Measuring Quality of Care in Moderate and Late Preterm Infants

Elizabeth G. Salazar, MD[1,2], **Sara C. Handley, MD MSCE**[1,2,3], **Lucy T. Greenberg, MS**[4,5], **Erika M. Edwards, PhD MPH**[4,5,6], **Scott A. Lorch, MD MSCE**[1,2,3]

[1]Division of Neonatology, The Children's Hospital of Philadelphia, Philadelphia, PA

[2]Leonard Davis Institute of Health Economics, Philadelphia, PA

[3]Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA

[4]Vermont Oxford Network, Burlington, VT

[5]Department of Mathematics and Statistics, The University of Vermont, Burlington, VT

[6]Department of Pediatrics, The Robert Larner MD, College of Medicine, The University of Vermont, Burlington, VT

Abstract

Objective—To examine quality measures for moderate and late preterm (MLP) infants.

Study Design—By prospectively analyzing Vermont Oxford Network's all NICU admissions database, we adapted Baby-MONITOR, a composite quality measure for extremely/very preterm infants, for MLP infants. We examined correlations between the adapted MLP quality measure (MLP-QM) in MLP infants and Baby-MONITOR in extremely and very preterm infants.

Result—We studied 376,219 MLP (30–36 weeks GA) and 57,595 extremely/very preterm (25–29 weeks GA) infants from 465 U.S. hospitals born from 2016 to 2020. MLP-QM summary scores in MLP infants had weak correlation with Baby-MONITOR scores in extremely and very preterm infants (r=0.47). There was weak correlation among survival (r=0.19), no pneumothorax (r=0.35), and no infection after 3 days (r=0.45), but strong correlation among human milk at discharge (r=0.79) and no hypothermia (r=0.76).

Conclusion—Modest correlation among hospital care measures in two preterm populations suggests need for MLP-specific care measures.

Address Correspondence to: Elizabeth G. Salazar, Division of Neonatology, 3401 Civic Center Blvd, 2NW, Philadelphia, PA 19103, salazare@chop.edu, Ph. 267-760-7659.

Introduction

Moderate and late preterm (MLP) infants (born between 32 and $36^{6/7}$ weeks' gestation) comprise 84% of all preterm births in the United States (U.S.). (1) Compared to full-term infants (39 weeks' gestation), MLP infants are at increased risk for prematurity-associated complications including respiratory distress syndrome (RDS), intraventricular hemorrhage (IVH), adverse neurodevelopmental outcomes, and death. (2,3) The mean total newborn hospitalization costs for the MLP population are nine times that of full-term infants. (4) Additionally, there is significant variation in MLP infant care between hospitals, such as the frequency of mechanical ventilation and provision of parenteral nutrition. (5)

Despite such variation in outcomes and care between hospitals, there are no population specific quality measures of care for the hospitalized MLP population, the majority of NICU patients. For the most preterm population, Baby-MONITOR (Measure Of Neonatal InTensive care Outcomes Research), a composite indicator of care quality for extremely and very preterm infants, has been developed. (6,7) Associated studies using Baby-MONITOR highlight variation in quality across hospitals with the same neonatal care level (8) and in care within and between hospitals by race and ethnicity. (9–11) Similar variation in care has been suggested in the early term and term population as assessed by the "Unexpected Complications among Term Newborns" quality measure, although much of this variation is in admission to neonatal intensive care units (NICUs) and hospital transfers. (12,13) Neither measure has been adapted for the MLP population and thus, similar insights into this large and resource intensive population are undefined.

To improve the care of the MLP population, we need to assess the quality of care provided in the NICU. Although previously validated quality measures, such as Baby-MONITOR, offer a starting point, many gestational age (GA) specific components in Baby-MONITOR or the "Unexpected Complications among Term Newborns" do not apply to the MLP population. Additional measures will likely be necessary to fully capture the quality of care provided to this population. The objective of this study was to examine how Baby-MONITOR and other potential measures of care quality relevant to the MLP population perform for assessing variation in the quality of care as measured in a large, national representative database of NICU admissions. To explore how quality of care for extremely and very preterm versus MLP infants may be correlated, we compared Baby-MONITOR scores to an adapted MLP measure (MLP-QM) within hospitals.

Materials/Subjects and Methods

Population

We conducted a prospective analysis of measures of care quality using data from the all NICU admissions database maintained by Vermont Oxford Network (VON), a voluntary worldwide community dedicated to improving the quality, safety, and value of perinatal and neonatal care. (14) The database includes: 1) VLBW (1500g) infants who are admitted anywhere in a hospital or die anywhere in a hospital within 28 days of birth; and 2) infants with a birth weight >1500g admitted to a NICU within 28 days of birth, where a NICU is defined as a location within a hospital where continuous positive airway pressure (CPAP)

or intermittent mechanical ventilation (MV) can be provided to infants (not including the delivery room or another location where respiratory interventions are provided briefly for stabilization) or infants with a birth weight >1500g who die anywhere in the hospital within 28 days of birth. (15)

To identify our analytic cohort, we excluded: infants with serious congenital anomalies (n=24,825); deaths in the delivery room or within 12 hours of admission to the NICU (n=1,213); infants transferred more than once (n=798); and infants with implausible values for birth weight (n=1,168). Implausible values for birthweight were defined as birth weight less than 201g or greater than four standard deviations from the mean for GA and sex. Infants were then divided into two groups by GA: MLP infants of $30^{0/7}$ to $36^{6/7}$ weeks GA and extremely and very preterm infants from $25^{0/7}$ to $29^{6/7}$ weeks GA. We examined infants from $30^{0/7}$ to $36^{6/7}$ weeks GA as these infants are not captured in existing quality measures. (7,16)

The institutional review board of the University of Vermont determined the use of the VON research repository for this analysis was not human subjects research.

