ORIGINAL RESEARCH

Using Weight Z-score Differences between Birth and Discharge to Compare and Monitor Nutritional Outcomes in Neonatal Units: Variables Associated with Poor Growth

Angela B Hoyos[1], Ariel Salas[2], Horacio Osiovich[3], Carlos A Fajardo[4], Martha Baez[5], Luis Monterrosa[6], Carolina Villegas-Alvarez[7], Fernando Aguinaga[8], Maria I Martinini[9]

Received on: 28 October 2024; *Accepted on*: 21 January 2025; *Published on*: 25 March 2025

Abstract

Introduction: There is a need for clear guidelines to support adequate nutrition and growth for premature neonates. Unfortunately, we do not have a consensus on the ideal parameters and timing for assessment of growth in these infants. Even though optimal postnatal growth should ideally replicate intrauterine rates, after the initial physiological normal drop, many premature infants follow gains below intrauterine rates. This extrauterine growth restriction (EUGR) can be quantified as lower weight Z-score medians at discharge than those at birth, indicated by a negative difference between birth and discharge (Δ Z-score) below 1 SD. We hypothesized that improved nutrition could reduce the incidence of EUGR in convalescing premature infants.

Materials and methods: We reviewed the clinical information from all EpicLatino units in the past 8 years (2015–2022); all infants who were born at ≤32 weeks' gestational age (GA) and discharged home at ≥34 weeks' corrected age were included. Statistical comparisons were performed to analyze growth parameters and potential causes of poor nutrition. The weight Δ Z-score from birth to discharge was used as a surrogate for adequacy of nutrition. Birth weight medians and interquartile ranges were correlated with weight Δ Z-score, GA, and head circumference (HC) at discharge.

Results: We reviewed 480 cases that met the established criteria. Gestational age at birth, necrotizing enterocolitis, unit of origin, rupture of membranes >24 hours, temperature at admission, and intraventricular hemorrhage were significantly different. There was a negative correlation between the Δ Z-score and corrected GA at discharge. Head circumference at discharge also correlated with weight Δ Z-score.

Conclusion: The frequency of EUGR varied between units. There were some clinical associations, but our sample size was not large enough to establish causality. The risk of EUGR may increase with severity of illness or could be higher in some specific populations. Quality improvement programs to optimize nutrition policies and practices may help.

Keywords: Difference between birth and discharge (Δ Z-score), EpicLatino neonatal database, Extrauterine growth restriction, Head circumference at discharge, Latin America, Newborns, Risk factors for poor growth.

Newborn (2025): 10.5005/jp-journals-11002-0117

Key Points

- Some premature infants, after the initial drop in weight after birth considered physiological, may follow a resumption at levels below those seen *in utero*. The drop in weight Z-score medians from birth to discharge (computed as negative Δ Z-scores) if it drops below 1 SD is sometime called extrauterine growth restriction (EUGR).
- We noted that the incidence of EUGR at discharge differed between different units of origin and correlated with various other clinical variables.
- A review of nutrition policies and practices suggests that focused quality improvement programs could possibly reduce EUGR in our organization.
- Discussions with colleagues all over the world suggest that this is a global issue, and there is a need for larger, well-designed randomized studies to clarify this problem.

Introduction

There is a need for clear guidelines to support adequate nutrition and growth for premature neonates. Even though optimal postnatal

[1]Department of Pediatrics, Universidad El Bosque, Bogota, Distrito Capital, Colombia

[2]Department of Pediatrics, University of Alabama at Birmingham, Birmingham, Alabama, United States

[3]Department of Pediatrics and Neonatology, University of British Columbia, Vancouver, British Columbia, Canada

[4]Department of Pediatrics and Neonatology, University of Calgary, Calgary, Alberta, Canada

[5]Department of Pediatrics and Neonatology, Clínica del Country, Bogota, Distrito Capital, Colombia

[6]Department of Pediatrics and Neonatology, Dalhousie University, Helifax, Nova Scotia, Canada

[7]Department of Pediatrics and Neonatology, Central Hospital Dr. Ignacio Morones Prieto, SLP, San luis Potosi, Mexico

[8]Department of Pediatrics and Neonatology, Hospital Metropolitano, Quito, Ecuador

