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اولین رسانه دیجیتال در حوزه علوم پزشکی

011-3335 5440
0901 601 9192
0901 601 9192

pezeshkamooz.co@gmail.com
poshtibani@pezeshkamooz.com
pezeshkamooz.com

Reference Range Values

for Pediatric Care

Lamia Soghier, MD, FAAP
Editor
Katherine Pham, PharmD, BCPS
Sara Rooney, PharmD, BCPS
Contributing Editors

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

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Editor
Lamia M. Soghier, MD, FAAP
Assistant Professor of Pediatrics
The George Washington University School of Medicine and Health Sciences
Medical Unit Director
Division of Neonatology
Children's National Health System
Washington, DC

Contributing Editors
Katherine Pham, PharmD, BCPS
NICU Clinical Specialist
Director-Pharmacy Residency Programs
Children's National Health System
Division of Pharmacy
Washington, DC

Sara Rooney, PharmD, BCPS
PICU Clinical Specialist
Children's National Health System
Division of Pharmacy
Washington, DC

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INTRODUCTION

Reference Range Values for Pediatric Care was created in response to an overwhelming need from pediatricians, pediatric residents, nurse practitioners, and other pediatric providers who acknowledged the utility of the reference range values section in *Quick Reference Guide to Pediatric Care*, part of the American Academy of Pediatrics (AAP) point-of-care offerings, which also include the AAP *Textbook of Pediatric Care* and *Pediatric Care Online*. Pediatricians have been quick to recognize both the ease of accessibility and breadth of knowledge that the Pediatric Care series allows, even as they continued to make "normal values" the most searched-for term in the series. As an answer to this, and in our effort to strike the ultimate balance between the practical and the comprehensive, we decided to develop a short stand-alone handbook of reference range values.

This handbook was designed with the busy practitioner in mind. Compact and clear-cut, it provides the most commonly used reference range values, charts, and formulas at your fingertips. The values span the gamut of age groups from newborn to adolescence, with a particular emphasis throughout on the values needed for the management of preterm newborns younger than 37 weeks. This focus is complemented by sections that address common newborn scores (eg, Apgar, Ballard) as well as the AAP newborn hyperbilirubinemia management charts. We have also included a new section for the series on commonly used antibiotics and antiseizure medications with recommended serum drug target levels; preterm and neonatal populations are highlighted to benefit the pediatrician responsible for the complex dosing for this age group. To that effect, we enlisted the help of 2 experienced pediatric pharmacists as contributing editors, Katherine Pham PharmD, BCPS, and Sara Rooney PharmD, BCPS. Additionally, the handbook features pain scales, growth measures for extremities, and the AAP immunization and periodicity schedules.

In writing *Reference Range Values for Pediatric Care,* I would like to thank 4 integral people without whom this book would not have come to light. Firstly, I am indebted to Dr Deborah Campbell, Division Chief

of Neonatology at the Children's Hospital at Montefiore, for all her help with the inception of the original chapter and, subsequently, this handbook. I would also like to thank Martha Cook for coalescing the concept of this book alongside Mark Grimes and the AAP editorial team. Lastly, I would like to thank Alain Park for his keen eye, fantastic input, and for keeping me on track during development.

I'd also like to give a special thanks to Drs Jennifer Chapman (pediatric emergency medicine), Aisha Davis (hospitalist division), and Kristin Arcana (pediatric endocrinology) at Children's National Health System for their thorough review and valuable contribution to the text.

As we strive to improve the health of all children, I hope this book is another little step to that end. Be on the lookout for the upcoming app!

Lamia Soghier, MD, FAAP

1. Conversions

CONVERSION FORMULAS

Height (length)	
1 mm = 0.04 in 1 cm = 0.4 in	1 in = 2.54 cm 1 m = 39.37 in
Weight	
60 mg = 1 g 28.35 g = 1 oz 453.6 g = 1 lb 1,000 g = 1 kg 1 kg = 2.2046 lb	1 L = 1.06 qt 1 fl oz = 29.57 mL 1 tbsp = 15 mL 1 tsp = 5 mL
Milligram–milliequivalent conversions	
mEq/L = mg/L × valence/atomic weight Equivalent weight = atomic weight/ valence	mg/L = mEq/L × atomic weight/valence
Milligram-millimole conversions	
mmol/L = mg/L ÷ molecular weight	
Milliosmols	
The milliequivalent (mEq) is roughly equivalent to the milliosmol (mOsm), the unit of measure of osmotic pressure or tonicity. One osmole (Osm) is the amount of a substance that dissociates in solution to form one mole (mol) of osmotically active particles.	

