrhage, such as optimizing the timing of umbilical cord clamping, midline head positioning, and individual neurodevelopmental care.(2–4) However, the constant growth of potential preterm neuro-centric care practices creates the possibility for significant variation in practice change at the unit level. The practice landscape, including when interventions were adopted and which practices are currently in place across NICUs is not known.(5, 6)

The objective of this survey was to describe the adoption and presence of preterm neuro-centric care practices across NICUs in California between 2005 and 2016. Given the limitations in the evidence surrounding a number of neuro-centric practices, we anticipate that there is marked variation across the state. Understanding both the presence and variation in practices across California may help inform future unit or collaborative quality improvement initiatives as well as the research surrounding the impact of neuroprotective practices on preterm neurologic outcomes.

Methods:

Survey development

This survey was developed by the investigators for the purposes of this study, to describe the landscape of preterm, neuro-centric practice patterns. In addition to basic demographics, including provider role in the NICU, years at the institution and years in current role, four practice themes were addressed in the survey. The themes included: 1) delivery room practices, including questions on personnel present at deliveries, preterm specific delivery education, implementation of delayed cord clamping, respiratory equipment used for resuscitation and delivery room temperature regulation; 2) nursing protocols, including minimal handling, midline head positioning, tracheal suctioning, elevation of head of the bed and skin-to-skin “Kangaroo” care; 3) provider management practices, including providers responsible for preterm infant management in the NICU, use of premedication for non-delivery room intubation, interventions to manage hypotension, infusion rates for saline boluses and blood product transfusions, use of sodium bicarbonate, use of prophylactic indomethacin, presence of an algorithm for patent ductus arteriosus (PDA) management, management of post-hemorrhagic hydrocephalus and timing of head ultrasound screening; and 4) quality improvement initiatives including, development of unit specific quality improvement projects targeting preterm neuroprotection. For relevant questions, respondents were asked to note the year in which a practice was adopted. The time period of interest of practice adoption was 2005 to 2016. The survey was piloted in two separate convenience samples to address issues of survey organization, question clarity, and response options

when appropriate, prior to distribution. This study was approved by the Stanford University Institutional Review Board.

Survey Distribution

Prior to survey distribution, an introductory email regarding the survey was sent to California NICU medical directors. Surveys were distributed via a secure, electronic platform. Consent was addressed in an introductory statement and inferred given voluntary participation. If a response was not received after two reminders, units were contacted individually by telephone and offered a repeat email, survey administration over the phone or delivery by post. Surveys were distributed between fall 2016 and summer 2017. Each survey was assigned a unique and confidential number.

One hundred forty seven California NICUs were included in the initial distribution, including California Perinatal Quality Care Collaborative (CPQCC) and non-CPQCC NICUs. Survey recipients could opt out (n=6) of the survey or forward the survey to another provider in the unit. Surveys were initially addressed to unit medical directors, however other neonatologists or care providers with knowledge of the unit practices were eligible to complete the survey. In the case of duplicate surveys (n=2), the most complete survey was used. Responses with less than 50% completion were excluded (n=3). A total of 95 surveys were completed.

Analysis

Survey responses were analyzed using SAS version 9.4 (SAS, Cary, NC, USA) and Stata version 14.2 (StataCorp, College Station, TX, USA). To facilitate detailed analysis of unit characteristics survey responses, units were merged with existing CPQCC data on hospital characteristics. To determine if the responses adequately represented units across California, a comparison of CPQCC survey responders and CPQCC survey non-responders was completed using two sample t-tests, Chi-square tests and Kruskal Wallis tests. Frequency of practice adoption was evaluated by California Children's Services (CCS) NICU level (intermediate, community and regional level NICUs, which closely parallel the American Academy of Pediatrics (AAP) levels II, III and IV), preterm delivery volume (number of infants <1500 grams/year), which was categorized as units with <25 infants/year, 25 to <50 infants/year, 50 to <100 infants/year and 100 infants/year, the eleven perinatal regions in California, urban versus rural location and teaching versus non-teaching NICU.⁽⁷⁾ These were compared using one-way ANOVA and Kruskal Wallis tests. When comparing the frequency of practices present, the cumulative presence in 2016 was used. Practice adoption over time was determined for available data. If a practice was adopted, but the year was unavailable, the oldest time point (before 2005) was assumed to maintain conservative estimates regarding practice adoption. Linear regression was used to evaluate the time trend of practice adoption over the entire study period as well as the change in trend after 2010. As a secondary set of outcomes, a latent class analysis of surveyed practices was performed to determine if there were clusters of practices adopted as a group, representing an underlying practice domain.