[9]Department of Pediatrics and Neonatology, Nuestra Sra. de las Mercedes Maternity, Tucuman, San Miguel de Tucuman, Argentina

Corresponding Author: Angela B Hoyos, Department of Pediatrics, Universidad El Bosque, Bogota, Distrito Capital, Colombia, Phone: +57 3157926533, e-mail: angelahoyos@hotmail.com

Table 1: Units belonging to the EpicLatino network

Units	*City/Country*
Centenario H. de Esp. Miguel Hidalgo	Aguascalientes, Mexico
Clínica Dávila	Santiago, Chile
Clínica de Santa María de Santiago	Santiago, Chile
Clínica del Country	Bogotá, Colombia
Clínica la Colina	Bogotá, Colombia
Clínica Materno Infantil San Luis	Bucaramanga, Colombia
Clínica San Felipe	Lima, Perú
Clínica Santa Bárbara	Quito, Ecuador
Clínica Somer	Rio Negro, Colombia
Clínica Universitaria Colombia	Bogotá, Colombia
Clínica Vespucio	Santiago, Chile
Colsanitas – Clínica Pediátrica UCI Neonatal	Bogotá, Colombia
Curaçao Medical Center	Willemstad, Curaçao
H Regional DR Rafael Pascacio Gamboa	Tuxtla Gutiérrez, México
Hospital Central Dr. Ignacio Morones Prieto	San Luis Potosí, México
Hospital Civil de Ipiales E.S.E	Ipiales, Colombia
Hospital de los Valles	Quito, Ecuador
Hospital Departamental San Vicente de Paul	Garzón, Huila, Colombia
Hospital Dr. Florencio Escardó	Tigre, Argentina
Hospital Español de Mendoza	Mendoza, Argentina
Hospital General EISS de Manta	Manta, Ecuador
Hospital Italiano de La Plata	La Plata, Argentina
Hospital Luis Lagomaggiore	Mendoza, Argentina
Hospital Metropolitano	Quito, Ecuador
Hospital Militar Central	Bogotá, Colombia
Hospital Regional Universitario de Colima	Colima, México
Hospital San Francisco de Quito	Quito, Ecuador
Hospital San José	Bogotá, Colombia
Hospital Santísima Trinidad	Asunción, Paraguay
Los Cobos Medical Center	Bogotá, Colombia
Maternidad Nuestra Sra. de las Mercedes	Tucumán, Argentina
S.E.S. Hospital de Caldas	Manizales, Colombia

growth should ideally replicate intrauterine rates, many premature infants show an initial drop in weight after birth (physiological) followed by gains below intrauterine rates.[1] In this article, we share our experience in EpicLatino, a network of 32 Neonatal Intensive Care Units (NICUs) in Latin America and the Caribbean islands (Table 1).[2] This EUGR can be quantified as lower weight Z-score medians at discharge than those at birth, indicated by a negative difference between birth and discharge (Δ Z-score) below 1 SD. For the past 9 years, we have been using the difference in weight Δ Z-score medians between birth and discharge to assess the nutritional outcomes.[1] With the normal postnatal contraction of the extracellular fluid compartment in the body, the difference between birth and discharge weights is often negative.[3–5]

After birth, preterm infants show a more pronounced initial drop in weight than their term counterparts; their weights can decrease by a 0.5–1 weight Z-score point on postnatal curves. Many clinicians have begun to accept growth patterns with a progressive gain in anthropometric parameters that are below intrauterine rates but are measurable, and the infant remains healthy and safe. Many recent studies have recognized this EUGR in preterm infants and have discussed possible steps to curtail these changes.[6] There is still no consensus about the best timing for assessment, the ideal growth monitoring tool(s), and therapeutic interventions. An ongoing debate persists even for the appropriate terminology to equate intrauterine and postnatal growth patterns. Consequently, we have not been able to accept uniform nutritional interventions. Early fortification of human milk soon after birth may promote gain in length but does not seem to increase fat-free mass accretion at 36 weeks' post-menstrual age; the head circumference (HC) may still show attrition.[7]

Extrauterine growth restriction can be defined in cross-sectional and longitudinal perspectives. Additionally, several growth charts are available to track postnatal growth, each yielding varying outcomes. According to a reviewed study, the prevalence of EUGR differs across growth charts.[8] The Italian neonatal study (INeS) reports 40.9%, Intergrowth-21 23.8%, and the Fenton shows 33.5%. When assessed longitudinally (defined as a loss of 1 SD), the rates were 20.4% for INeS, 4% for Intergrowth-21, and 15% for Fenton ($p < 0.001$). Cross-sectional EUGR, based on a discharge weight below the 10th percentile, showed similar variability: 22.8%, 28.2%, and 22.4%, respectively ($p = 0.27$).