TEMPERATURE CONVERSION

Celsius: °C = 5/9 (°F − 32)
Fahrenheit: °F = 9/5 (°C + 32)

Fahrenheit to Celsius Conversion

125	51.6	**92**	33.3	**59**	15.0	**26**	-3.3	**-7**	-21.6
124	51.1	**91**	32.7	**58**	14.4	**25**	-3.9	**-8**	-22.2
123	50.5	**90**	32.2	**57**	13.9	**24**	-4.4	**-9**	-22.8
122	50.0	**89**	31.6	**56**	13.3	**23**	-5.0	**-10**	-23.3
121	49.4	**88**	31.1	**55**	12.8	**22**	-5.6	**-11**	-23.9
120	48.8	**87**	30.5	**54**	12.2	**21**	-6.1	**-12**	-24.4
119	48.3	**86**	30.0	**53**	11.7	**20**	-6.7	**-13**	-25.0
118	47.7	**85**	29.4	**52**	11.1	**19**	-7.2	**-14**	-25.5
117	47.2	**84**	28.9	**51**	10.5	**18**	-7.8	**-15**	-26.1
116	46.6	**83**	28.3	**50**	10.0	**17**	-8.3	**-16**	-26.6
115	46.1	**82**	27.8	**49**	9.4	**16**	-8.9	**-17**	-27.2
114	45.5	**81**	27.2	**48**	8.9	**15**	-9.4	**-18**	-27.8
113	45.0	**80**	26.6	**47**	8.3	**14**	-10.0	**-19**	-28.3
112	44.4	**79**	26.1	**46**	7.8	**13**	-10.5	**-20**	-28.9
111	43.8	**78**	25.5	**45**	7.2	**12**	-11.1	**-21**	-29.4
110	43.3	**77**	25.0	**44**	6.7	**11**	-11.7	**-22**	-30.0
109	42.7	**76**	24.4	**43**	6.1	**10**	-12.2	**-23**	-30.5
108	42.2	**75**	23.9	**42**	5.6	**9**	-12.8	**-24**	-31.1
107	41.6	**74**	23.3	**41**	5.0	**8**	-13.3	**-25**	-31.6
106	41.1	**73**	22.8	**40**	4.4	**7**	-13.9	**-26**	-32.2
105	40.5	**72**	22.2	**39**	3.9	**6**	-14.4	**-27**	-32.7
104	40.0	**71**	21.6	**38**	3.3	**5**	-15.0	**-28**	-33.3
103	39.4	**70**	21.1	**37**	2.8	**4**	-15.5	**-29**	-33.9
102	38.9	**69**	20.5	**36**	2.2	**3**	-16.1	**-30**	-34.4
101	38.3	**68**	20.0	**35**	1.7	**2**	-16.7	**-31**	-35.0
100	37.7	**67**	19.4	**34**	1.1	**1**	-17.2	**-32**	-35.5
99	37.2	**66**	18.9	**33**	0.6	**0**	-17.8	**-33**	-36.1
98	36.6	**65**	18.3	**32**	0.0	**-1**	-18.3	**-34**	-36.6
97	36.1	**64**	17.8	**31**	-0.6	**-2**	-18.9	**-35**	-37.2
96	35.5	**63**	17.2	**30**	-1.1	**-3**	-19.4	**-36**	-37.7
95	35.0	**62**	16.7	**29**	-1.7	**-4**	-20.0	**-37**	-38.3
94	34.4	**61**	16.1	**28**	-2.2	**-5**	-20.5	**-38**	-38.9
93	33.9	**60**	15.5	**27**	-2.8	**-6**	-21.1	**-39**	-39.4
								-40	-40.0