Quality Measures

Baby-MONITOR consists of both infant-level process measures (any human milk at discharge, no admission hypothermia, no health care-associated infection, antenatal steroid exposure, timely retinal examination) and outcome measures (survival to hospital discharge, no pneumothorax, no chronic lung disease, greater than median growth velocity). (6) We examined the distribution of the Baby-MONITOR summary scores and the components in both the MLP and the extremely and very preterm population at the infant level. The adapted MLP-QM kept measures relevant to all preterm infants: any human milk at discharge, no admission hypothermia, no health care-associated infection, survival to hospital discharge, and no pneumothorax. Baby-MONITOR components specific to the most preterm infants were replaced with new MLP relevant measures after examination of all proposed measures in the creation of Baby-MONITOR. (6) Antenatal steroid exposure and timely retinal examination are less applicable to the MLP population (Supplemental Table 1). Chronic lung disease (CLD) is defined among infants born before 33 weeks because the traditional definition of oxygen use at 36 weeks corrected GA may lead to overestimation of lung disease in older infants (Supplemental Table 1). (17) As the "no CLD" measure is not applicable to all MLP infants, it was replaced with no oxygen at 28 days or no oxygen at discharge if discharged earlier than 28 days. (5,17) Although the Baby-MONITOR growth velocity measure has only been validated in the VLBW population, growth remains a critical aspect in MLP infant care. (18) Change in weight z-score was included in the adapted MLP-QM as it has been validated in populations with wide ranges of gestational ages to capture significant weight loss regardless of birth weight. (19) Additionally, we included extreme length of stay as several studies have demonstrated variation in the postmenstrual age at discharge in the MLP population. (20–22) Extreme length of stay was defined as total hospital stay greater than the 95th percentile for the predicted value, based on a multivariable risk adjustment model including birth weight, ventilation status, respiratory distress syndrome, surgery (other than for retinopathy of prematurity [ROP]), 1

minute APGAR score, small for gestational age, reason for transfer, vaginal delivery, inborn/outborn, sex, prenatal care, and major birth defect. (23–27)

Measures in both the Baby-MONITOR and MLP-QM score were adjusted for relevant infant characteristics (GA, sex, 5-minute Apgar score, whether the mother received prenatal care, whether the infant was inborn or outborn, small for GA, part of a multiple birth, or born by cesarean delivery) as in prior work (Supplemental Table 2). (6,10,28) Oxygen use at 28 days of life and CLD were adjusted for the center's elevation. (29) Measures were calculated to appropriately attribute events for infants transferred between hospitals after birth by excluding infants if they were either transferred out by day 3 from the growth, infection, and human milk measures or if they were admitted after day 3 for the oxygen measures. Consistent with previous studies of Baby-MONITOR, measures were standardized relative to other NICUs in the dataset. (28,30) For component scores, the estimate was calculated by observed minus expected percentage for the hospital, divided by the standard error, and scaled so the standard deviation across hospitals equals one. The standardized scores for each component of the composite measure were equally weighted after placing them on a common scale and averaged to derive the summary Baby-MONITOR and MLP-QM scores. A higher score indicates higher quality of care. Further details regarding the quality score methodology used in this analysis are described in prior work. (6,7,31)

Statistical Analysis

For each hospital, we derived scores for Baby-MONITOR and each of its components based on extremely and very preterm infants, and scores for MLP-QM and each of its components based on MLP infants. To receive scores, hospitals needed data on at least one infant for each measure. We examined the distributions of MLP-QM summary scores and components overall and by NICU level. We used Pearson correlation coefficients to determine the correlation of the summary MLP-QM score in MLP infants with the Baby-MONITOR score in extremely and very preterm infants cared for at the same hospital. We also compared the individual components of MLP-QM between MLP and extremely and very preterm infants within hospitals. Correlations were rated as weak (<0.5), moderate ($0.5 - 0.75$), strong ($0.75 - 0.9$), very strong ($0.9 - 1$), or perfect (1). (32) R version 4.0.2 was used for all data analyses.

Results

We included infants at 465 U.S. hospitals born at 25–36 completed weeks' gestation between January 2016 and December 2020. After applying exclusion criteria, 433,814 infants were eligible for analysis: 376,219 (87%) moderate and late preterm (30–36 weeks GA) and 57,595 (13%) extremely and very preterm (25–29 weeks GA).