Results:

The survey response rate was 65% (95/147) overall and 65% (88/135) for CPQCC NICUs. Eighty-eight percent of respondents were NICU medical directors. The mean time at the current institution was 16.7 years (standard deviation 11.1 years) with an average time as medical director of 11.4 years (standard deviation 10.2 years). When utilizing data available in the CPQCC, including CCS level, AAP level, unit region, unit size, preterm delivery volume, urban versus rural location and teaching status, there were no significant differences in the characteristics of CPQCC survey responders and CPQCC survey non-responders (Table 1).

Practice Adoption Over Time

The adoption and presence of all surveyed practices increased over the study period, though the rates of adoption varied by practice (Figure 1). There was a significant increase in the adoption of a number of practices between 2005 and 2016, including delivery room temperature regulation, minimal handling, midline head positioning, elevation of head of the bed, avoidance of tracheal suctioning, skin-to-skin “Kangaroo” care, premedication for non-delivery room intubation, indomethacin prophylaxis, and PDA treatment algorithm. A subset of practices underwent significant changes in the rate of adoption after 2010, including delivery room temperature regulation, delayed cord clamping, elevation of head of the bed, premedication for non-delivery room intubation, and PDA treatment algorithm. Of note, the adoption of delayed cord clamping only had a significant increase in rate of adoption after 2010.

The most widely adopted practice by 2016 was presence of a temperature regulation protocol in the delivery room, which by 2016 had been adopted by 92.6% of NICUs who responded to the survey. The practice with the most uptake over the study period was delayed cord clamping, which increased 78-fold and by 2016 was reported to be adopted by 82% of NICUs. After delayed cord clamping, the second practice with the most change in uptake was premedication for non-delivery room intubations, which increased 5-fold with 40% of units reporting adoption of this practice by 2016.

Practice Adoption by CCS Level and Perinatal Region

There were some differences in practice presence by CCS level (Table 2). Specifically, by 2016, rates of premedication in non-delivery room intubation were significantly different between NICUs, with community NICUs reporting the lowest rates (35%) of adoption, relative to regional level NICUs (69%) and intermediate level NICUs (71%) (p-value=0.02). The adoption and presence of a PDA management algorithm was significantly higher in regional level NICUs (69%) compared to community level NICUs (29%) and intermediate level NICUs (14%) (p-value=0.03). The presence of a PDA management algorithm also differed significantly by perinatal region, ranging from 0% to 78% (p-value=0.004). When assessing differences in practice by preterm delivery volume, there were no significant differences.

Latent Class Analysis

Results of the latent class analysis revealed two domains in adoption and presence of practices, 1) the adoption of any preterm practice and 2) the adoption of preterm practices in the delivery room, which specifically included temperature regulation in the delivery room, delayed cord clamping, very low birth weight specific resuscitation training and standard bolus administration times. These domains suggest that adoption of delivery room based preterm, neuro-centric care practices are distinct from adoption of preterm neuro-centric care practices as a whole. As shown in Table 2, within the delivery room domain, there was not a significant difference in the number of practices adopted by CCS level (p -value=0.12), however difference in the domain of adopting any preterm practice approached statistical significance with higher CCS level NICUs adopting more practices (p -value=0.05).

Discussion:

This survey highlights the marked variation in the uptake and differential rate of uptake of preterm neuro-centric care practices across California. The adoption of all surveyed practices increased over the study period, though in 2010 there was an inflection point, after which rates of practice adoption significantly increased in 50% of the practices surveyed. This variation in both rates of uptake and the presence of a practice by 2016, emphasizes wide range of practices that units are choosing to adopt. As additional evidence emerges regarding other potential neuro-centric practices, between unit variation may continue to increase. Although California reflects a portion of the neonatal care provided in the United States, this survey captured a wide variety of units and their practices. Based on these data, it is plausible that preterm neuro-centric care practices are variable across the neonatal community as a whole. Future study of the individual NICU culture or perinatal regional context surrounding practice adoption and promotion may further the understanding of variation in adoption and implementation of care practices.

