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Growth During Infancy After Extremely Preterm Birth: Associations with Later Neurodevelopmental and Health Outcomes

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Abstract

Objective—To evaluate associations between changes in weight, length, and weight/length ratio during infancy and outcomes later in life among individuals born extremely preterm.

Study design—Among participants in the Extremely Low Gestational Age Newborn (ELGAN) study, we measured weight and length at discharge from the neonatal intensive care unit (NICU) and at age 2 years and evaluated neurocognitive, psychiatric, and health outcomes at age 10 years and 15 years. Using multivariable logistic regression, we estimated associations between gains in weight, length, and weight/length ratio *z*-scores between discharge and 2 years and outcomes at 10 and 15 years. High gain was defined as the top quintile of change; low gain, as the bottom quintile of change.

Results—High gains in weight and weight/length were associated with greater odds of obesity at 10 years, but not at 15 years. These associations were found only for females. High gain in length *z*-score was associated with lower odds of obesity at 15 years. The only association found between high gains in growth measures and more favorable neurocognitive or psychiatric outcomes was between high gain in weight/length and lower odds of cognitive impairment at age 10 years.

Conclusions—During the 2 years after NICU discharge, females born extremely preterm with high gains in weight/length or weight have greater odds of obesity at 10 years, but not at 15 years. Infants with high growth gains in the 2 years after NICU discharge have neurocognitive and psychiatric outcomes in middle childhood and adolescence similar to those of infants with lower gains in weight and weight/length.

Monitoring growth is a central aspect of health care for infants born extremely preterm during and after their discharge from the neonatal intensive care unit (NICU).[1,2] Whereas a majority of extremely preterm infants experience a decrease in weight *z*-score during their neonatal hospitalization,[3,4] following discharge from the NICU, their weight *z*-scores typically increase,[5–8] a change referred to as "catch-up" growth.[9,10] By middle childhood, body mass index (BMI) *z*-scores of extremely preterm children are similar to those born at term,[11] and about one-quarter of children born extremely preterm are overweight or obese at school age.[12,13] Failure to exhibit catch-up growth in early childhood has been associated with worse neurodevelopmental outcome,[14] suggesting that trade-offs might exist between beneficial effects of improved nutrition on brain growth and adverse effects on BMI.[15] Clarifying these trade-offs is critical to informing diet-based and other interventions to promote optimal weight gain in extremely preterm infants after discharge from the NICU.

We used data from the Extremely Low Gestational Age Newborn (ELGAN) study to analyze associations of changes in weight, length, and weight-for-length *z*-score in the first 2 postnatal years after discharge from the NICU with neurocognitive, psychiatric, and health outcomes of extremely preterm children at age 10 years and 15 years.

Methods

All procedures for this study were approved by the Institutional Review Board of each of the 12 participating study sites.

Data were acquired from the ELGAN study, a prospective observational study of children born extremely preterm[16] in which 1249 women and their 1506 newborns delivered before

28 weeks of gestational age were enrolled in 14 hospitals across 5 US states from 2002 to 2004. The Figure (available at www.jpeds.com) presents a flow diagram describing the derivation of the study sample.

Prenatal and Postnatal Data

Within a few days of delivery, a trained research coordinator interviewed the mother about demographic and prenatal factors and reviewed medical records to collect data on perinatal and neonatal factors.[16] Birth weight *z*-scores were derived from reference data reported by Fenton et al.[17] In prior publications, we presented definitions used in the ELGAN study for neonatal chronic lung disease,[18] ultrasound-diagnosed cerebral white matter injury,[19,20] neonatal bacteremia,[21] spontaneous intestinal perforation and necrotizing enterocolitis,[22,23] and severe retinopathy.[24]

Change in Weight and Length *Z*-Scores From NICU Discharge to Age 2 Years

Prior to discharge from the NICU, weight and length were measured by NICU staff following local practices. Follow-up visits occurred at around 2 years corrected age, calculated as actual age minus (40 - gestational age). At these visits, weight and length were measured by research coordinators, clinic nurses, or follow-up examiners. Weight and length *z*-scores for postmenstrual age at discharge were derived from reference data reported by Fenton et al[17]; weight and length *z*-scores at approximately 2 years corrected age were derived from World Health Organization reference data[25] using macros published by the SAS Institute: https://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas-who.htm for infants aged ≤731 days; https://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm for infants aged >731 days. Weight/length ratio *z*-scores were derived from the study sample.

Outcomes at Age 10 Years

Weight and height were measured by research coordinators using standardized procedures, which included having the participants remove shoes and over garments, at age 10 years, and BMI percentiles were calculated based on measured weight and height and age- and sex-specific US growth standards.[25] Obesity was defined as a BMI ≥95th percentile.[13] The diagnosis of asthma was based on parent or guardian report of a health care provider's diagnosis of asthma.[26] General health was assessed with the following question, with the parent or guardian as respondent: "How would you describe your child's health in general?" (excellent/very good/good/fair/poor).

As described in detail elsewhere, latent profile analysis was used to classify study participants' level of cognitive function (normal, low-normal, moderate impairment, severe impairment) based on verbal and nonverbal IQ and 5 executive function measures from the Differential Ability Scales-II and a Developmental NEuroPSYchological Assessment.[27] In this study, the outcome of cognitive impairment at age 10 years included individuals with either moderate or severe impairment of cognitive function, based on the aforementioned latent profile analysis. Psychiatric disorders were identified at age 10 years using the Child Symptom Inventory, Fourth Edition (CSI-4), a 97-item screening tool for emotional and behavioral disorders.[28–30] For assessment of attention deficit hyperactivity disorder

(ADHD), 3 contexts were considered: (1) the parent or caregiver completed the CSI-4, (2) the child's current teacher completed the CSI-4 Teacher Checklist, and (3) information based on the parent's indication of the child having been diagnosed previously by a clinician to have ADHD. Participants who met criteria in any 2 of these 3 contexts were classified with ADHD.[31] Anxiety and depression also were identified with the CSI-4. Children were classified as having an anxiety disorder if they screened positive for social phobia, separation anxiety, or generalized anxiety disorder and were classified as having depression if they screened positive for either major depressive disorder or dysthymic disorder.[30]

Outcomes at Age 15 Years

Data on asthma, anthropometric measurements, and general health were collected at age 15 years using methods similar to those described above for data collection at 10 years, except that 3 measurements were obtained for weight and height, from which the mean was calculated.

Cognitive abilities were assessed at age 15 years with the Wechsler Abbreviated Scale of Intelligence Second Edition (WASI-II)[32] and the National Institutes of Health Toolbox Cognition Battery (NTCB).[33,34] Latent profile analysis was used to classify study participants' level of cognitive functioning (normal, low-normal, impaired) based on WASI-II verbal IQ and nonverbal IQ and the 7 NTCB subtests. In this study, the outcome of cognitive impairment at age 15 years included individuals with impaired cognitive function, based on the latent profile analysis of WASI-II and NTCB scores just described. Across the 9 assessments used to characterize cognitive function, the mean *z*-scores for the group with impaired cognitive function ranged from −1 to −2.