Table 1 compares population demographics in the MLP population with the extremely and very preterm population at the infant and NICU level. Infants in both groups had similar rates of multiple gestation and prenatal care as well as similar 5-minute Apgar scores. Extremely and very preterm infants were more likely to be delivered via cesarean delivery.

Table 1 also compares Baby-MONITOR and MLP-QM components in the MLP population with the extremely and very preterm population. Of the components common to Baby-MONITOR and MLP-QM, MLP infants were more likely to be discharged home on human milk (Median 68.2% [IQR 58.2, 76.5] vs. Median 48.2% [IQR 38.7, 60.4]), have lower in-hospital mortality (Median 0.3% [IQR 0.1, 0.6] vs. Median 6% [IQR 3.8, 8.1], and have lower infection after day of life 3 (Median 0.4% [IQR 0.1, 0.7] vs. Median 7.2% [4.2,10.3]). Of the adapted new MLP-QM measures, extreme length of stay and greater than median weight z-score change were similar in the MLP and extremely and very preterm populations. All MLP-QM components demonstrated variability at the hospital level, with the majority having normal distributions (Supplemental Figure 1).

Figure 1 displays a hospital level comparison of the summary Baby-MONITOR score in extremely and very preterm infants with the MLP-QM score in MLP infants (Pearson correlation coefficient r = 0.47). The weak correlation between scores suggests that hospitals that have high scores in the MLP-QM for MLP infants may not have corresponding high scores in Baby-MONITOR for the extremely and very preterm infants.

Figure 2 depicts the correlation between the individual components of the adapted MLP-QM scores in the MLP population with the extremely and very preterm population. There was weak correlation among survival (r = 0.19), no pneumothorax (r = 0.35), and no infection after 3 days (r = 0.45). There was strong correlation among human milk at discharge (r = 0.79) and no hypothermia (r = 0.76). There was moderate correlation for no extreme length of stay (r = 0.59), no oxygen at 28 days (r = 0.52), change in weight z score greater than median (r = 0.54), and overall MLP monitor score (r = 0.59).

Discussion

We adapted Baby-MONITOR, an existing measure of care quality designed for the extremely and preterm infant population, for the MLP population to create an adapted MLP quality measure, MLP-QM. We found weak correlation between MLP-QM summary scores in MLP infants and Baby-MONITOR summary scores in extremely and very preterm infants at the hospital level. While some components, such as human milk at discharge and no hypothermia, were highly correlated, there was weak correlation of survival, no pneumothorax, and no infection after 3 days between MLP and extremely and very preterm infants cared for at the same hospital. These inconsistent correlations suggest that while hospital care practices addressing some areas, such as human milk feeding or thermoregulation, are equally robust in MLP and extremely and very preterm infants, other hospital care practices may vary greatly in the two populations.

We aimed to assess whether an established VLBW quality measure, Baby-MONITOR, could be adapted to potentially evaluate the quality of care in the MLP population. (7) Given the high prevalence of MLP infants in the NICU, assessing the quality of care provided to these infants is critical to improving NICU care. (1) However, Baby-MONITOR contains several components that are not applicable for the MLP population: antenatal steroids, timely ROP exam, and no CLD. (6) Adapting Baby-MONITOR to include oxygen use at 28 days, extreme length of stay, and greater than median z-score gives MLP-QM improved face

validity as these outcomes are relevant and common in the MLP population. Additionally, several studies have demonstrated variation in the postmenstrual age at discharge and degree of respiratory support provided in the MLP population, suggesting that length of stay and oxygen use could be used as quality measures in this population. (20,22,33) The observed strong correlation between human milk at discharge and hypothermia in Baby-MONITOR and MLP-QM suggests that these components may be appropriate for an MLP-specific quality measure. The added measures, including oxygen use at 28 days, extreme length of stay, and greater than median z-score, as well as human milk at discharge and hypothermia may provide a starting point for formal development of an MLP specific quality measure through a Delphi process with established experts or through a statistical approach. (34) Formal measure development for MLP infants is essential to create a definition of quality of care for this population.

Poor correlation in hospital performance in Baby-MONITOR in extremely and very preterm infants with the adapted MLP-QM in MLP infants cautions against applying definitions of quality validated in one, specific population to other populations and associated assumptions about the quality of care. Studies in adults have demonstrated poor correlation in hospital mortality rates for individual diagnoses at a single hospital, implying that providing high quality care for one population or disease may not translate into high quality care in other populations or diseases. (35) The National Quality Forum (NQF) has not endorsed any disease-specific quality measures for adult intensive care, as they do not adequately assess the overall quality of care within a specific ICU. (36–38) Similarly, careful consideration must be taken when developing quality measures to evaluate NICU care given population heterogeneity with respect to the wide range of GAs and their associated risk profiles, resource utilization, and outcome likelihood. While unexpected complications in term newborns is an NQF endorsed measure, this measure does not capture the quality of care for infants admitted to the NICU, such as MLP infants. (39) To address this complex problem of assessing quality in a heterogenous population, Silber et al. proposed using a specific template of patients standardized for diagnoses and patient characteristics and diagnoses to compare quality across hospitals. (40,41) While the heterogeneity of the NICU population may not be merit this approach to quality assessment, composite quality measures for overall NICU care must accurately weight process and outcome measures for infants of all GAs. Validated quality measures are certainly needed for the MLP population given their prevalent NICU admissions. (42,43)