Surveys have been used to capture, describe, and begin to understand practice variation in a variety of settings. The Canadian Neonatal Network has reported marked variation in screening practices for retinopathy of prematurity and the use of non-invasive respiratory support.(8, 9) A survey of neonatologists in the American Academy of Pediatrics reported marked variation in the use of amplitude-integrated electroencephalography and identified barriers to adoption.(10) These are examples of how practice variation data, like that which we have reported, can highlight opportunities to improve and standardize screening guidelines, evaluate the impact of practice variation on outcomes and identify barriers to beneficial or evidence-based practices.

The adoption of delayed cord clamping has a distinctly different pattern of uptake relative to the other practices captured by the survey, as there was no significant uptake prior to 2010, which was followed by rapid uptake most notably after 2014. There are many potential barriers to practice adoption, ranging from limited evidence to provider awareness and openness. Since 2004, evidence from Cochrane reviews, published in 2004 and updated in 2012, recommendations from the International Liaison Committee on Resuscitation (2010) and Neonatal Resuscitation Program (2016) have been accumulating to support the adoption of delayed cord clamping in infants who do not require resuscitation.(3, 11–13)

Dissemination of evidence and associated practices is challenging; a collaborative network like the CPQCC has the ability to provide support and additional resources surrounding practices and protocol implementation. In January 2016, the CPQCC introduced a Delayed Cord Clamping Project, in which nearly 50 centers participated in voluntary data collection, data that as of 2018 are now standardly collected across the collaborative.(14) Given the timing, the impact of the CPQCC project on the adoption of delayed cord clamping is not completely captured by the survey, but may be contributing to the rate of adoption reported in 2016, which increased from 51% of NICUs in 2015 to 82% of units in 2016. The impact of this project on practices and outcomes is ongoing, but serves as a model to disseminate and increase evidence-based practice adoption and implementation at a collaborative level.

We identified two practice domains, preterm delivery room practices and any preterm practices in adoption patterns. There was a trend towards adoption of more preterm practices in regional units, but no difference in the preterm delivery room practice domain across CCS levels. Although not captured by these practice domains, preterm neuro-centric care starts prior to delivery with the identification of mothers who are likely to deliver preterm, and instituting appropriate preventative management strategies such as antenatal steroids.(15) Opportunities to provide neuro-centric care continue in the delivery room. Preterm delivery room based care bundles at the unit and collaborative level have been shown to effectively decrease rates of hypothermia and delivery room intubation.(16, 17) Given that many units have already adopted some preterm delivery room practices, additional education or new implementation techniques surrounding specific delivery room neuro-centric practices that are accessible and feasible for NICUs of all levels may further optimize preterm delivery room care.

Two practices differed by CCS level, premedication for non-delivery room intubation and presence of a PDA algorithm. Interestingly, premedication for intubation also had the second greatest increase over the study period, increasing five-fold. There was notable heterogeneity in the medications used; of the 40% of units (n=38) who reported using premedication, 55% (n=21) used a vagolytic and 40% (n=15) used a muscle relaxant. Premedication for non-delivery room, non-emergent intubation is widely debated among neonatal care providers. Reasons include limited literature surrounding the best medications, non-standard doses and medication combinations, concerns surrounding pain, and potentially harmful effects of intubation on preterm babies, including an association with severe intraventricular hemorrhage. (18–20) The presence of a PDA algorithm differed by CCS level and perinatal region. The regional difference in presence of a PDA algorithm may suggest the influence of the perinatal regionalization structure on practice dissemination. While regionalization is often viewed from the perspective of transferring patients to a higher level of care, regionalized quality improvement, whether targeting management decisions or education, may be an example of an additional pathway to leverage health care structure and policy to disseminate practices. The decision for a unit to adopt, or not adopt a practice is likely multifactorial and poorly understood. We hypothesize there are a variety of factors, which are not captured by this survey or standard datasets, that may provide insight into unit practice adoption decisions, from the impact of individual unit organizational culture to the context provided by the regional perinatal organization.