Mental health outcomes at age 15 years were identified using the Mini International Neuropsychiatric Interview–Kid edition 7.0.2 (MINI-KID),[35] a structured clinical diagnostic interview to identify current *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*, in children aged 6–17 years.[35] Participants with a full-scale IQ <50 or a verbal IQ <50 were evaluated with the parent version of the MINI-KID, and those with a verbal IQ of 50-<70 and/or full-scale IQ of 50-<70 were evaluated by interviewing the adolescent alongside their parent or guardian using the adolescent version of the interview. For the current study, we defined an anxiety disorder as including generalized anxiety disorder, panic disorder, agoraphobia, separation anxiety disorder, social anxiety disorder, and specific phobia and defined depression as a diagnosis of major depressive disorder. We considered only current diagnoses identified by the MINI-KID.

Statistical Analyses

For primary analyses of relationships between change in weight, length, or weight/length ratio *z*-scores between NICU discharge and 2 years corrected age, we classified *z*-score changes into quintiles. To analyze associations between changes in *z*-scores in the interval between NICU discharge and age 2 years and the 10-year and 15-year outcomes, we estimated unadjusted ORs and aORs and 95% CIs for 2 types of exposures: top quintile change in weight, length, or weight/length ratio *z*-scores and bottom quintile change in *z*-scores. Individuals with a *z*-score change in quintiles 2–4 served as the referent groups.

We created causal models (ie, directed acyclic graphs) to inform our analytic plan[36,37] by identifying the minimally sufficient adjustment sets of variables to include in our multivariable regression models. All adjustment sets included gestational age, chronic lung disease, neonatal cerebral white matter abnormality, and an indicator of maternal socioeconomic status. Statistical significance was defined as a 2-sided *P* value <.05.

Results

Compared with all 1222 study participants who were discharged alive from the NICU, the subset of participants seen at the 10- and 15-year follow-up visits were less likely to have mothers who were unmarried or had no formal education beyond high school or were covered by Medicaid or a state-supported medical insurance program (Table I; available at www.jpeds.com).

Of study participants who contributed data to this analysis, 49% were female, and 21% were born at 23–24 weeks of gestation, 45% at 25–26 weeks, and 34% at 27 weeks. Fifty-one percent had neonatal chronic lung disease, 21% had ultrasound-identified cerebral white matter injury, and 3.3% had necrotizing enterocolitis necessitating surgery.

Correlates of Weight *Z*-Score and Length *Z*-Score Change Between NICU Discharge and Approximately 2 Years of Age

Quintiles for change in weight *z*-score between NICU discharge and approximately 2 years corrected age were derived as <−0.28, ≥−0.28 and <0.60, ≥0.60 and <1.29, ≥1.29 and <2.02, and ≥2.02 (Table II; available at www.jpeds.com). Quintiles for change in length *z*-score from NICU discharge until 2 years corrected age were <0.48, ≥0.48 and <1.28, ≥1.28 and <2.08, ≥2.08 and <2.98, and ≥2.98. Compared with infants in the highest quartile for weight gain during the NICU hospitalization, infants in the lowest quartile were more likely to be in the highest quintile for change in weight *z*-score or change in length *z*-score between NICU discharge and age 2 years.

Associations Between Weight *Z*-Score Change Between NICU Discharge and Age 2 Years and Outcomes at 10 and 15 Years

No associations were found between either top or bottom quintile change in weight *z*-score between NICU discharge and approximately age 2 years and outcomes at age 10 or 15 years (Table III). In sex-stratified analyses, the aOR for the association between top quintile change in weight *z*-score and obesity at 10 years was 2.8 (95% CI, 1.3–5.9) in females and 1.0 (95% CI, 0.4–2.3) in males (Table IV). The aORs for the association between top quintile change in weight *z*-score and asthma at 10 years were 2.1 (95% CI, 1.2–3.7) in females and 0.8 (95% CI, 0.4–1.3) in males. aORs for the association between top quintile change in weight *z*-score and asthma at age 15 years were 2.3 (95% CI, 1.1–4.7) for females and 0.6 (95% CI, 0.3–1.3) for males.

Associations Between Length *Z*-Score Change Between NICU Discharge and Approximately 2 Years of Age and Outcomes at 10 and 15 Years

Study participants in the top quintile for change in length *z*-score from NICU discharge to age 2 years had higher odds of cognitive impairment at 10 years of age (aOR, 1.9; 95% CI, 1.1–3.1) and lower odds of obesity at 15 years (Table V; available at www.jpeds.com). Among males, low gain in length *z*-score was associated with parent report of fair or poor health at 15 years (Table VI; available at www.jpeds.com).

Associations Between Weight/Length Ratio *Z*-Score Change Between NICU Discharge and Age 2 Years and Outcomes at 10 and 15 Years

Top quintile of change in weight/length ratio *z*-score was associated with higher odds of obesity at 10 years of age (aOR, 2.1; 95% CI, 1.2–3.6) (Table VII) but not at age 15 years. Sex-stratified analyses identified this association only in females (Table VIII). The top quintile of change in weight/length ratio *z*-score was associated with lower odds of cognitive impairment among males at age 10 years (aOR, 0.4; 95% CI, 0.2–0.9) and ADHD (aOR, 0.4; 95% CI, 0.2–0.9). The lowest quintile of change in weight/length ratio *z*-score was associated with higher odds of parent-reported fair or poor health among males at age 15 years (aOR, 2.6; 95% CI, 1.2–5.9) and with higher odds of anxiety among females at age 15 years (aOR, 3.7; 95% CI, 1.1–12.1).

Discussion

In a multicenter cohort of individuals born extremely preterm, we evaluated associations between gains in weight, length, and weight/length ratio during the first 2 years after discharge from the NICU and developmental and health outcomes at age 10 and 15 years. Of the outcomes analyzed, only obesity was less prevalent among children born preterm compared with children born at term.[26,30,38–43] We identified associations between a top quintile gain in weight *z*-score and weight/length ratio *z*-score and obesity at age 10 years, but these associations were found only in females and were not found at age 15 years. Also associated with top quintile weight gain in females, but not in males, was a higher odds of asthma, which is more prevalent among children with obesity. These results suggest that among females born extremely preterm, high gains in weight/length ratio and weight might increase the likelihood of obesity and asthma, at least in middle childhood. A lower odds of obesity at age 15 years was associated with high gains in length during the first 2 years after discharge from the NICU. Because we evaluated a large number of associations, it is likely that some of the statistically significant associations are attributable to chance; however, associations between gains in weight, length, and weight/length ratio early in life and subsequent BMI are biologically plausible and are consistent with findings from a recent systematic review.[44]

In our analyses, the only finding consistent with the possibility that extremely preterm infants who exhibit top quintile growth gains during infancy might have better neurodevelopmental outcomes was the association between high gain in weight/length ratio and lower odds of cognitive impairment and ADHD, but this was found only in males and only at age 10 years. Overall, our findings suggest that within the range of weight, length,

and weight/length gains experienced by the ELGAN cohort, greater gains in weight and weight/length ratio are not associated with more favorable neurodevelopmental outcomes but might contribute, in females only, to obesity in middle childhood but not to obesity in adolescence.