2. Scales and Scoring

APGAR SCORE

	0 Points	1 Point	2 Points	Points Totaled
Activity (muscle tone)	Limp	Some flexion	Active motion	
Pulse	Absent	<100 beats/min	>100 beats/ min	
Grimace (reflex irritability)	No response	Grimace	Cry or active withdrawal	
Appearance (skin color/ complexion)	Pale or blue	Acrocyanotic (body pink, extremities blue	Completely pink	
Respiration/ Breathing	Absent	Weak cry; hypo-ventilation	Good; crying	

Severely depressed	0–3
Moderately depressed	4–6
Excellent condition	7–10

MATURATIONAL ASSESSMENT OF GESTATIONAL AGE (New Ballard Score)

NAME _____ SEX _____
HOSPITAL NO. _____ BIRTH WEIGHT _____
RACE _____ LENGTH _____
DATE/TIME OF BIRTH _____ HEAD CIRCUMFERENCE _____
DATE/TIME OF EXAM _____ EXAMINER _____
AGE WHEN EXAMINED _____
APGAR SCORE: 1 MINUTE _____ 5 MINUTES _____ 10 MINUTES _____

NEUROMUSCULAR MATURITY

NEUROMUSCULAR MATURITY SIGN	SCORE							RECORD SCORE HERE
	−1	0	1	2	3	4	5	
POSTURE								
SQUARE WINDOW (Wrist)	 >90°	 90°	 60°	 45°	 30°	 0°		
ARM RECOIL		 180°	 140-180°	 110-140°	 90-110°	 <90°		
POPLITEAL ANGLE	 180°	 160°	 140°	 120°	 100°	 90°	 <90°	
SCARF SIGN								
HEEL TO EAR								
							TOTAL NEUROMUSCULAR MATURITY SCORE	

PHYSICAL MATURITY

PHYSICAL MATURITY

PHYSICAL MATURITY SIGN	SCORE							RECORD SCORE HERE
	−1	0	1	2	3	4	5	
SKIN	sticky friable transparent	gelatinous red translucent	smooth pink visible veins	superficial peeling and/or rash, few veins	cracking pale areas rare veins	parchment deep cracking no vessels	leathery cracked wrinkled	
LANUGO	none	sparse	abundant	thinning	bald areas	mostly bald		
PLANTAR SURFACE	heel-toe 40-50 mm: −1 <40 mm: −2	>50 mm no crease	faint red marks	anterior transverse crease only	creases ant. 2/3	creases over entire sole		
BREAST	inperceptible	barely perceptible	flat areola no bud	stippled areola 1-2 mm bud	raised areola 3-4 mm bud	full areola 5-10 mm bud		
EYE/EAR	lids fused loosely: −1 tightly: −2	lids open pinna flat stays folded	sl. curved pinna; soft; slow recoil	well-curved pinna; soft but ready recoil	formed and firm instant recoil	thick cartilage ear stiff		
GENITALS (Male)	scrotum flat, smooth	scrotum empty faint rugae	testes in upper canal rare rugae	testes descending few rugae	testes down good rugae	testes pendulous deep rugae		
GENITALS (Female)	clitoris prominent and labia flat	prominent clitoris and small labia minora	prominent clitoris and enlarging minora	majora and minora equally prominent	majora large minora small	majora cover clitoris and minora		
							TOTAL PHYSICAL MATURITY SCORE	

Source: Ballard JL, Khoury JC, Wedig K, et al. New Ballard score, expanded to include extremely premature infants. *J Pediatr* 1991; 119:417-423. Reprinted by permission of Dr. Ballard and Mosby–Year Book, Inc.

SCORE

Neuromuscular_____

Physical_____

Total_____

MATURITY RATING

SCORE	WEEKS
−10	20
−5	22
0	24
5	26
10	28
15	30
20	32
25	34
30	36
35	38
40	40
45	42
50	44

GESTATIONAL AGE
(weeks)

By dates_____

By ultrasound____

By exam_____

PAIN SCALES

Wong-Baker FACES® Foundation (2014). Wong-Baker FACES® Pain Rating Scale. Retrieved January 1, 2014, with permission from http://www.WongBakerFACES.org.