In general, there were surprisingly few differences between practices by CCS level and region and no significant differences by preterm delivery volume. Though there are limited data available regarding practices and levels of care, this is an interesting finding given the known association between both level of care and patient volume on neonatal outcomes.(21–23) One contributing factor is likely the heterogeneity within CCS level designations, specifically community level NICUs, which make up 55% of the of NICUs in California. CCS and AAP level designations are very similar, and community level NICUs had been further subdivided by the AAP into level IIIA, IIIB and IIIC for part of the study period, which were not analyzed separately in this study.(24) Additionally, the non-CCS/non-CPQCC NICUs, which represent 19% of the units in California are also potentially quite heterogeneous. Thus, there may be differences at the unit level, but the survey findings are likely driven by the relative non-specificity of CCS level categories.

California has benefited from a community of learning and collaborative work over the past 20 years through the CPQCC. Discovery of practice variation in this community has led to focused quality improvement projects across the state in order to reduce variation and adopt potentially better practices. However, the benefit of belonging to a community of learning and quality improvement need not solely rely on official statewide collaboratives. As we know that publication of guidelines and new evidence from clinical trials and meta-analyses are variably adopted, there is a role for both informal and formal learning communities to spur each other toward providing optimal care. In particular, smaller NICUs and NICUs not belonging to organizations such as CPQCC, may benefit from belonging to a community of improvement, perhaps organized by the larger regional center in their geographic region, in order to more efficiently adopt new evidence-based practices.

These data begin to describe the varied landscape of preterm neuro-centric care across California. The practice variation reported here provides an opportunity to guide future quality improvement efforts, harness available and new avenues for practice dissemination, begin to measure and assess the quality of preterm neuro-centric care, and evaluate the impact of practice variation on outcomes.

Limitations

The 65% response rate is a limitation of this study, though we did assess and confirm that respondents were representative of the CPQCC NICUs, which includes the majority of NICUs in California. Our survey asked respondents to report on current practices in place, as well as when practices were adopted over the past decade. Thus, this aspect of the survey data may be particularly susceptible to recall bias and could result in possible misclassification of when practices were reportedly adopted. However, the final rate of practice uptake in 2016 is least susceptible to recall bias and provides valuable data regarding current practices. Although the presence or absence of a practice provides some information regarding the neuro-centric status of a NICU, the survey does not provide detail as to how a practice was implemented.

Conclusion:

The adoption and presence of preterm neuro-centric practices across California has increased, though there is variation in adoption by practice and unit level. There is a subset of practices that have been more rapidly adopted in recent years and may reflect changes in the awareness of potential, neuro-centric care practices, available literature and recommendations, or an increase in unit and collaborative quality improvement efforts. This survey provides a foundation to inform quality improvement initiatives, standardization of evidence-based care, assessment of the quality of preterm neuro-centric care, and explorations of the associations between practices and neurologic outcomes. Gathering additional data regarding implementation of practices, the individual NICU organizational culture and regional perinatal organizational context will further our understanding of drivers of practice, and potentially outcome, variation.