After NICU discharge, nutritional modifications for extremely preterm infants can increase the rate of weight and length gain[45,46] but are of uncertain benefit for neurodevelopment.[14,47] Our finding that greater gains in weight and length were not associated with improved neurocognitive or psychiatric outcomes are in contrast to those from the Infant Health and Development Program (IHDP) cohort of children born preterm with low birth weight, in whom a 1-unit increase in weight *z*-score gain from term to 12 months was associated with an 1.9-point increase in IQ,[48] and more rapid linear growth from term to 4 months and more rapid BMI gain from 4 to 12 months were associated with a lower odds of IQ <85.[15] Comparing IHDP and ELGAN cohorts, the years of birth differed by 17–18 years (1985–1986 for IHDP versus 2002–2004 for ELGAN), an interval during which numerous nutritional practices for preterm infants changed, including fortification of human milk,[49] micronutrient supplementation,[50] protein and energy intake,[51] and nutrient-enriched formula for preterm infants after NICU discharge.[47] Changes also occurred in rates of obesity and cultural norms around food.[52]

Consistent with prior studies of growth after preterm birth,[12–14,53] obesity was found more frequently among females in the top quintile of change in weight and weight/length ratio *z*-scores. In the ELGAN cohort[54] and studies of children not selected on gestational age,[55–59] obesity has been associated with asthma. In the IHDP cohort, more rapid BMI gain in the first year of life was associated with asthma at age 8 years.[60] These associations between greater weight gain and obesity warrant further study, and it is possible that limiting "catch-up" growth might confer health benefits to subgroups of individuals born extremely preterm. The potential importance of timing of high weight gain is suggested by one study that found no association between weight gain in the first 12 weeks after NICU discharge and obesity,[61] in contrast to another study that found an association between weight gain at 2.5–6 years and higher BMI.[62]

Limitations of our study that could introduce bias include sample attrition, which was approximately 50% greater in children whose mothers were Medicaid-eligible at the time of delivery. In addition, we lacked data on specific aspects of study participants' nutrition, such as the relative proportions of human milk and formula, which could affect weight gain,[63] and on genetic and environment factors associated with both postdischarge weight gain and the risk of adverse outcomes. Also, fat-free mass might be a more informative indicator of nutrient accretion than weight, length, or weight/length ratio.[64] Furthermore, standardized procedures were not used for measurement of weight and length at the time of NICU discharge and at age 2 years. Related to the outcomes that we studied, BMI is an imperfect measure of adiposity, and parental report of physician-diagnosed asthma is less valid than objective assessment of lung function.[65]

Regarding the generalizability of our findings, we focused on gains in weight, length, and weight/length in the first 2 years after discharge from the NICU, so our conclusions about

the relationship of infant growth to later outcomes might not apply to growth between birth and NICU discharge, an interval during which nutritional fortification[66] and greater growth velocity in infants born very preterm or with extremely low birth weight[67,68] has been associated with better neurodevelopmental outcomes at age 18–22 months. In addition, we focused on individuals born extremely preterm whose caregivers, owing to differing perceptions of weight and health, might feed their children differently from children born at term.[69] Importantly, the distributions of gains in weight, length, and weight/length found in the ELGAN cohort might differ considerably from those of other samples of individuals born extremely preterm.

Strengths of the study include the relatively large sample size, the use of gestational age rather than birthweight to select the study sample,[70] and outcome assessments by examiners who were unaware of participants' growth data.

During the 2 years after NICU discharge, extremely preterm female infants with high gains in weight/length or weight had higher odds of obesity at 10 years, but not at 15 years. Infants with high growth gains in the 2 years after NICU discharge had neurocognitive and psychiatric outcomes similar to those of infants with lower gains in weight and weight/length.

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Data Statement

Data sharing statement available at www.jpeds.com.

Glossary

ADHD	Attention deficit hyperactivity disorder
BMI	Body mass index
CSI-4	Child Symptom Inventory 4
ELGAN	Extremely Low Gestational Age Newborn
IHDP	Infant Health and Development Program
MINI-KID	Mini International Neuropsychiatric Interview–Kid Edition
NICU	Neonatal intensive care unit
NTCB	National Institutes of Health Toolbox Cognition Battery

WASI-II Wechsler Abbreviated Scale of Intelligence, Second Edition

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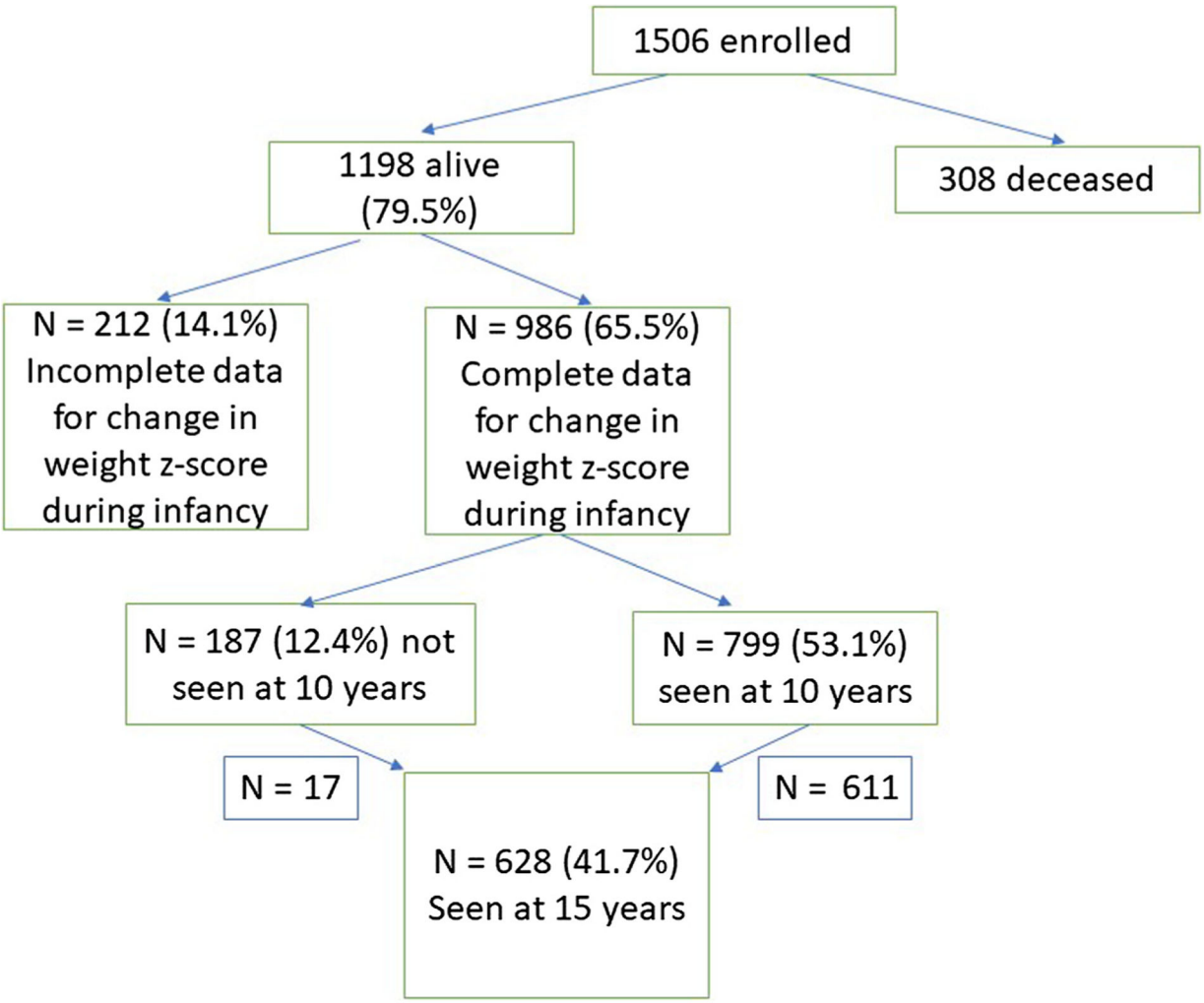

Figure.
Derivation of the study sample.