Materials and Methods

We analyzed data from the past 8 years (2015–2022) in surviving homes to at least 34 weeks corrected age infants with ≤32 weeks gestational age (GA) at birth. To identify the variables that need to be controlled to measure the risk of poor nutrition unrelated to outdated or unvalidated unit policies, we conducted a series of statistical comparisons with variables that have been mentioned as potential causes of poor nutrition in the literature, if available in our database.[9,10] We used the weight Δ Z-score from birth to discharge as a surrogate for nutrition. The first risk variable is GA. We also included necrotizing enterocolitis (NEC), intraventricular hemorrhage (IVH), and the time (before/during-after 2020, pandemic). We added small for gestational age (SGA), temperature at admission, sex, presentation, inborn/outborn, oxygen at 36 weeks post-menstrual age, delivery type, antenatal corticosteroids, premature rupture of membranes (PROM) more than 24 hours, suspected chorioamnionitis, and the unit of origin. Only inborn surviving patients who were discharged home beyond 34 weeks corrected GA were included. We also obtained the weight Δ Z-score median and interquartile range (IQR) from all the EpicLatino units. We performed a nonparametric median logistic regression adjusted for the mentioned variables and included the different units of origin as well. We also calculated the correlation between weight Δ Z-score and GA and HC at discharge to see if change in weight z-score affects the GA at discharge or the HC also at discharge and calculated a regression analysis corrected by GA, unit of origin, and SGA. We used Stata 18, StataCorp LLC, Texas, USA.

How to cite this article: Hoyos AB, Salas A, Osiovich H, *et al*. Using Weight Z-score Differences between Birth and Discharge to Compare and Monitor Nutritional Outcomes in Neonatal Units: Variables Associated with Poor Growth. Newborn 2025;4(1):1–5.

Source of support: Nil

Conflict of interest: None

Results

There were 480 cases that met the established criteria. The statistical significance of the different variables used in the nonparametric median regression model is shown in Table 2. Gestational age at birth, NEC, unit of origin, PROM >24 hours, temperature at admission, and IVH were significant.

The box plot results from the different units of origin (median and IQR) are presented in Figure 1. There was a negative correlation between weight Δ Z-score and corrected GA at discharge of −0.38, $p < 0.0001$ (Fig. 2). The regression analysis of weight Δ Z-score versus GA at discharge was significant when adjusted by GA and unit of origin but not with SGA. Head circumference at discharge also correlated with weight Δ Z-score; Spearman's rho = −0.2657, $p < 0.001$ also adjusted by the same variables (Fig. 3).

Discussion

There was considerable variability in the different units of origin. Regarding risk factors, as shown in Table 2, GA, NEC, unit of origin, PROM, temperature at admission, and IVH were significant. When looking for risk factors, we confirmed that the characteristics of the study population are determinant to EUGR at discharge. The degree of longitudinal EUGR is influenced by the birth weight Z-score: the lower the birth weight centile, the lower the

Table 2: Variables, their impact (percent of normal), and the results of the nonparametric median logistic regression results

Variable	*% Normal or mean*	*p*
GA	29.6 ± 2.3 weeks	**<0.0000**
No NEC	93%	**<0.0000**
Unit of origin	32 units	**<0.0000**
No ROM >24 hours	87%	**0.0190**
Temperature at admission	36.0°C ± 1	**0.0350**
No IVH pathology	71%	**0.0350**
Sex M	55%	0.056
Presentation (cephalic)	71%	0.072
Inborn	89%	0.091
No oxygen at 36 weeks	79%	0.095
Vaginal delivery	22%	0.146
Receive antenatal corticosteroids	72%	0.218
AGA	89%	0.234
No suspected chorioamnionitis	91%	0.346
Period (before/after 2020)	45%	0.636

AGA, appropriate for gestational age; IVH, intraventricular hemorrhage; M, masculine; NEC, necrotizing enterocolitis; ROM, premature rupture of membranes. Statistically significant in bold