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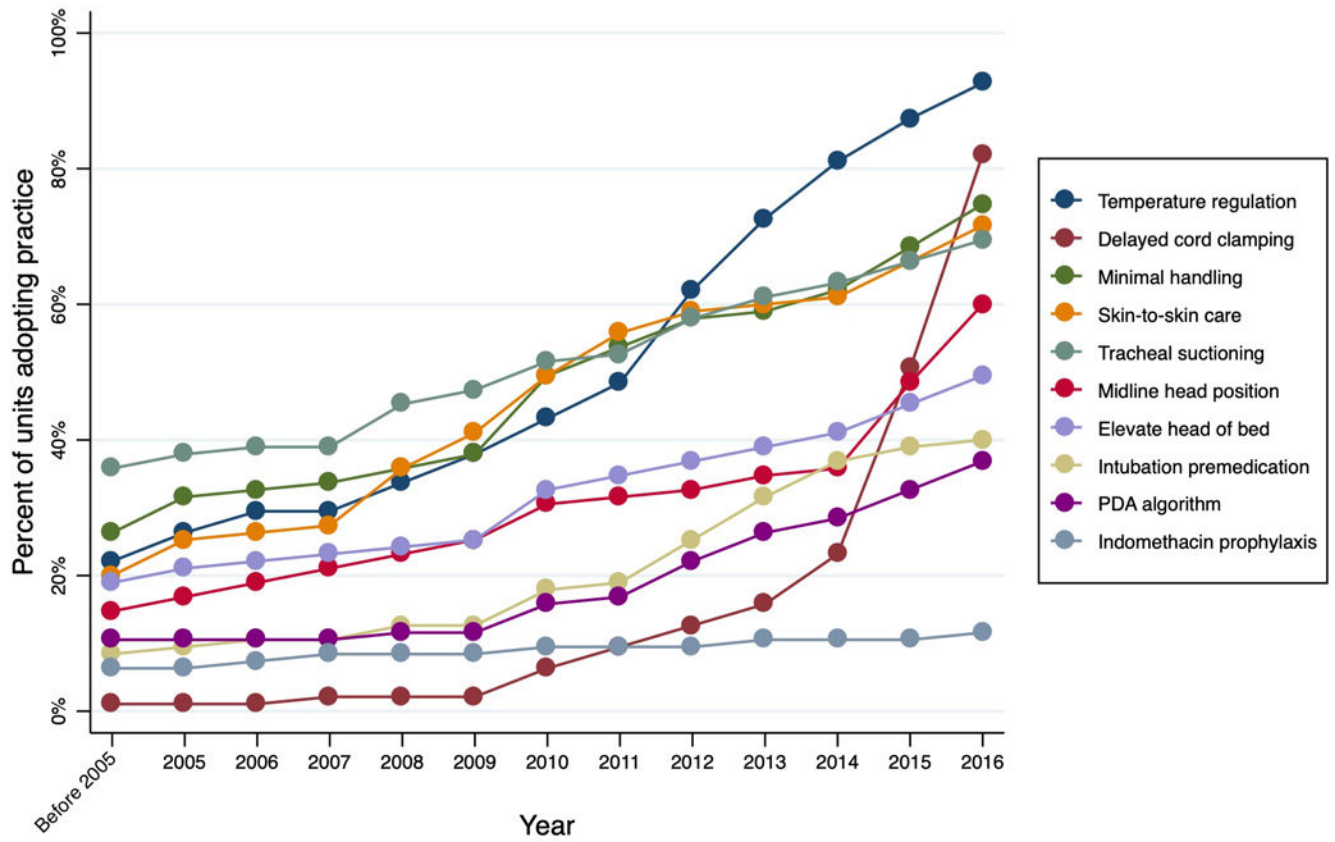


Figure 1:
Practice adoption trends over time across California NICUs.

Table 1.