Table I.

Comparison of ELGAN study participants at discharge alive from the NICU, at age 10 years, and at age 15 years

Characteristics	Discharge alive from NICU (N = 1222), n (%)	Age 10 y (N = 889), n (%)	Age 15 y (N = 694), n (%)
Maternal age, y			
<21	174 (14)	115 (13)	80 (12)
21–35	820 (67)	594 (67)	445 (67)
>35	228 (19)	180 (20)	144 (22)
Unmarried mother	533 (44)	353 (40)	235 (35)
Maternal education, y			
≤12	521 (44)	367 (41)	250 (37)
>12-<16	276 (24)	210 (24)	153 (23)
≥16	378 (32)	312 (35)	266 (40)
Mother covered by Medicaid or other state-supported medical insurance	483 (40)	314 (35)	217 (32)
Race			
Asian, Native American, or mixed race	153 (13)	98 (11)	61 (9)
Black	336 (28)	227 (26)	159 (24)
White	722 (60)	562 (63)	449 (67)
Hispanic			
Yes	147 (12)	86 (9.7)	57 (8.6)
No	1068 (88)	800 (90)	609 (91)
Maternal prepregnancy BMI, kg/m^2			
<18.5	91 (7.8)	68 (7.9)	47 (7.3)
18.5–<30	824 (70)	595 (69)	444 (69)
≥30	256 (22)	194 (23)	154 (24)
Cesarean delivery	809 (66)	590 (66)	440 (66)
Sex			
Male	638 (52)	455 (51)	341 (51)
Female	584 (48)	434 (49)	328 (49)
Multiple gestation	365 (32)	293 (35)	236 (38)
Gestational age, wk			
23–24	251 (21)	187 (21)	144 (22)

Characteristics	Discharge alive from NICU (N = 1222), n (%)	Age 10 y (N = 889), n (%)	Age 15 y (N = 694), n (%)
25–26	562 (46)	400 (45)	305 (46)
27	409 (34)	302 (34)	220 (33)
Birth weight, g			
≤750	448 (37)	332 (37)	253 (38)
750–1000	529 (43)	382 (43)	284 (43)
>1000	245 (20)	175 (20)	132 (20)
Birth weight *z*-score <−2	65 (5.3)	53 (6.0)	41 (6.1)
Average daily weight gain in NICU			
Lowest quartile	301 (25)	207 (23)	156 (23)
Highest quartile	308 (25)	225 (25)	167 (25)
Bacteremia	382 (31)	279 (31)	205 (30)
White matter injury on neonatal ultrasound	246 (20)	188 (21)	138 (21)
Severe retinopathy of prematurity	162 (14)	118 (14)	94 (14)
Medical necrotizing enterocolitis	11 (0.9)	8 (0.9)	5 (0.7)
Surgical necrotizing enterocolitis	45 (3.7)	32 (3.6)	25 (3.7)
Spontaneous intestinal perforation	36 (2.9)	29 (3.3)	20 (3.0)
Chronic lung disease	616 (50)	461 (52)	357 (51)

Table II.

Maternal and neonatal characteristics and child outcomes according to quintile of change in weight z-scores from NICU discharge to approximately age 2 years

	Growth from NICU discharge to 2 y (change in weight *z*-score), n (%)				
Characteristics/outcomes	**Quintile 1 (<−0.28) (N = 152)**	**Quintile 2 (≥−0.28; <0.60) (N = 170)**	**Quintile 3 (≥0.60; <1.29) (N = 164)**	**Quintile 4 (≥1.29; <2.02) (N = 150**	**Quintile 5 (≥2.02) (N = 163)**
Maternal characteristics					
Age, y					
<21	17 (11)	21 (12)	19 (12)	21 (14)	23 (14)
21–35	102 (67)	118 (69)	110 (67)	103 (69)	99 (61)
>35	33 (22)	31 (18)	35 (21)	26 (17)	41 (25)
Unmarried	58 (38)	51 (30)	74 (45)	70 (47)	61 (37)
Education, y					
≤12	59 (40)	66 (40)	71 (45)	62 (42)	58 (37)
>12–<16	33 (22)	40 (24)	35 (22)	38 (26)	31 (20)
≥16	56 (38)	60 (36)	53 (33)	47 (32)	66 (43)
IQ					
≤−2	8 (5.6)	7 (4.2)	8 (5.2)	5 (3.4)	4 (2.6)
>−2, ≤−1	8 (5.6)	12 (7.2)	10 (6.5)	12 (8.3)	11 (7.1)
>−1, ≤1	96 (68)	123 (74)	108 (70)	108 (74)	107 (69)
Medicaid or other state-supported medical insurance	59 (40)	54 (32)	64 (40)	49 (33)	51 (32)
Race					
Asian, Native American, or mixed race	11 (7.3)	21 (13)	21 (13)	19 (13)	14 (8.6)
Black	34 (23)	40 (24)	43 (27)	43 (29)	41 (25)
White	105 (70)	107 (64)	95 (60)	88 (59)	107 (66)
Hispanic					
No	143 (95)	152 (90)	147 (90)	135 (90)	144 (89)
Yes	8 (5.3)	17 (10)	17 (10)	15 (10)	18 (11)
Prepregnancy BMI, kg/m^2					
<18.5	22 (15)	12 (7.3)	12 (7.6)	8 (5.4)	6 (3.9)
18.5–<30	101 (68)	110 (67)	111 (70)	105 (71)	111 (73)

Characteristics/outcomes	Growth from NICU discharge to 2 y (change in weight *z*-score), n (%)				
	Quintile 1 (<−0.28) (N = 152)	**Quintile 2 (≥−0.28; <0.60) (N = 170)**	**Quintile 3 (≥0.60; <1.29) (N = 164)**	**Quintile 4 (≥1.29; <2.02) (N = 150**	**Quintile 5 (≥2.02) (N = 163)**
≥30	25 (17)	43 (26)	35 (22)	34 (23)	35 (23)
Histologic chorioamnionitis	87 (57)	87 (51)	74 (45)	65 (43)	82 (50)
Indication for delivery					
Preterm labor	69 (45)	77 (45)	77 (47)	68 (45)	77 (47)
Premature rupture of membranes	34 (22)	38 (22)	40 (24)	27 (18)	34 (21)
Preeclampsia	18 (12)	21 (12)	20 (12)	25 (17)	20 (12)
Placental abruption	14 (9.2)	21 (12)	14 (8.5)	13 (8.7)	22 (13)
Cervical insufficiency	10 (6.6)	7 (4.1)	4 (2.4)	11 (7.3)	5 (3.1)
Fetal indication	7 (4.6)	6 (3.5)	9 (5.5)	6 (4.0)	5 (3.1)
Cesarean delivery	98 (64)	109 (64)	116 (71)	100 (67)	108 (66)
Neonatal characteristics					
Sex					
Female	85 (56)	90 (53)	74 (45)	67 (45)	76 (47)
Male	67 (44)	80 (47)	90 (55)	83 (55)	87 (53)
Multiple gestation	48 (33)	61 (38)	55 (36)	47 (34)	58 (38)
Gestational age, wk					
23–24	35 (23)	44 (26)	22 (13)	21 (14)	40 (25)
25–26	66 (43)	74 (44)	82 (50)	76 (51)	65 (40)
27	51 (34)	52 (31)	60 (37)	53 (35)	58 (36)
Birth weight, g					
≤750	59 (39)	69 (41)	45 (27)	49 (33)	67 (41)
750–1000	62 (41)	72 (42)	73 (45)	73 (49)	67 (41)
>1000	31 (20)	29 (17)	46 (28)	28 (19)	29 (18)
Birth weight *z*-score					
<−2	5 (3.3)	9 (5.3)	5 (3.0)	14 (9.3)	13 (8.0)
≥−2, <−1	18 (12)	27 (16)	17 (10)	18 (12)	24 (15)
≥−1	129 (85)	134 (79)	142 (87)	118 (79)	126 (77)
Average daily weight gain in NICU					
Lowest quartile	28 (18)	31 (18)	27 (16)	34 (23)	68 (42)