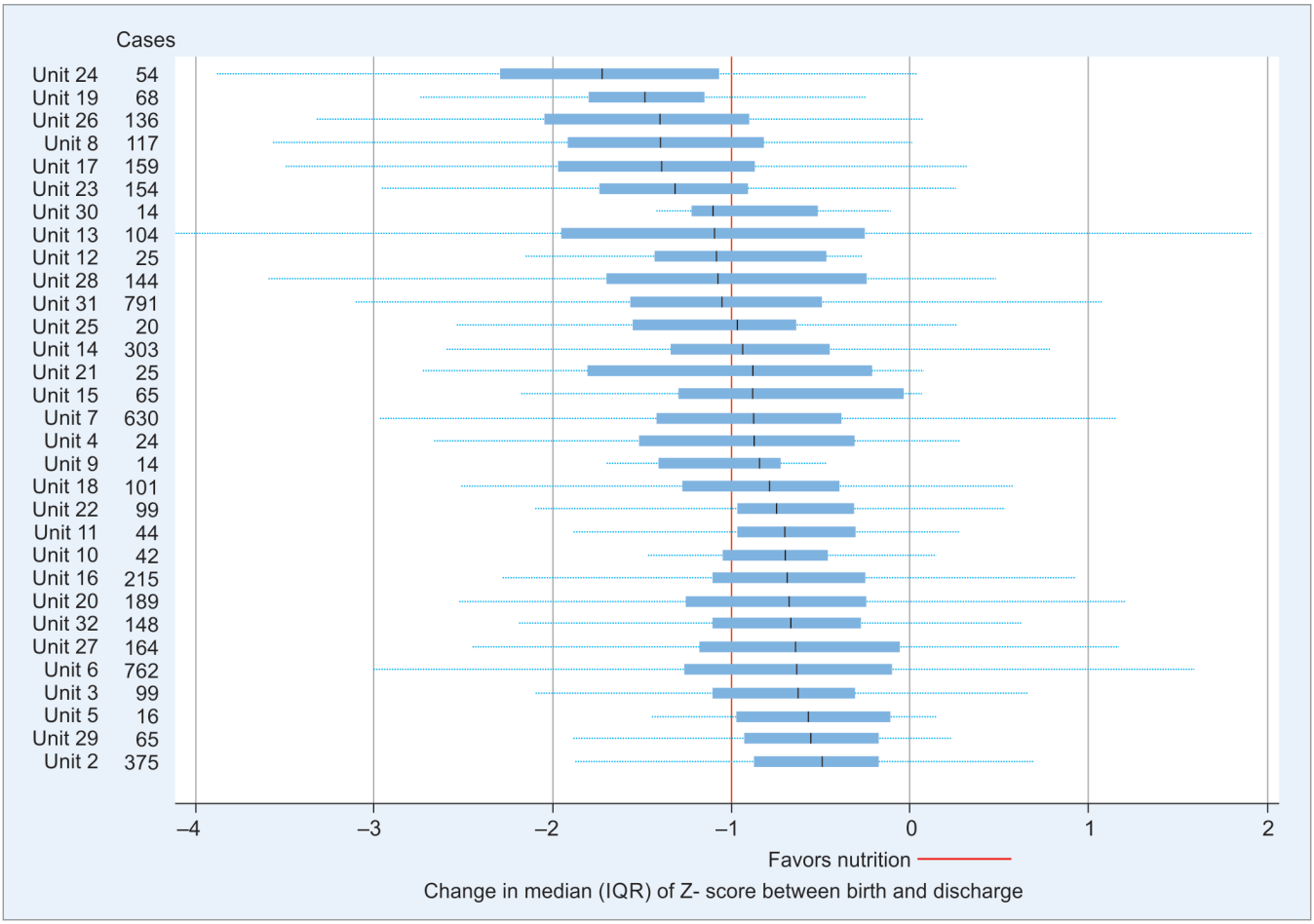

Fig. 1: Changes of median and interquartile range (IQR) of Z-score change between birth and discharge of the units in EpicLatino network arranged in ascending order. Unit 1 excluded for only one case. In second column number of cases in each unit