FLACC Pain Scale

Each of the 5 categories is scored from 0 to 2: (F) Face; (L) Legs; (A) Activity; (C) Cry; (C) Consolability. **The total score will be between 0 and 10.**

For pediatric/preverbal (validated 2 months to 7 years)
Not valid for children with developmental delay

CATEGORY	SCORING		
	0	1	2
Face	No particular expression or smile	Occasional grimace or frown, withdrawn, disinterested	Frequent to constant quivering chin, clenched jaw
Legs	Normal position or relaxed	Uneasy, restless, tense	Kicking or legs drawn up
Activity	Lying quietly, normal position, moves easily	Squirming, shifting back and forth, tense	Arched, rigid, or jerking
Cry	No cry (awake or asleep)	Moans or whimpers; occasional complaint	Crying steadily, screams or sobs, frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching, hugging, or being talked to; distractible	Difficult to console or comfort

The FLACC Behavioral Scale for Postoperative Pain in Young Children. Merkel Sl, et al. (1997).

The FLACC: a behavioral scale for scoring postoperative pain in young children. Pediatric Nursing, 23(3), 293–297.

Pediatric Early Warning Score (PEWS)

	0	1	2	3	Score
Behavior	Playing/ Appropriate	Sleeping	Irritable	Lethargic/ confused **OR** Reduced response to pain	
Cardio-vascular	Pink **OR** Capillary refill 1–2 seconds	Pale or dusky **OR** Capillary refill 3 seconds	Grey or cyanotic **OR** Capillary refill 4 seconds **OR** Tachycardia of 20 beats/ min above normal rate	Grey or cyanotic and mottled **OR** Capillary refill 5 seconds or above **OR** Tachycardia of 30 beats/min above normal rate **OR** Bradycardia	
Respiratory	Within normal parameters, no retractions	>10 breaths/ min above normal parameters **OR** Using accessory muscles **OR** 30+%FIO_2 or 3+ liters/min	>20 breaths/ min above normal parameters **OR** Retractions **OR** 40+%FIO_2 or 6+ liters/min	≥5 breaths/ min below normal parameters with retractions, or, grunting **OR** 50+%FIO_2 or 8+ liters/min	

- Score by starting with the most severe parameters first.
- Score 2 extra for every 15-minute nebs (includes continuous nebs) or persistent postoperative vomiting.
- Use "liters/min" to score regular nasal cannula.
- Use "FIO_2" to score a high flow nasal cannula.

Adapted from Monaghan A. Detecting and managing deterioration in children. *Paediatric Nursing.* 2005;17:32–35.

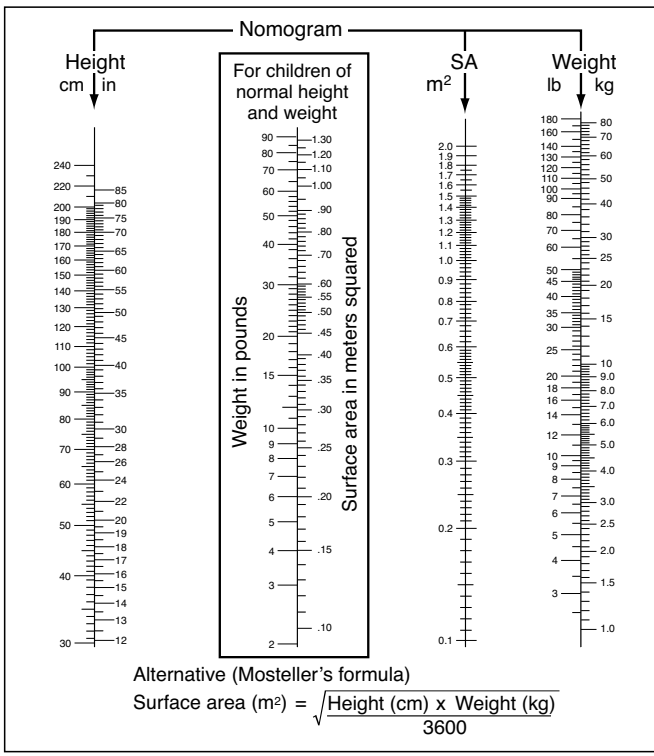
Pediatric Early Warning Score (PEWS), continued

	Heart Rate at Rest (beats/min)	Respiratory Rate at Rest (breaths/min)
Birth – 1 mo	100–180	40–60
1 – 12 mo	100–180	35–40
1 – 3 y	70–110	25–30
4 – 6 y	70–110	21–23
7 – 12 y	70–110	19–21
13 – 19 y	55–90	16–18

3. Growth

DETERMINING BODY SURFACE AREA

Based on the nomogram, a straight line joining the patient's height and weight will intersect the center column at the calculated body surface area (BSA). For children of normal height and weight, use the child's weight in pounds, and then read across to the corresponding BSA in meters squared. Alternatively, you can use Mosteller's formula.