Characteristics/outcomes	Growth from NICU discharge to 2 y (change in weight z-score), n (%)				
	Quintile 1 (<−0.28) (N = 152)	**Quintile 2 (≥−0.28; <0.60) (N = 170)**	**Quintile 3 (≥0.60; <1.29) (N = 164)**	**Quintile 4 (≥1.29; <2.02) (N = 150**	**Quintile 5 (≥2.02) (N = 163)**
Highest quartile	63 (41)	56 (33)	41 (25)	24 (16)	11 (6.7)
Bacteremia	40 (26)	49 (29)	58 (35)	47 (31)	54 (33)
White matter injury on neonatal ultrasound	43 (28)	33 (19)	27 (16)	27 (18)	35 (21)
Severe retinopathy of prematurity	17 (11)	27 (16)	12 (7.5)	19 (13)	26 (16)
Necrotizing enterocolitis/SIP					
Medical	1 (0.7)	1 (0.6)	2 (1.2)	1 (0.7)	3 (1.8)
Surgical	2 (1.3)	5 (2.9)	4 (2.4)	5 (3.3)	11 (6.7)
Spontaneous intestinal perforation	4 (2.6)	4 (2.4)	3 (1.8)	3 (2.0)	11 (6.7)
Chronic lung disease	65 (44)	98 (59)	75 (46)	71 (48)	95 (58)
SNAP score					
<20	83 (55)	81 (49)	82 (52)	85 (57)	84 (52)
20–29	35 (23)	44 (26)	44 (28)	37 (25)	34 (21)
30+	32 (21)	42 (25)	33 (21)	27 (18)	43 (27)
Child outcomes at 10 y					
Cognitive impairment	36 (24)	36 (22)	32 (20)	37 (25)	32 (20)
Anxiety	19 (13)	25 (15)	32 (20)	22 (15)	21 (13)
ADHD	21 (14)	29 (17)	34 (21)	30 (21)	22 (14)
Depression	9 (6.1)	10 (5.9)	13 (8.0)	12 (8.2)	10 (6.3)
Obesity	11 (7.4)	18 (11)	18 (11)	19 (13)	27 (17)
Asthma	50 (33)	63 (37)	66 (40)	50 (33)	66 (40)
Fair/poor health by parent report	6 (3.9)	8 (4.7)	6 (3.7)	5 (3.3)	8 (4.9)
One or more adverse outcomes[†]	93 (61)	105 (62)	118 (72)	105 (70)	107 (66)
Child outcomes at 15 y					
Cognitive impairment	18 (17)	14 (11)	15 (13)	20 (18)	16 (12)
Anxiety	7 (6.5)	9 (7.3)	12 (10)	10 (9.0)	9 (7.0)
ADHD	10 (9.3)	6 (4.9)	6 (5.1)	7 (6.3)	9 (7.0)
Depression	5 (4.6)	8 (6.5)	7 (5.9)	5 (4.5)	6 (4.6)
Obesity	18 (19)	18 (17)	22 (20)	21 (20)	26 (22)
Asthma	28 (25)	27 (22)	33 (27)	28 (25)	32 (24)

Characteristics/outcomes	Growth from NICU discharge to 2 y (change in weight *z*-score), n (%)				
	Quintile 1 (<−0.28) (N = 152)	**Quintile 2 (≥−0.28; <0.60) (N = 170)**	**Quintile 3 (≥0.60; <1.29) (N = 164)**	**Quintile 4 (≥1.29; <2.02) (N = 150**	**Quintile 5 (≥2.02) (N = 163)**
Fair/poor health by parent report	29 (26)	29 (23)	27 (22)	23 (20)	22 (17)
One or more adverse outcomes *	61 (54)	69 (55)	83 (67)	65 (57)	79 (59)

SIP, spontaneous intestinal perforation; *SNAP*, Score for Neonatal Acute Physiology.

All percentages are based on denominators that do not include participants with missing values.

* Adverse outcomes that were assessed: bilateral blindness, hearing impairment requiring amplification, cerebral palsy, asthma, obesity, epilepsy, autism spectrum disorder, cognitive impairment, ADHD, anxiety, and depression.

Table III.

Associations between change in weight *z*-score from NICU discharge to age 2 years and outcomes at age 10 years and 15 years for individuals with lower gains in weight *z*-score (quintile 1) and individuals with higher gains in weight *z*-score (quintile 5) compared with the referent group (quintiles 2–4)

	Quintile 1 vs quintiles 2–4		Quintile 5 vs quintiles 2–4	
Outcomes	**Unadjusted OR (95% CI)**	**aOR (95% CI)**	**Unadjusted OR (95% CI)**	**aOR (95% CI)**
Outcomes at 10 y (n = 799)				
Cognitive impairment	1.1 (0.7–1.7)	1.0 (0.6–1.6)	0.9 (0.6–1.4)	0.8 (0.5–1.4)
Anxiety	0.7 (0.4–1.3)	0.7 (0.4–1.2)	0.8 (0.5–1.3)	0.7 (0.4–1.3)
ADHD	0.7 (0.4–1.1)	0.6 (0.4–1.1)	0.7 (0.4–1.1)	0.7 (0.4–1.2)
Depression	0.8 (0.4–1.7)	0.9 (0.4–1.9)	0.8 (0.4–1.8)	1.0 (0.5–2.1)
Obesity	0.6 (0.3–1.2)	0.6 (0.3–1.2)	1.5 (0.9–2.5)	1.6 (0.9–2.7)
Asthma	0.8 (0.6–1.2)	0.9 (0.6–1.3)	1.2 (0.8–1.7)	1.2 (0.8–1.8)
Fair/poor health by parent report	1.0 (0.4–2.6)	0.9 (0.3–2.3)	1.3 (0.5–2.9)	1.5 (0.6–3.6)
One or more adverse outcomes [*]	0.7 (0.5–1.1)	0.7 (0.5–1.1)	0.9 (0.6–1.3)	0.9 (0.6–1.3)
Outcomes at 15 y (n = 611)				
Cognitive impairment [†]	1.2 (0.7–2.2)	1.2 (0.6–2.4)	0.9 (0.5–1.6)	0.8 (0.4–1.5)
Anxiety [‡]	0.7 (0.3–1.7)	0.8 (0.4–2.0)	0.8 (0.4–1.7)	0.8 (0.3–1.8)
ADHD [‡]	1.8 (0.8–4.0)	1.6 (0.7–3.6)	1.3 (0.6–3.0)	1.5 (0.6–3.5)
Depression [‡]	0.8 (0.3–2.2)	0.7 (0.2–2.1)	0.8 (0.3–2.0)	0.8 (0.3–2.1)
Obesity [§]	1.0 (0.5–1.7)	1.1 (0.6–2.0)	1.2 (0.7–2.0)	1.1 (0.6–2.0)
Asthma [¶]	1.0 (0.6–1.7)	1.0 (0.6–1.8)	1.0 (0.6–1.6)	1.1 (0.7–1.9)
Fair/poor health by parent report [**]	1.2 (0.8–2.0)	1.2 (0.7–2.0)	0.7 (0.4–1.2)	0.8 (0.5–1.4)
One or more adverse outcomes [*]	0.8 (0.5–1.2)	0.8 (0.5–1.2)	1.0 (0.7–1.5)	1.0 (0.6–1.5)