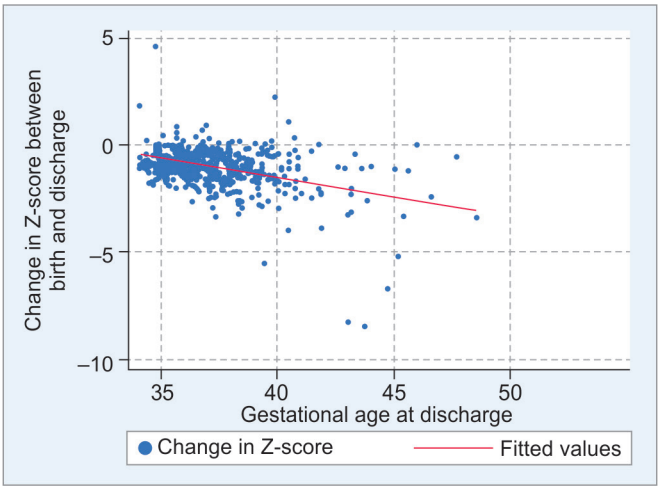

Fig. 2: Changes of median Δ Z-score between birth and discharge (*y-axis*) in cases discharged home at ≥34 weeks corrected GA in babies born at ≤32 weeks, correlation with corrected GA at discharge. 8 years (2015–2022)

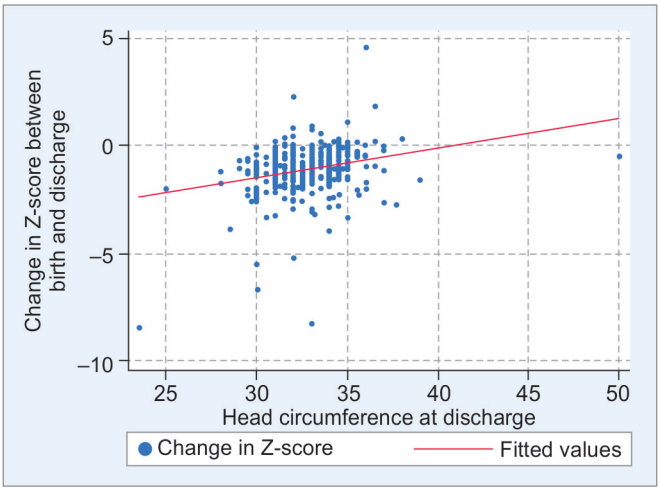

Fig. 3: Changes of median Δ Z-score between birth and discharge (*y-axis*) in cases discharged home at ≥34 weeks corrected GA in babies born at ≤32 weeks, correlation with HC at discharge. 8 years (2015–2022)

probability of losing 1 or 2 SDs.[11] As known, these associations do not establish causality. Some of these variables may identify the challenge of nourishing a sick or very small preterm infant, but the unit of origin variability identifies nutrition policies and practices that can be modified through a quality improvement program; the wide variability of results in Figure 1 confirms these observations.

The correlation between changes in weight Z-score and corrected age at discharge suggested that babies with less drop in weight Z-score were able to go home with lower GA; the length of hospital stay was also shorter at various GAs. The correlation of less drop in weight Z-score with HC size in Figure 3 confirmed that better growth with a larger overall size of the infant was likely better for earlier discharge.[12,13] Previous studies have shown that larger HC at discharge has been associated with better neurodevelopment, especially in preterm infants.[12,14–17]

Limitations of our study are inherent to the retrospective observational nature of the study and the use of database cases. Another limitation may lie in the choice of discharge as a time point for assessing EUGR, as there is a wide range of time of evaluation, and a long time passes between birth and discharge.

Our study was done because knowing and monitoring the prevalence of EUGR in our units, is considered to be a quality measure of care for preterm infants.[11] There are no management guidelines that can precisely determine which parameters should be maintained in the units, but aiming to prevent a weight Δ Z-score drop beyond -1 could be a reasonable goal.