Poor correlation between adapted MLP quality score and components in MLP infants and the Baby-MONITOR score in extreme and very preterm population suggests that at a single hospital, quality of care for extremely and very preterm infants may not correlate with quality of care for MLP infants. One potential reason for this finding is that processes implemented to improve care for VLBW infants may not apply to other subpopulations, such as MLP infants. (34) For example, discordance in infection rates in extremely and very preterm and MLP infants may be secondary to GA specific differences in vascular access management. (44) As higher rates of intubation and surfactant administration are seen in extremely and very preterm infants compared to MLP infants, discordance in pneumothorax could be secondary to GA specific processes of respiratory management. Centers with low levels of pneumothorax in extremely and very preterm infants but higher levels in MLP

infants who have lower risk of pneumothorax may be providing lower quality care. (45) Poor correlation between survival in extremely and very preterm infants and MLP infants has not previously been reported. Both process-level factors (e.g., unit use of standardized care guidelines) and hospital-related factors (e.g. unit size, unit level of care, staffing models) may contribute to this observation. Further research on how process, hospital, and other factors contribute to these survival differences is necessary.

This study has limitations. First, while we efficiently adapted Baby-MONITOR for MLP infants by selecting evidence-based measures previously evaluated by experts, the current evaluative standard for formal measure development is measure selection through expert consensus or statistical assessment of validity. (6,17,19–22) Second, other potential quality measures reflecting relevant aspects of MLP care, such as time to initiate enteral feeds or time to reach full feeds, are not included in the adapted MLP-QM because such measures were not available in the data. Third, we examined infants from 30–36 weeks GA together to capture the quality of care for infants not measured by Baby-MONITOR or term infant measures; however, in doing so, we may not capture differences in quality between moderate and late preterm infants. Future quality measure development should consider potential differences within smaller GA subgroups. Fourth, similar to established NICU quality measures, the MLP-QM does not incorporate components of patient-centered care, such as family involvement at bedside or education. These measures are likely relevant to the MLP population, whose NICU care may be more amendable to family involvement than the extremely preterm population, and merit consideration and further study. Finally, we used a convenience-based sample of hospitals participating in the VON all-admission database. Formal measure development for MLP infants could address these limitations, creating a valid MLP-specific measure.

Despite these limitations, this study uses a large, contemporary dataset of NICU admissions across many hospital types to demonstrate the need for a quality measure in the prevalent MLP population. The robust dataset facilitated study of new candidate MLP quality measures and their associated variability as well as examination of correlation of the MLP-QM with previously described VLBW quality measures. This work is the first endeavor to develop a quality measure for this important population, comprising the majority of NICU patients.

Conclusion

We developed an adapted quality measure to assess quality of care in MLP infants that demonstrated poor correlation between overall and component quality scores in extremely and very preterm infants cared for at the same hospital. Additional research is needed to develop a validated quality measure for the MLP population. Weak correlation between summary and component scores suggests that different processes may mediate positive outcomes in MLP infants compared to extremely and very preterm infants. Further study is needed to elucidate how process and hospital-level factors influence MLP quality of care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

References

1. Shapiro-Mendoza CK, Lackritz EM. Epidemiology of late and moderate preterm birth. Semin Fetal Neonatal Med. 2012;17(3):120–5. [PubMed: 22264582]

2. Teune MJ, Bakhuizen S, Bannerman CG, Opmeer BC, Van Kaam AH, Van Wassenaer AG, et al. A systematic review of severe morbidity in infants born late preterm. American Journal of Obstetrics and Gynecology. 2011;205(4):374.e1–374.e9. [PubMed: 21864824]

3. Stewart DL, Barfield WD. Updates on an at-risk population: Late-preterm and early-term infants. Pediatrics. 2019;144(5).

4. Phibbs CS, Schmitt SK, Cooper M, Gould JB, Lee HC, Profit J, et al. Birth Hospitalization Costs and Days of Care for Mothers and Neonates in California, 2009–2011. J Pediatr. 2019 Jan;204:118–25. [PubMed: 30297293]

5. McCormick MC, Escobar GJ, Zheng Z, Richardson DK. Place of birth and variations in management of late preterm ("near-term") infants. Semin Perinatol. 2006;30(1):44–7. [PubMed: 16549213]

6. Profit J, Gould JB, Zupancic J, Stark AR, Wall KM, Kowalkowski MA, et al. Formal selection of measures for a composite index of NICU quality of care: Baby-MONITOR. J Perinatol. 2011;31:702–10. [PubMed: 21350429]

7. Profit J, Kowalkowski MA, Zupancic JA, Pietz K, Richardson P, Draper D, Hysong SJ, Thomas EJ, Petersen LA GJ. Baby-MONITOR: A Composite Indicator of NICU Quality. Pediatrics. 2014;134(1):X8–X8.