[*] Adverse outcomes that were assessed: bilateral blindness, hearing impairment requiring amplification, cerebral palsy, asthma, obesity, epilepsy, autism spectrum disorder, cognitive impairment, ADHD, anxiety, and depression.

[†] Adjusted for gestational age, maternal education, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

[‡] Adjusted for birth weight *z*-score, gestational age, maternal eligibility for Medicaid, maternal education, mother's marital status, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

[§] Adjusted for birth weight *z*-score, gestational age, maternal education, neonatal chronic lung disease, and white matter damage.

[¶]Adjusted for birth weight *z*-score, neonatal chronic lung disease, gestational age, public insurance, maternal education, unmarried mother, and white matter damage.

[**]Adjusted for gestational age, maternal education, maternal Medicaid eligibility, mother marital status, neonatal chronic lung disease, and white matter damage.

Table IV.

Sex-stratified adjusted associations between change in weight *z*-score from NICU discharge to age 2 years and outcomes at age 10 years and 15 years for individuals with lower gains in weight *z*-score (quintile 1) and individuals with higher gains in weight *z*-score (quintile 5) compared with the referent group (quintiles 2–4)

	Quintile 1 vs quintiles 2–4, aOR (95% CI)		Quintile 5 vs quintiles 2–4, aOR (95% CI)	
Outcomes	**Females**	**Males**	**Females**	**Males**
Outcomes at 10 y (n = 799)				
Cognitive impairment	0.9 (0.4–1.9)	1.2 (0.6–2.4)	0.8 (0.4–1.9)	0.8 (0.4–1.5)
Anxiety	0.9 (0.4–1.9)	0.6 (0.2–1.3)	1.1 (0.5–2.4)	0.5 (0.2–1.2)
ADHD	0.8 (0.4–1.9)	0.6 (0.3–1.2)	1.1 (0.5–2.6)	0.5 (0.2–1.0)
Depression	0.9 (0.3–2.9)	0.9 (0.3–2.7)	2.3 (0.9–6.1)	0.3 (0.1–1.4)
Obesity	0.4 (0.1–1.1)	0.7 (0.3–2.0)	**2.8 (1.3–5.9)**	1.0 (0.4–2.3)
Asthma	0.8 (0.4–1.3)	1.0 (0.6–1.9)	**2.1 (1.2–3.7)**	0.8 (0.4–1.3)
Fair/poor health by parent report	0.4 (0.1–1.9)	2.1 (0.6–7.8)	2.1 (0.6–7.3)	1.1 (0.3–4.3)
One or more adverse outcomes *	0.6 (0.4–1.1)	0.8 (0.4–1.5)	1.2 (0.6–2.2)	0.6 (0.3–1.0)
Outcomes at 15 y (n = 611)				
Cognitive impairment †	1.1 (0.4–3.4)	1.4 (0.6–3.2)	0.8 (0.2–2.4)	0.7 (0.3–1.7)
Anxiety‡	0.6 (0.2–2.1)	1.5 (0.4–6.3)	0.9 (0.3–2.7)	0.6 (0.1–2.8)
ADHD‡	1.4 (0.4–5.5)	1.8 (0.6–5.8)	2.9 (0.8–10.1)	1.0 (0.3–3.4)
Depression‡	0.2 (0.0–1.5)	2.7 (0.5–14.3)	0.7 (0.2–2.6)	1.3 (0.2–8.1)
Obesity§	1.2 (0.5–2.6)	1.2 (0.5–3.3)	1.1 (0.5–2.5)	1.1 (0.5–2.5)
Asthma¶	0.8 (0.3–1.9)	1.2 (0.6–2.6)	**2.3 (1.1–4.7)**	0.6 (0.3–1.3)
Fair/poor health by parent report **	0.5 (0.2–1.2)	**2.3 (1.1–4.9)**	1.3 (0.6–2.6)	0.5 (0.2–1.1)
One or more adverse outcomes *	0.6 (0.3–1.2)	0.9 (0.5–1.9)	1.3 (0.7–2.6)	0.7 (0.4–1.4)

Bold type indicates OR significant at $P < .05$.

*Adverse outcomes that were assessed: bilateral blindness, hearing impairment requiring amplification, cerebral palsy, asthma, obesity, epilepsy, autism spectrum disorder, cognitive impairment, ADHD, anxiety, and depression.

†Adjusted for gestational age, maternal education, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

‡Adjusted for birth weight *z*-score, gestational age, maternal eligibility for Medicaid, maternal education, mother's marital status, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

§Adjusted for birth weight *z*-score, gestational age, maternal education, neonatal chronic lung disease, and white matter damage.

¶Adjusted for birth weight *z*-score, neonatal chronic lung disease, gestational age, public insurance, maternal education, unmarried mother, and white matter damage.

**Adjusted for gestational age, maternal education, maternal Medicaid eligibility, mother's marital status, neonatal chronic lung disease, and white matter damage.

Table V.

Associations between change in length *z*-score from NICU discharge to age 2 years and outcomes at age 10 years and 15 years for individuals with lower gains in length *z*-score (quintile 1) and individuals with higher gains in length *z*-score (quintile 5) compared with the referent group (quintiles 2–4)