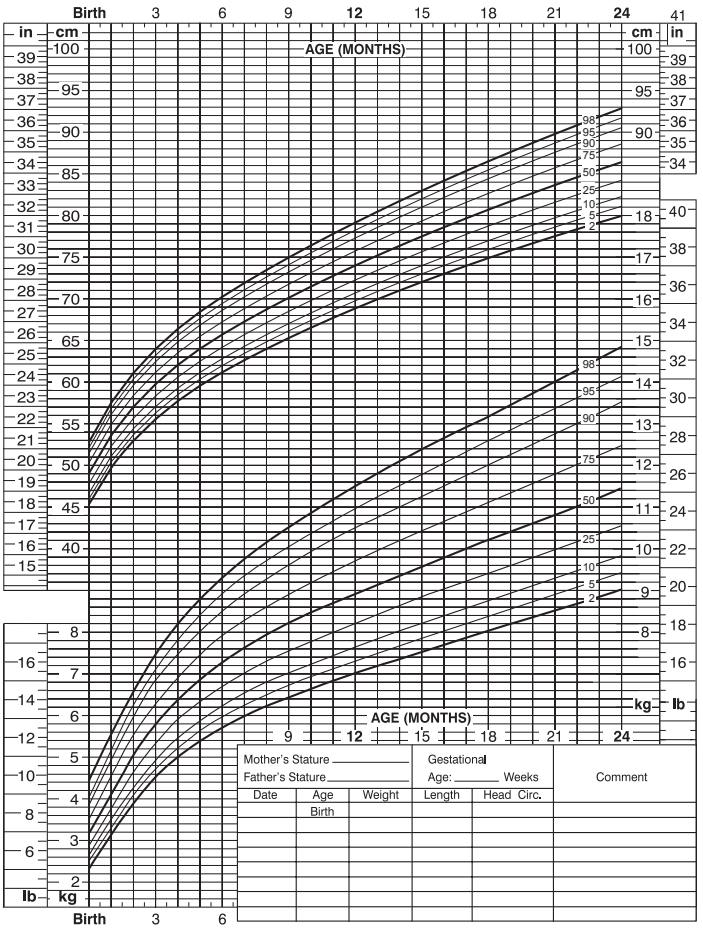
Nomogram and equation to determine body surface area.
From Arcara KM, Tschudy MM, eds. *The Harriet Lane Handbook.* 19th ed. St Louis, MO: Mosby; 2012. Reproduced with permission. Copyright © 2012 Elsevier.

GROWTH CHARTS

Birth to 24 months: Girls
Length-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____