Characteristics of CPQCC Survey Respondents and Non-Respondents

Hospital Characteristics	Total	CPQCC Non-respondents	CPQCC Respondents	P-value
n	135	47 (34.8%)	88 (65.2%)	
CCS Level				0.19
Non-CCS	15 (11.1%)	3 (6.4%)	12 (13.6%)	
Intermediate	15 (11.1%)	8 (17.0%)	7 (7.8%)	
Community	82 (60.7%)	26 (55.3%)	56 (63.6%)	
Regional	23 (17.0%)	10 (21.3%)	13 (14.8%)	
AAP Level				0.18
Level II	21 (15.6%)	9 (19.2%)	12 (13.6%)	
Level III	88 (65.2%)	26 (55.3%)	62 (70.5%)	
Level IV	22 (16.3%)	9 (19.2%)	13 (14.8%)	
AAP level missing	4 (3.0%)	3 (6.4%)	1 (1.1%)	
Number of NICU Beds	20 (12–30)	20 (13–30)	20 (12–29.5)	0.68
Annual average of deliveries <32 weeks, median (IQR)	31.1 (18.3–53.6)	33.0 (20.4–57.3)	31.0 (17.4–51.0)	0.59
Annual average of deliveries <1500 grams, median (IQR)	30.3 (17.9–52.0)	31.8 (19.1–57.3)	30.0 (16.7–50.0)	0.62
Neonatologist coverage 24 hours /day	89 (65.9%)	34 (72.3%)	55 (62.5%)	0.25
Region				0.15
Region 1	10 (7.4%)	1 (2.1%)	9 (10.2%)	
Region 2	10 (7.4%)	3 (6.4%)	7 (8.0%)	
Region 3	10 (7.4%)	5 (10.6%)	5 (5.7%)	
Region 4	12 (8.9%)	2 (4.3%)	10 (11.4%)	
Region 5	12 (8.9%)	4 (8.5%)	8 (9.1%)	
Region 6	29 (21.5%)	12 (25.5%)	17 (19.3%)	
Region 7	11 (8.2%)	3 (6.4%)	8 (9.1%)	
Region 8	8 (5.9%)	1 (2.1%)	7 (8.0%)	
Region 9	12 (8.9%)	8 (17.0%)	4 (4.6%)	
Region 10	8 (5.9%)	4 (8.5%)	4 (4.6%)	
Region 11	13 (9.6%)	4 (8.5%)	9 (10.2%)	
Urban hospital	124 (96.9%)	42 (95.5%)	82 (97.6%)	0.50
Teaching hospital	26 (20.3%)	10 (22.7%)	16 (19.1%)	0.62

Abbreviations: CCS-California Children's Services, AAP-American Academy of Pediatrics, IQR-interquartile range

Table 2.

Adoption of Practices by NICU CCS Level

	Total	Non-CCS/CPQCC	Intermediate	Community	Regional	P-value
All NICUs	147	28	15	81	23	
Survey respondents	95 (64.6%)	19 (67.9%)	7 (46.7%)	56 (69.1%)	13 (56.5%)	
Practices						
Delayed cord clamping	78 (82.1%)	14 (73.7%)	5 (71.4%)	48 (85.7%)	11 (84.6%)	0.57
Additional preterm resuscitation training	78 (82.1%)	15 (79.0%)	6 (85.7%)	45 (80.4%)	12 (92.3%)	0.75
Preterm nursing guidelines	85 (89.5%)	18 (94.7%)	5 (71.4%)	49 (87.5%)	13 (100.0%)	0.19
Temperature control in the DR	88 (92.6%)	17 (89.5%)	5 (71.4%)	54 (96.4%)	12 (92.3%)	0.11
Minimal handling	71 (74.7%)	14 (73.7%)	5 (71.4%)	42 (75.0%)	10 (76.9%)	0.99
Midline head position	57 (60.0%)	11 (57.9%)	4 (57.2%)	33 (58.9%)	9 (69.2%)	0.91
Elevation of head of the bed	47 (49.5%)	7 (36.8%)	3 (42.9%)	29 (51.8%)	8 (61.5%)	0.53
Tracheal suctioning frequency	66 (69.5%)	12 (63.2%)	3 (42.9%)	41 (73.2%)	10 (76.9%)	0.33
Skin-to-skin care	68 (71.6%)	13 (68.4%)	3 (42.9%)	41 (73.2%)	11 (84.6%)	0.25
Premedication for intubation	38 (40.0%)	5 (26.3%)	5 (71.4%)	19 (33.9%)	9 (69.2%)	0.02
Indomethacin prophylaxis	11 (11.6%)	3 (15.8%)	0 (0%)	6 (10.7%)	2 (15.4%)	0.69
PDA treatment algorithm	32 (33.7%)	6 (31.6%)	1 (14.3%)	16 (28.6%)	9 (69.2%)	0.03
Unit developed preterm specific QI projects	46 (48.4%)	8 (42.1%)	3 (42.9%)	25 (44.6%)	10 (76.9%)	0.18
Practice domains						
Delivery room practices, median (IQR)	4 (4–3)	4 (3–4)	3 (2–4)	3 (2–4)	4 (4–4)	0.12
Any preterm practice, median (IQR)	11 (8–13)	11 (8–13)	9 (2–10)	10 (9–12)	12 (11–15)	0.05

Abbreviations: CCS-California Children's Services, QI-Quality Improvement, IQR-interquartile range