	Quintile 1 vs quintiles 2–4		Quintile 5 vs quintiles 2–4	
Outcomes	**Unadjusted OR (95% CI)**	**aOR (95% CI)**	**Unadjusted OR (95% CI)**	**aOR (95% CI)**
Outcomes at 10 y (n = 799)				
Cognitive impairment	1.4 (0.8–2.2)	1.4 (0.8–2.4)	2.3 (1.5–3.6)	**1.9 (1.1–3.1)**
Anxiety	0.7 (0.4–1.4)	0.7 (0.3–1.3)	1.3 (0.8–2.2)	1.2 (0.7–2.1)
ADHD	1.0 (0.5–1.7)	0.9 (0.5–1.7)	1.0 (0.6–1.7)	0.9 (0.5–1.5)
Depression	0.4 (0.2–1.1)	0.4 (0.2–1.1)	0.5 (0.2–1.1)	0.5 (0.2–1.2)
Obesity	0.7 (0.4–1.4)	0.7 (0.4–1.4)	0.8 (0.5–1.5)	0.9 (0.5–1.7)
Asthma	1.0 (0.6–1.5)	1.0 (0.6–1.6)	1.2 (0.8–1.8)	1.2 (0.8–1.8)
Fair/poor health by parent report	0.6 (0.2–2.2)	0.7 (0.2–2.5)	1.2 (0.4–3.1)	1.0 (0.3–2.9)
One or more adverse outcomes *	0.8 (0.6–1.3)	0.8 (0.5–1.2)	1.5 (1.0–2.3)	1.2 (0.7–1.9)
Outcomes at 15 y (n = 611)				
Cognitive impairment †	1.0 (0.5–2.1)	1.2 (0.6–2.5)	1.7 (1.0–3.1)	1.3 (0.7–2.6)
Anxiety ‡	0.5 (0.2–1.3)	0.5 (0.1–1.4)	0.8 (0.4–1.9)	0.9 (0.4–2.2)
ADHD ‡	1.9 (0.8–4.8)	1.9 (0.7–5.1)	1.6 (0.7–4.1)	1.3 (0.5–3.4)
Depression ‡	0.3 (0.1–1.5)	0.3 (0.1–1.5)	0.7 (0.3–2.1)	0.7 (0.2–2.2)
Obesity §	1.0 (0.5–1.7)	1.0 (0.5–1.9)	0.5 (0.3–1.0)	**0.5 (0.2–0.9)**
Asthma ¶	1.2 (0.7–2.1)	1.6 (0.9–2.9)	1.0 (0.6–1.8)	1.2 (0.7–2.2)
Fair/poor health by parent report **	1.3 (0.8–2.2)	1.4 (0.8–2.5)	0.8 (0.5–1.4)	0.8 (0.4–1.5)
One or more adverse outcomes *	1.1 (0.7–1.7)	1.3 (0.8–2.2)	1.1 (0.7–1.8)	0.9 (0.5–1.4)

Bold type indicates OR significant at $P < .05$.

*Adverse outcomes that were assessed: bilateral blindness, hearing impairment requiring amplification, cerebral palsy, asthma, obesity, epilepsy, autism spectrum disorder, cognitive impairment, ADHD, anxiety, and depression.

†Adjusted for gestational age, maternal education, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

‡Adjusted for birth weight *z*-score, gestational age, maternal eligibility for Medicaid, maternal education, mother's marital status, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

[§]Adjusted for birth weight *z*-score, gestational age, maternal education, neonatal chronic lung disease, and white matter damage.

[¶]Adjusted for birth weight *z*-score, neonatal chronic lung disease, gestational age, public insurance, maternal education, unmarried mother, and white matter damage.

[**]Adjusted for gestational age, maternal education, maternal Medicaid eligibility, mother marital status, neonatal chronic lung disease, and white matter damage.

Table VI.

Sex-stratified adjusted associations between the change in length *z*-score from NICU discharge to age 2 years and outcomes at 10 years and 15 years

Outcomes	10-y outcomes (n = 434)		15-y outcomes (n = 300)	
	Quintile 1 vs quintiles 2–4, aOR (95% CI)	Quintile 5 vs quintiles 2–4, aOR (95% CI)	Quintile 1 vs quintiles 2–4, aOR (95% CI)	Quintile 5 vs quintiles 2–4, aOR (95% CI)
Females				
Cognitive impairment *	1.0 (0.4–2.6)	2.0 (0.9–4.6)	0.8 (0.2–3.4)	1.8 (0.6–5.1)
Anxiety †	0.7 (0.3–1.9)	1.0 (0.4–2.5)	0.6 (0.2–2.1)	0.7 (0.2–2.4)
ADHD †	0.7 (0.3–2.1)	1.4 (0.6–3.5)	0.9 (0.2–4.7)	0.5 (0.1–3.3)
Depression †	0.2 (0.0–1.8)	0.8 (0.3–2.9)	0.2 (0.0–1.5)	0.7 (0.2–3.1)
Obesity ‡	0.8 (0.3–2.0)	1.2 (0.5–3.0)	0.9 (0.4–2.2)	0.4 (0.1–1.1)
Asthma §	0.7 (0.3–1.4)	2.0 (1.0–3.7)	1.9 (0.8–4.6)	2.2 (0.9–5.2)
Fair/poor health by parent report ¶	1.6 (0.3–10.4)	0.6 (0.1–4.6)	0.9 (0.4–2.0)	0.5 (0.2–1.3)
One or more adverse outcomes **	0.5 (0.3–1.0)	1.5 (0.7–3.2)	1.2 (0.6–2.7)	0.8 (0.4–1.7)
Males				
Cognitive impairment *	1.5 (0.8–3.1)	1.6 (0.8–3.2)	1.5 (0.6–3.7)	1.1 (0.5–2.9)
Anxiety †	0.6 (0.2–1.6)	1.2 (0.6–2.6)	††	0.3 (0.1–2.0)
ADHD †	0.9 (0.4–2.0)	0.6 (0.3–1.2)	2.9 (0.7–11.7)	2.0 (0.5–8.5)
Depression †	0.6 (0.2–1.9)	0.2 (0.0–1.1)	0.5 (0.1–4.8)	0.4 (0.0–3.9)
Obesity ‡	0.6 (0.2–1.5)	0.6 (0.2–1.6)	1.1 (0.4–2.8)	0.7 (0.2–2.1)
Asthma §	1.2 (0.6–2.2)	0.7 (0.4–1.3)	1.3 (0.6–2.9)	0.7 (0.3–1.8)
Fair/poor health by parent report ¶	0.3 (0.0–2.9)	1.0 (0.3–3.9)	**2.4 (1.1–5.3)**	1.1 (0.5–2.7)
One or more adverse outcomes **	1.2 (0.6–2.2)	0.7 (0.4–1.3)	1.3 (0.6–2.9)	0.7 (0.3–1.8)

Bold type indicates OR significant at $P < .05$.

*Adjusted for gestational age, maternal education, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

†Adjusted for birth weight *z*-score, gestational age, maternal eligibility for Medicaid, maternal education, mother's marital status, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

‡Adjusted for birth weight *z*-score, gestational age, maternal education, neonatal chronic lung disease, and white matter damage.

[§]Adjusted for neonatal chronic lung disease, gestational age, public insurance, maternal education, maternal single, and white matter damage.

[¶]Adjusted for birth weight *z*-score, gestational age, maternal education, maternal prepregnancy body mass index, neonatal chronic lung disease, and white matter damage.

[**]Adverse outcomes that were assessed: bilateral blindness, hearing impairment requiring amplification, cerebral palsy, asthma, obesity, epilepsy, autism spectrum disorder, cognitive impairment, ADHD, anxiety, and depression.

[††]The low weight gain group had too few instances of anxiety to estimate associations.

Table VII.