8. Profit J, Gould JB, Bennett M, Goldstein BA, Draper D, Phibbs CS, et al. The Association of Level of Care with NICU Quality. Pediatrics. 2016;137(3).

9. Profit J, Gould JB, Bennett M, Goldstein BA, Draper D, Phibbs CS, et al. Racial/ethnic disparity in NICU quality of care delivery. Pediatrics. 2017;140(3).

10. Horbar JD, Edwards EM, Greenberg LT, Profit J, Draper D, Helkey D, et al. Racial Segregation and Inequality in the Neonatal Intensive Care Unit for Very Low-Birth-Weight and Very Preterm Infants. JAMA Pediatr. 2019;173(5).

11. Edwards E, Greenberg L, Profit J, Draper D, Helkey D, Horbar J. Quality of Care in US NICUs by Race and Ethnicity. Pediatrics. 2021 Aug;148(2).

12. Sebastião YV, Womack LS, Castillo HL, Balakrishnan M, Bruder K, Alitz P, et al. Hospital Variations in Unexpected Complications Among Term Newborns. Pediatrics. 2017;139(3).

13. Clapp MA, James KE, Bates SV., Kaimal AJ. Patient and Hospital Factors Associated With Unexpected Newborn Complications Among Term Neonates in US Hospitals. JAMA Netw open. 2020;3(2):e19194–98.

14. Horbar JD, Edwards EM, Greenberg LT, Morrow KA, Soll RF, Buus-Frank ME, et al. Variation in Performance of Neonatal Intensive Care Units in the United States. JAMA Pediatr. 2017 Mar;171(3).

15. Vermont Oxford Network. Manual of Operations: Part 1. Guidelines for Database Participation. Burlington; VT: Vermont Oxford Network; 2016.

16. Sebastiao YV, Womack LS, Castillo HL, Balakrishnan M, Bruder K, Alitz P, et al. Hospital variations in unexpected complications among term newborns. Pediatrics. 2017 Mar 1;139(3).

17. Jensen E, Dysart K, Gantz M, McDonald S, Bamat N, Keszler M, et al. The Diagnosis of Bronchopulmonary Dysplasia in Very Preterm Infants. An Evidence-based Approach. Am J Respir Crit Care Med. 2019 Sep;200(6):751–9. [PubMed: 30995069]

18. Patel AL, Engstrom JL, Meier PP, Kimura RE. Accuracy of methods for calculating postnatal growth velocity for extremely low birth weight infants. Pediatrics. 2005 Dec;116(6):1466–73. [PubMed: 16322172]

19. Simon L, Hanf M, Frondas-Chauty A, Darmaun D, Rouger V, Gascoin G, et al. Neonatal growth velocity of preterm infants: The weight Z-score change versus Patel exponential model. PLoS One. 2019 Feb;14(6).

20. Altman M, Vanpée M, Cnattingius S, Norman M. Moderately preterm infants and determinants of length of hospital stay. Arch Dis Child Fetal Neonatal Ed. 2009;94(6):414–8.

21. Escobar GJ, McCormick MC, Zupancic JAF, Coleman-Phox K, Armstrong MA, Greene JD, et al. Unstudied infants: Outcomes of moderately premature infants in the neonatal intensive care unit. Arch Dis Child Fetal Neonatal Ed. 2006;91(4):238–44.

22. Profit J, McCormick MC, Escobar GJ, Richardson DK, Zheng Z, Coleman-Phox K, et al. Neonatal intensive care unit census influences discharge of moderately preterm infants. Pediatrics. 2007;119(2):314–9. [PubMed: 17272621]

23. Lee HC, Bennett MV., Schulman J, Gould JB, Profit J. Estimating Length of Stay by Patient Type in the Neonatal Intensive Care Unit. Am J Perinatol. 2016 Jul 1;33(8):751–7. [PubMed: 26890437]

24. Seaton SE, Barker L, Draper ES, Abrams KR, Modi N, Manktelow BN. Estimating neonatal length of stay for babies born very preterm. Arch Dis Child Fetal Neonatal Ed. 2019 Mar 27;104(2):F182–6. [PubMed: 29588296]

25. Campos Bannwart D De, Rebello CM, Sadeck LDSR, Pontes MD, Araujo Ramos JL, Leone CR. Prediction of length of hospital stay in neonatal units for very low birth weight infants. J Perinatol. 1999;19(2):92–6. [PubMed: 10642966]

26. Cegolon L, Mastrangelo G, Campbell OM, Giangreco M, Alberico S, Montasta L, et al. Length of stay following cesarean sections: A population based study in the Friuli Venezia Giulia region (North-Eastern Italy), 2005–2015. PLoS One. 2019 Feb 1;14(2).

27. Cegolon L, Campbell O, Alberico S, Montico M, Mastrangelo G, Monasta L, et al. Length of stay following vaginal deliveries: A population based study in the Friuli Venezia Giulia region (North-Eastern Italy), 2005–2015. PLoS One. 2019 Jan 1;14(1).

28. Draper D GM. Statistical analysis of performance indicators in UK higher education. J R Stat Soc. 2004;167(3):449–74.