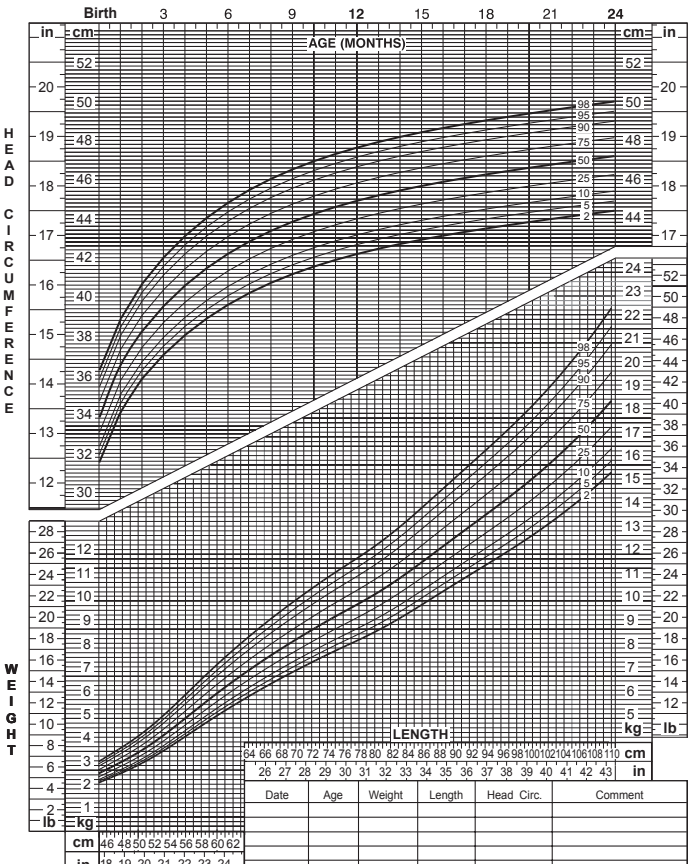


Published by the Centers for Disease Control and Prevention, November 1, 2009
SOURCE: WHO Child Growth Standards (http://www.who.int/childgrowth/en)

Birth to 24 months: Girls
Head circumference-for-age and
Weight-for-length percentiles

NAME _____

RECORD # _____



Date	Age	Weight	Length	Head Circ.	Comment

Published by the Centers for Disease Control and Prevention, November 1, 2009
SOURCE: WHO Child Growth Standards (http://www.who.int/childgrowth/en)

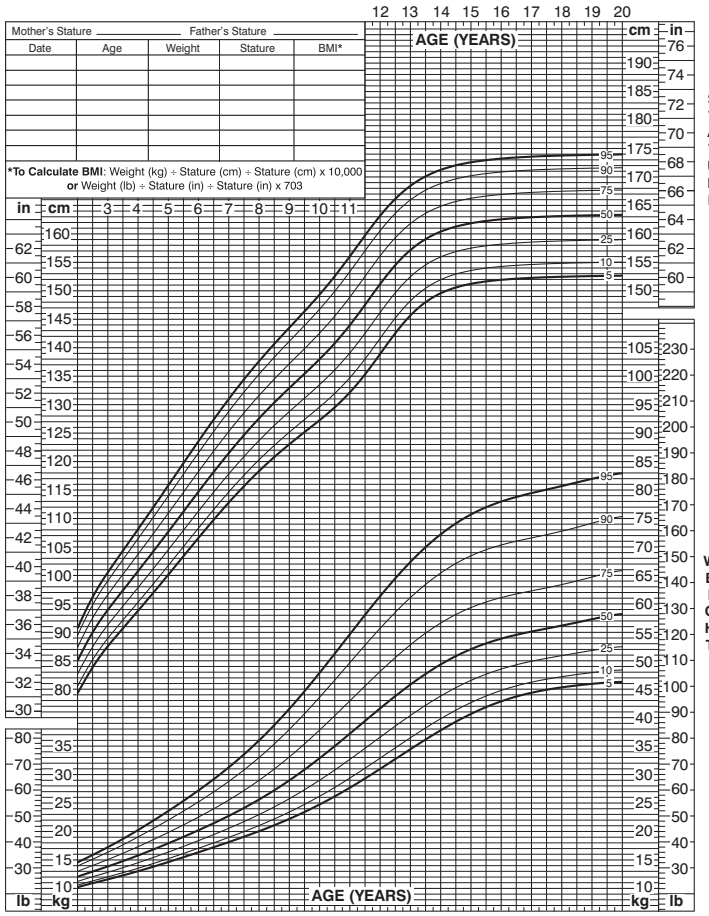
GROWTH CHARTS, continued

2 to 20 years: Girls

Stature-for-age and Weight-for-age percentiles 5th to 95th

NAME _____

RECORD # _____



Revised and corrected November 21, 2000.