Associations between change in weight/length ratio *z*-score from NICU discharge to age 2 years and outcomes at age 10 years and 15 years for individuals with lower gains in weight/length ratio *z*-score (quintile 1) and individuals with higher gains in weight/length ratio *z*-score (quintile 5) compared with the referent group (quintiles 2–4)

	Quintile 1 vs quintiles 2–4		Quintile 5 vs quintiles 2–4	
Outcomes	**Unadjusted OR (95% CI)**	**aOR (95% CI)**	**Unadjusted OR (95% CI)**	**aOR (95% CI)**
Outcomes at 10 y (n = 799)				
Cognitive impairment	2.1 (1.4–3.2)	1.4 (0.9–2.2)	0.5 (0.3–0.9)	0.7 (0.4–1.2)
Anxiety	1.1 (0.7–2.0)	0.8 (0.4–1.5)	1.0 (0.5–1.7)	1.3 (0.7–2.3)
ADHD	1.1 (0.7–1.9)	0.9 (0.5–1.5)	0.5 (0.3–0.9)	0.6 (0.3–1.1)
Depression	0.8 (0.3–1.8)	0.8 (0.3–2.0)	1.2 (0.6–2.4)	1.3 (0.6–2.9)
Obesity	0.8 (0.4–1.7)	0.8 (0.4–1.6)	2.1 (1.2–3.5)	**2.1 (1.2–3.6)**
Asthma	1.1 (0.7–1.6)	1.0 (0.7–1.6)	1.0 (0.7–1.5)	1.0 (0.7–1.6)
Fair/poor health by parent report	2.1 (0.8–5.2)	1.6 (0.6–4.6)	1.0 (0.3–3.2)	1.6 (0.5–5.3)
One or more adverse outcomes *	1.6 (1.0–2.5)	1.4 (0.8–2.3)	0.9 (0.6–1.3)	1.0 (0.6–1.5)
Outcomes at 15 y (n = 611)				
Cognitive impairment †	2.8 (1.6–4.8)	1.8 (1.0–3.4)	0.8 (0.4–1.5)	1.2 (0.6–2.5)
Anxiety‡	1.9 (0.8–4.3)	2.5 (1.0–6.2)	1.9 (0.9–4.2)	1.5 (0.7–3.4)
ADHD‡	2.8 (1.2–6.3)	2.4 (0.9–5.9)	1.0 (0.3–2.8)	1.4 (0.5–4.2)
Depression‡	0.8 (0.3–2.6)	0.9 (0.3–2.9)	1.1 (0.4–2.9)	1.1 (0.4–3.2)
Obesity§	0.8 (0.4–1.5)	0.9 (0.4–1.8)	1.6 (0.9–2.8)	1.5 (0.8–2.6)
Asthma¶	1.3 (0.8–2.2)	1.1 (0.6–2.1)	1.3 (0.8–2.2)	1.3 (0.8–2.4)
Fair/poor health by parent report **	1.9 (1.1–3.2)	1.7 (1.0–3.1)	1.5 (0.9–2.4)	1.6 (0.9–2.9)
One or more adverse outcomes *	2.1 (1.3–3.5)	1.6 (0.9–2.9)	1.1 (0.7–1.7)	1.5 (0.9–2.5)

Bold type indicates OR significant at $P < .05$.

*Adverse outcomes that were assessed: bilateral blindness, hearing impairment requiring amplification, cerebral palsy, asthma, obesity, epilepsy, autism spectrum disorder, cognitive impairment, ADHD, anxiety, depression.

†Adjusted for gestational age, maternal education, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

[‡]Adjusted for birth weight *z*-score, gestational age, maternal eligibility for Medicaid, maternal education, mother's marital status, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

[§]Adjusted for birth weight *z*-score, gestational age, maternal education, neonatal chronic lung disease, and white matter damage.

[¶]Adjusted for birth weight *z*-score, neonatal chronic lung disease, gestational age, public insurance, maternal education, unmarried mother, and white matter damage.

[**]Adjusted for gestational age, maternal education, maternal Medicaid eligibility, mother marital status, neonatal chronic lung disease, and white matter damage.

Table VIII.

Sex-stratified adjusted associations between change in weight/length ratio *z*-score from NICU discharge to age 2 years and outcomes at age 10 years and 15 years for individuals with lower gains in weight/length ratio *z*-score (quintile 1) and individuals with higher gains in weight/length ratio *z*-score (quintile 5) compared with the referent group (quintiles 2–4)

	Quintile 1 vs quintiles 2–4, aOR (95% CI)		Quintile 5 vs quintiles 2–4, aOR (95% CI)	
Outcomes	**Females**	**Males**	**Females**	**Males**
Outcomes at 10 y (n = 799)				
Cognitive impairment	0.9 (0.4–1.9)	1.9 (1.0–3.8)	1.1 (0.4–2.8)	**0.4 (0.2–0.9)**
Anxiety	0.9 (0.3–2.3)	0.9 (0.4–2.0)	1.2 (0.5–3.2)	1.3 (0.6–2.8)
ADHD	1.3 (0.5–3.2)	0.7 (0.3–1.5)	0.8 (0.3–2.3)	0.4 (0.2–0.9)
Depression	1.5 (0.4–5.5)	0.5 (0.1–1.9)	2.6 (0.8–8.4)	0.8 (0.3–2.3)
Obesity	0.3 (0.1–1.3)	1.0 (0.4–2.5)	**3.2 (1.4–7.3)**	1.4 (0.6–3.4)
Asthma	0.9 (0.4–1.7)	1.3 (0.7–2.5)	1.2 (0.6–2.3)	0.9 (0.5–1.7)
Fair/poor health by parent report	1.6 (0.3–9.0)	1.8 (0.5–7.3)	1.4 (0.2–9.0)	1.2 (0.2–6.6)
One or more adverse outcomes [*]	1.3 (0.6–2.8)	1.6 (0.7–3.4)	1.7 (0.8–3.4)	0.7 (0.4–1.2)
Outcomes at 15 y (n = 611)				
Cognitive impairment [†]	1.8 (0.7–5.1)	1.9 (0.8–4.3)	1.0 (0.3–3.7)	1.1 (0.4–2.8)
Anxiety [‡]	**3.7 (1.1–12.1)**	1.7 (0.3–8.3)	2.6 (0.9–7.6)	0.5 (0.1–3.1)
ADHD [‡]	4.1 (0.9–18.4)	1.3 (0.4–4.6)	3.2 (0.6–17.4)	0.8 (0.1–3.9)
Depression [‡]	1.4 (0.3–6.2)	0.7 (0.1–7.8)	0.9 (0.2–3.8)	1.3 (0.2–8.1)
Obesity [§]	0.6 (0.2–1.8)	1.4 (0.5–4.0)	1.5 (0.7–3.5)	1.4 (0.6–3.2)
Asthma [¶]	2.0 (0.8–5.0)	0.8 (0.3–1.9)	1.4 (0.6–3.3)	1.1 (0.5–2.5)
Fair/poor health by parent report [**]	1.1 (0.4–2.7)	**2.6 (1.2–5.9)**	1.5 (0.7–3.4)	1.8 (0.8–4.1)
One or more adverse outcomes [*]	1.4 (0.6–3.3)	2.1 (0.9–4.8)	1.7 (0.8–3.7)	1.3 (0.7–2.7)

Bold type indicates OR significant at $P < .05$.

[*]Adverse outcomes that were assessed: bilateral blindness, hearing impairment requiring amplification, cerebral palsy, asthma, obesity, epilepsy, autism spectrum disorder, cognitive impairment, ADHD, anxiety, and depression.

[†]Adjusted for gestational age, maternal education, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

[‡]Adjusted for birth weight *z*-score, gestational age, maternal eligibility for Medicaid, maternal education, mother's marital status, neonatal chronic lung disease, and neonatal ultrasound-identified white matter abnormality.

[§]Adjusted for birth weight *z*-score, gestational age, maternal education, neonatal chronic lung disease, and white matter damage.

[¶]Adjusted for birth weight *z*-score, neonatal chronic lung disease, gestational age, public insurance, maternal education, unmarried mother, and white matter damage.

[**]Adjusted for gestational age, maternal education, maternal Medicaid eligibility, mother marital status, neonatal chronic lung disease, and white matter damage.