29. Altitude Britton J., oxygen and the definition of bronchopulmonary dysplasia. J Perinatol. 2012;32(11):880–5. [PubMed: 22343395]

30. Helkey D DD. dghrank: Construct Draper-Gittoes-Helkey Institution Rankings. [Internet]. 2018. [cited 2018 Dec 12]. Available from: https://github.com/dhelkey/dghrank

31. Dhurjati R, Sigurdson K, Profit J. Patient- and Family-Centered Care as a Dimension of Quality. Vol. 34, American Journal of Medical Quality. SAGE Publications Inc.; 2019. p. 307–8. [PubMed: 30501498]

32. Aberson C Applied Power Analysis for the Behavioral Sciences. New York, NY: Taylor & Francis Group LLC; 2010.

33. Escobar GJ, Clark RH, Greene JD. Short-term outcomes of infants born at 35 and 36 weeks gestation: We need to ask more questions. Semin Perinatol. 2006;30(1):28–33. [PubMed: 16549211]

34. Profit J, Typpo KV., Hysong SJ, Woodard LCD, Kallen MA, Petersen LA. Improving benchmarking by using an explicit framework for the development of composite indicators: An example using pediatric quality of care. Implement Sci. 2010;5(1):1–10. [PubMed: 20047652]

35. Rosenthal G Weak associations between hospital mortality rates for individual diagnoses: implications for profiling hospital quality. Am J Public Health. 1997;87(3):429–33. [PubMed: 9096547]

36. National Quality Forum. Endorsement Summary: Cardiovascular Measures [Internet]. 2012 [cited 2021 Dec 9]. Available from: https://www.qualityforum.org/News_And_Resources/Endorsement_Summaries/Endorsement_Summaries.aspx

37. National Quality Forum. Endorsement Summary: Pulmonary and Critical Care Measures [Internet]. 2012 [cited 2021 Dec 9]. Available from: https://www.qualityforum.org/News_And_Resources/Endorsement_Summaries/Endorsement_Summaries.aspx

38. National Quality Forum. Endorsement Summary: Neurology Measures [Internet]. 2013 [cited 2021 Dec 9]. Available from: https://www.qualityforum.org/News_And_Resources/Endorsement_Summaries/Endorsement_Summaries.aspx

39. National Quality Forum. Perinatal and Women's Health, Spring 2020 Cycle, CDP Report. 2021.

40. Silber JH, Rosenbaum PR, Ross RN, Ludwig JM, Wang W, Niknam BA, et al. A Hospital-Specific Template for Benchmarking its Cost and Quality. Heal Serv Res. 2014;49(5):1475–97.

41. Silber J, Rosenbaum P, Ross R, Ludwig J, Wang W, Niknam B, et al. Indirect Standardization Matching: Assessing Specific Advantage and Risk Synergy. Health Serv Res. 2016 Dec;51(6):2330–57. [PubMed: 26927625]

42. Schulman J, Braun D, Lee HC, Profit J, Duenas G, Bennett MV, Dimand RJ, Jocson M GJ. Association Between Neonatal Intensive Care Unit Admission Rates and Illness Acuity. JAMA Pediatr. 2018;172(1):17–23. [PubMed: 29181499]

43. Edwards EM HJ. Variation in Use by NICU Types in the United States. Pediatrics. 2018;142(5):e20180457. [PubMed: 30282782]

44. Smazal A, Kavars A, Carlson S, Tolaizy T, Dagle J. Peripherally inserted central catheters optimize nutrient intake in moderately preterm infants. Pediatr Res. 2016 Aug 1;80(2):185–9. [PubMed: 27057735]