Orcid

Angela B Hoyos https://orcid.org/0000-0002-5403-3268
Ariel Salas https://orcid.org/0000-0002-4676-7747
Horacio Osiovich https://orcid.org/0000-0001-5290-2565
Carlos A Fajardo https://orcid.org/0000-0001-7353-0385
Martha Baez https://orcid.org/0009-0002-7530-0713
Luis Monterrosa https://orcid.org/0000-0001-7576-7036
Carolina Villegas-Alvarez https://orcid.org/0000-0002-3930-8745
Fernando Aguinaga https://orcid.org/0000-0001-7685-7279
Maria I Martinini https://orcid.org/0000-0001-6905-1955

References

1. Fenton T. Z Score calculation using 2013 growth chart. Available from: https://www.ucalgary.ca/fenton/2013chart. Calgary, Canada: Calgary University; 2013.
2. EpicLatino. EpicLatino Network Database. 2024. Available from: https://epiclatino.co/reportes/.
3. Rutledge A, Murphy HJ, Harer MW, et al. Fluid balance in the critically ill child section: "How bad is fluid in neonates?". Front Pediatr 2021;9:651458. DOI: 10.3389/fped.2021.651458.
4. Segar JL. A physiological approach to fluid and electrolyte management of the preterm infant: Review. J Neonatal Perinatal Med 2020;13(1):11–19. DOI: 10.3233/NPM-190309.
5. Selewski DT, Gist KM, Nathan AT, et al. The impact of fluid balance on outcomes in premature neonates: A report from the AWAKEN study group. Pediatr Res 2020;87(3):550–557. DOI: 10.1038/s41390-019-0579-1.
6. González-López C, Solís-Sánchez G, Lareu-Vidal S, et al. Variability in definitions and criteria of extrauterine growth restriction and its association with neurodevelopmental outcomes in preterm infants: A narrative review. Nutrients 2024;16(7):968. DOI: 10.3390/nu16070968.
7. Salas AA, Gunawan E, Nguyen K, et al. Early human milk fortification in infants born extremely preterm: A randomized trial. Pediatrics 2023;152(3):e2023061603. DOI: 10.1542/peds.2023-061603.
8. Starc M, Giangreco M, Centomo G, et al. Extrauterine growth restriction in very low birth weight infants according to different growth charts: A retrospective 10 years observational study. PLoS One 2023;18(4):e0283367. DOI: 10.1371/journal.pone.0283367.
9. Bracken JM, Pappas L, Wilkins J, et al. Measuring growth in critically ill neonates and children. Nutr Clin Pract. Oct 2023;38 Suppl 2:S28–S38. DOI: 10.1002/ncp.11057.
10. Goldberg DL, Becker PJ, Brigham K, et al. Identifying malnutrition in preterm and neonatal populations: Recommended indicators. J Acad Nutr Diet 2018;118(9):1571–1582. DOI: 10.1016/j.jand.2017.10.006.
11. Lin Z, Green RS, Chen S, et al. Quantification of EUGR as a measure of the quality of nutritional care of premature infants. PLoS One 2015;10(7):e0132584. DOI: 10.1371/journal.pone.0132584.
12. Selvanathan T, Guo T, Kwan E, et al. Head circumference, total cerebral volume and neurodevelopment in preterm neonates. Arch Dis Child Fetal Neonatal Ed 2022;107(2):181–187. DOI: 10.1136/archdischild-2020-321397.

13. Tan MJ, Cooke RW. Improving head growth in very preterm infants–A randomised controlled trial I: Neonatal outcomes. Arch Dis Child Fetal Neonatal Ed 2008;93(5):F337–F341. DOI: 10.1136/adc.2007.124230.
14. Belfort MB, Rifas-Shiman SL, Sullivan T, et al. Infant growth before and after term: Effects on neurodevelopment in preterm infants. Pediatrics 2011;128(4):e899–e906. DOI: 10.1542/peds.2011-0282.
15. Ehrenkranz RA, Dusick AM, Vohr BR, et al. Growth in the neonatal intensive care unit influences neurodevelopmental and growth outcomes of extremely low birth weight infants. Pediatrics 2006;117(4):1253–1261. DOI: 10.1542/peds.2005-1368.
16. Neubauer V, Griesmaier E, Pehböck-Walser N, et al. Poor postnatal head growth in very preterm infants is associated with impaired neurodevelopment outcome. Acta Paediatr 2013;102(9):883–888. DOI: 10.1111/apa.12319.
17. Power VA, Spittle AJ, Lee KJ, et al. Nutrition, growth, brain volume, and neurodevelopment in very preterm children. J Pediatr 2019;215:50–55.e3. DOI: 10.1016/j.jpeds.2019.08.031.