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

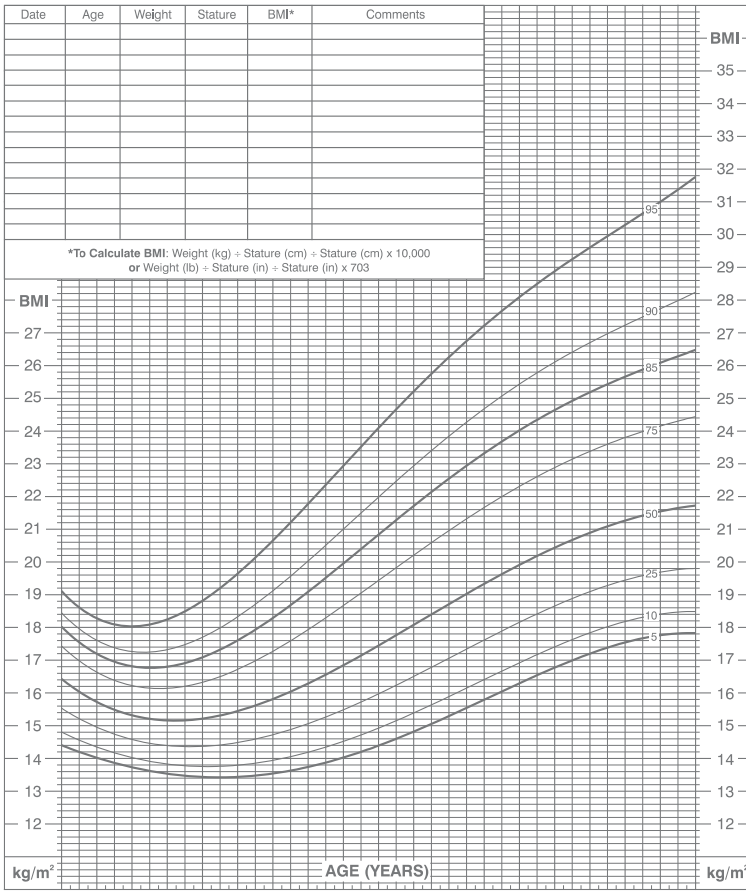
2 to 20 years: Girls
Body mass index-for-age percentiles

NAME _____

RECORD # _____

Date	Age	Weight	Stature	BMI*	Comments

***To Calculate BMI:** Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



Published May 30, 2000 (modified 10/16/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

CDC
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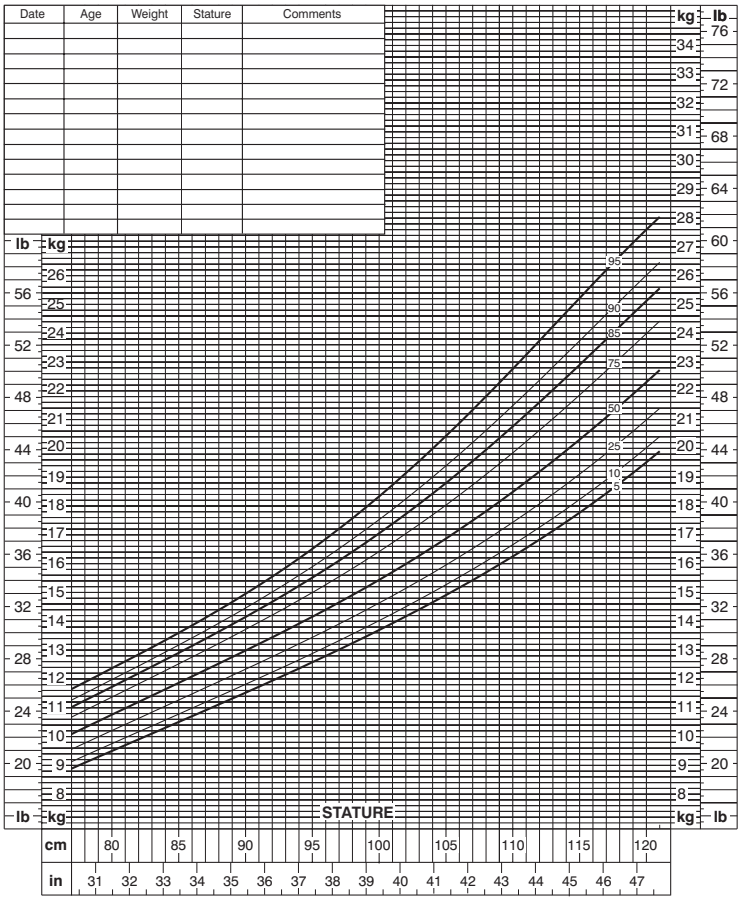
GROWTH CHARTS, continued