45. Duong HH, Mirea L, Shah PS, Yang J, Lee SK, Sankaran K. Pneumothorax in neonates: Trends, predictors and outcomes. J Neonatal Perinatal Med. 2014;7(1):29–38. [PubMed: 24815703]
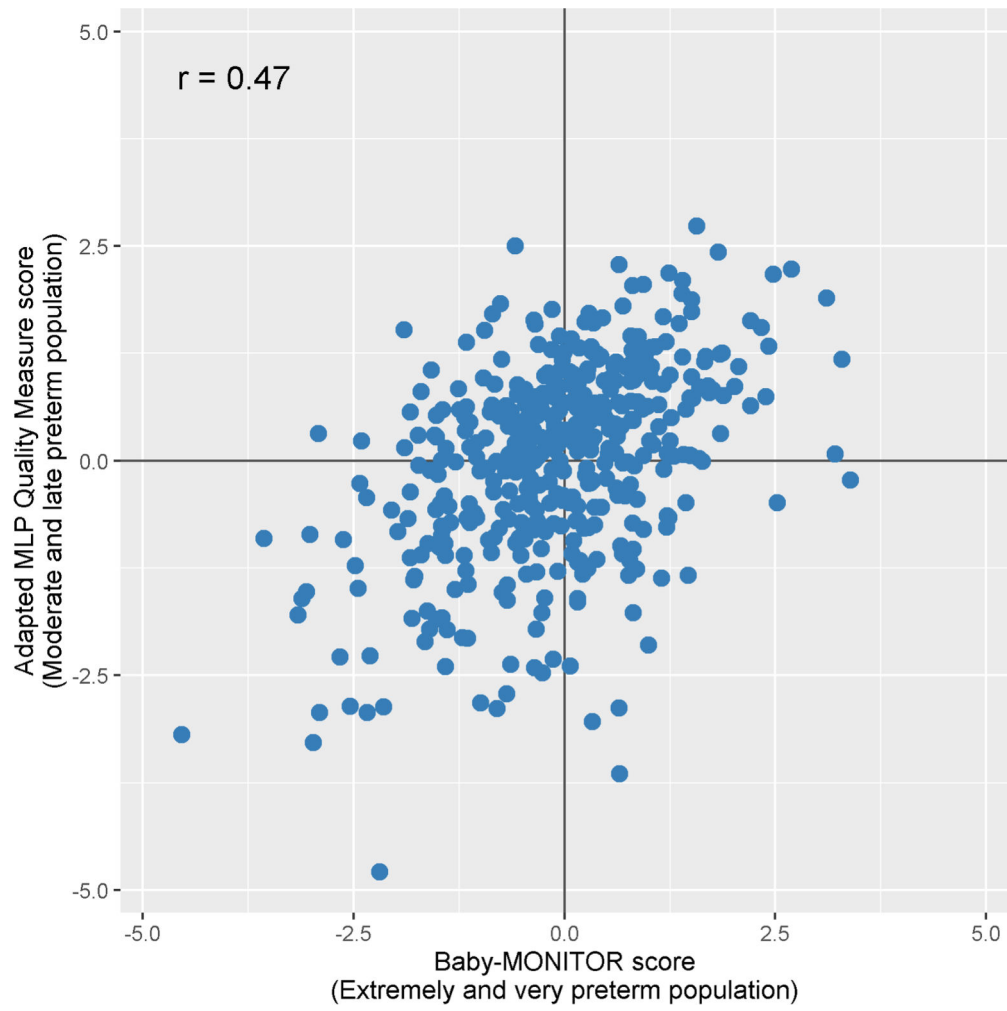
Figure 1:
Correlation of Summary Adapted MLP Quality Measure Scores in MLP Infants with Baby-MONITOR Scores in Extremely and Very Preterm Infants
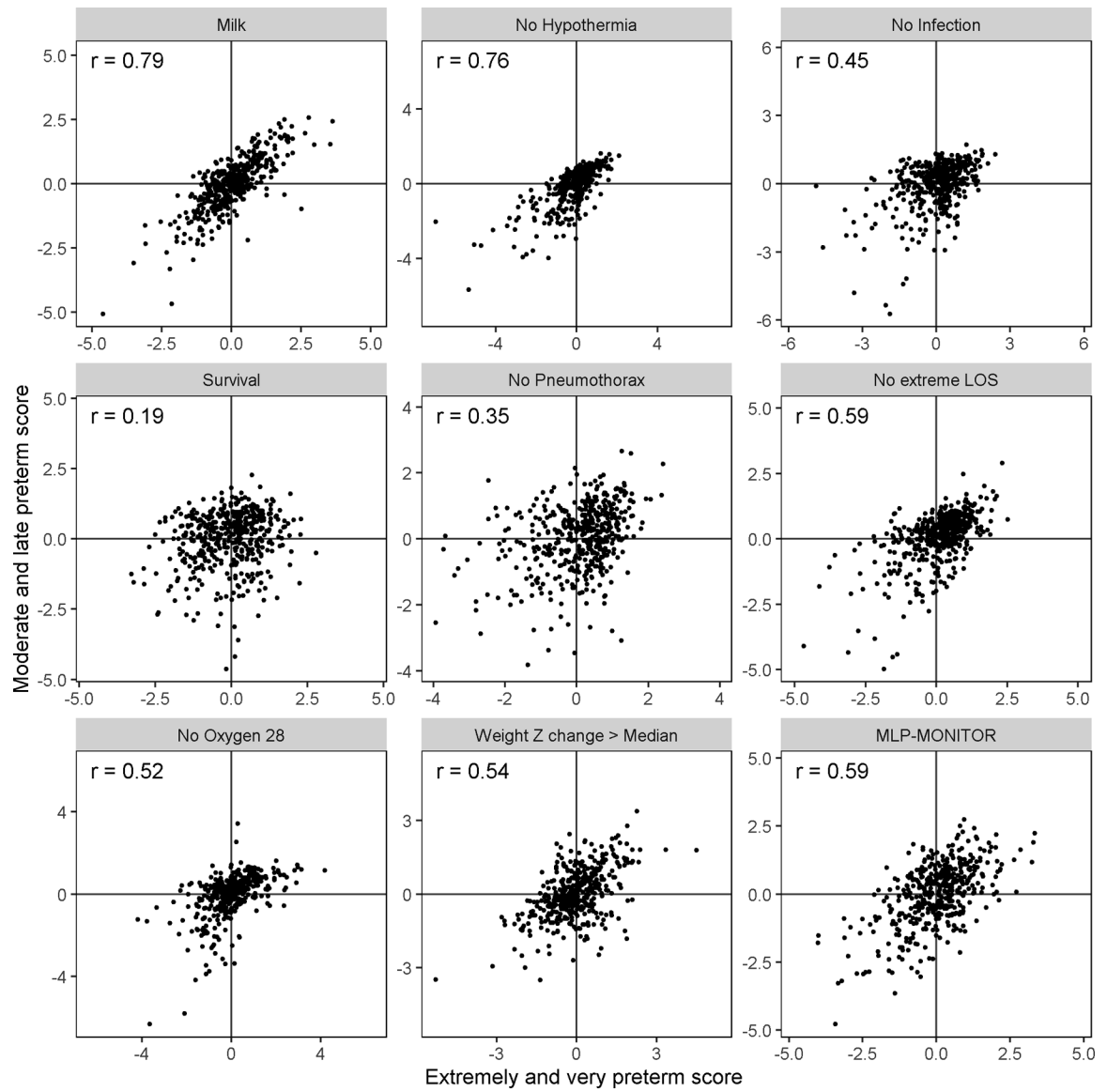
Figure 2:
Correlation of Adapted MLP Quality Measure Components in MLP Infants and Extremely and Very Preterm Infants

Table 1.

Characteristics of 433,814 Infants 25–36 Weeks' Gestational Age Reported by 465 U.S. Hospitals

| Characteristics | 30 – 36 Weeks Gestational Age (Moderate and Late Preterm) | | | 25 – 29 Weeks Gestational Age (Extremely and Very Preterm) | | |
| | Infant Level | | NICU Level | Infant Level | | NICU Level |
	N	No. (%) or Mean (SD)	Median [IQR]	N	No. (%) or Mean (SD)	Median [IQR]
Gestational age at birth, wks	376219	34.2 (1.7)	34.3 [34.1,34.5]	57595	27.7 (1.4)	27.8 [27.6,28.0]
Birth weight, g	376168	2225 (575)	2248 [2183,2301]	57591	1036 (275)	1052 [1020,1097]
Small for gestational age	376147	41900 (11.1)	11.0 [9.2,12.7]	57582	4976 (8.6)	7.2 [4.0,9.9]
Male	376198	204181 (54.3)	54.4 [52.7,56.0]	57586	30173 (52.4)	52.8 [49.2,56.6]
Apgar score at 5 min	373795	8.3 (1.2)	8.3 [8.2,8.5]	56985	7.1 (1.8)	7.2 [6.9,7.5]
Cesarean delivery	376125	227884 (60.6)	59.7 [55.4,64.9]	57584	42210 (73.3)	72.7 [67.9,77.7]
Multiple gestation	376202	90892 (24.2)	23.1 [20.0,26.3]	57590	13637 (23.7)	22.4 [16.9,27.5]
Any prenatal care	375218	363520 (96.9)	97.2 [95.6,98.4]	57394	54991 (95.8)	96.4 [93.3,98.4]
Admissions			644 [360,1138]			83 [36,179]
Inborn	376219	334704 (89.0)	94.4 [87.0,98.5]	57595	48987 (85.1)	92.6 [84.3,98.5]
Baby-MONITOR and MLP-QM measures						
Any human milk at discharge	372077	249536 (67.1)	68.2 [58.2,76.5]	52624	25015 (47.5)	48.2 [38.7,60.4]
Hypothermia on admission	370493	19971 (5.4)	2.1 [0.9,6.9]	56418	3465 (6.1)	3.4 [0.6,7.9]
Any infection after day 3	365397	1752 (0.5)	0.4 [0.1,0.7]	56642	4874 (8.6)	7.2 [4.2,10.3]
In hospital mortality	375788	1445 (0.4)	0.3 [0.1,0.6]	57251	3600 (6.3)	6 [3.8,8.1]
Pneumothorax	376153	5879 (1.6)	1.5 [0.9,2.1]	57556	2359 (4.1)	3 [0.5.2]
Original Baby-MONITOR measures						
Chronic lung disease	82200	5056 (6.2)	4.2 [2,7]	53288	16589 (31.1)	25.7 [15.5,36.7]
Greater than median growth velocity	28973	14785 (51)	51 [42.3,60.7]	48016	24508 (51)	50.7 [41.9,60]
Any antenatal Steroids	134546	115223 (85.6)	86.1 [79.7,90]	57337	50047 (87.3)	86.7 [79.2,91.5]
Timely eye examination	18897	14648 (77.5)	77.4 [63.3,90.4]	53803	50472 (93.8)	95 [88.6,97.8]
New MLP-QM measures						
Extreme length of stay	373022	17438 (4.7)	3.7 [2.1,5.5]	53551	3196 (6)	4.7 [1.9,7.7]
Oxygen on day 28 or earlier discharge	359339	9538 (2.7)	1.5 [0.7,2.7]	51882	28266 (54.5)	53.8 [39.3,64.2]
Greater than median weight z-score change	371074	185349 (49.9)	49.9 [43.5,58.2]	53431	26714 (50)	50 [38.5,59.5]

Infants that were greater than 30 weeks gestational age but less than 1500g were classified according to their gestational age. Please see the methods for additional details.