NAME _____

RECORD # _____

Weight-for-stature percentiles: Girls

Date	Age	Weight	Stature	Comments



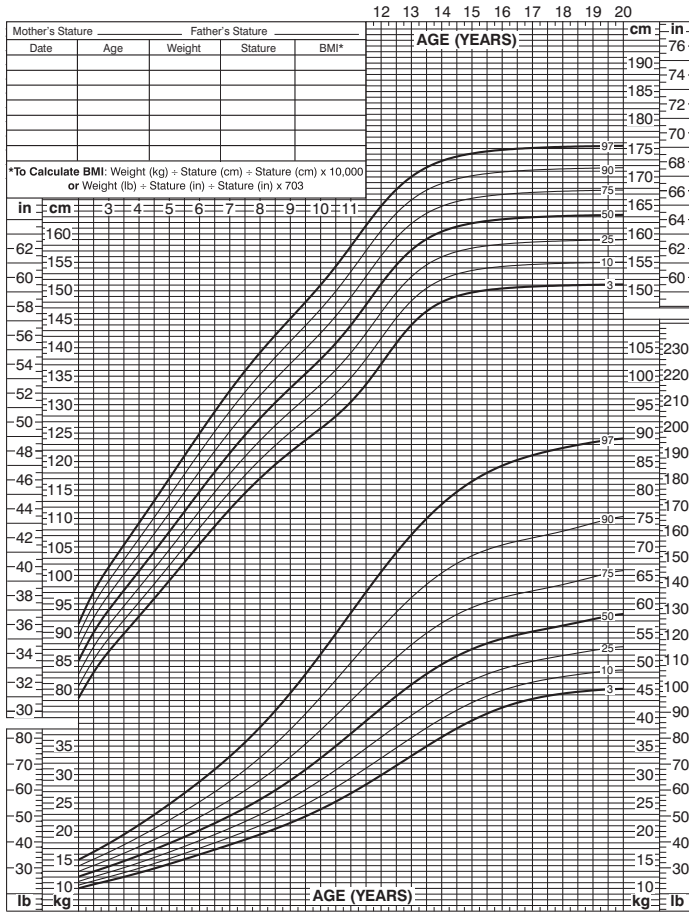
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

CDC

2 to 20 years: Girls
Stature-for-age and Weight-for-age percentiles 3rd to 97th

NAME _____

RECORD # _____



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GROWTH CHARTS, continued

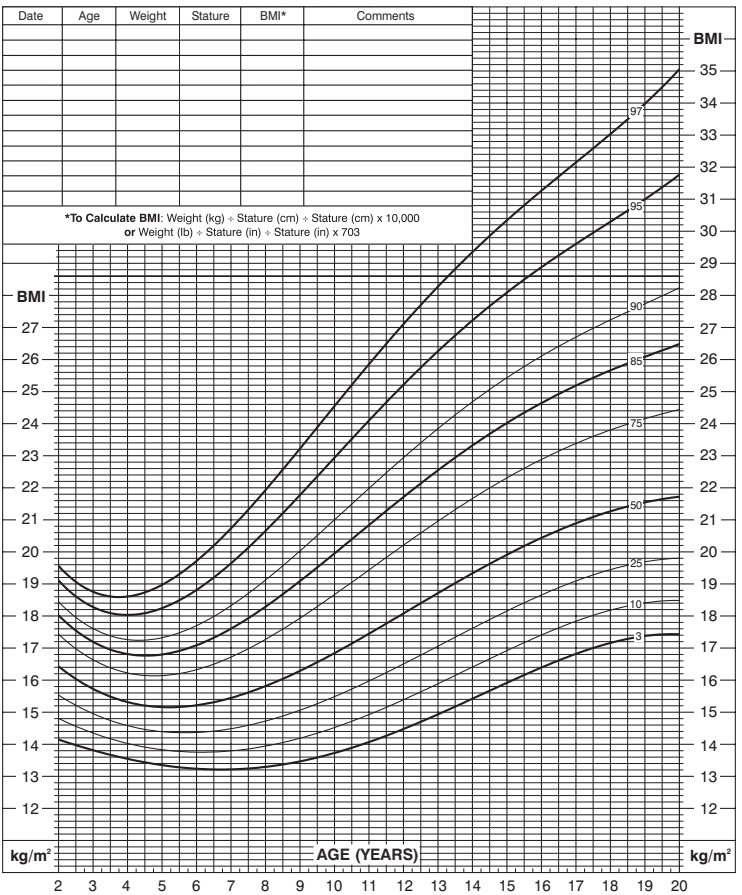
2 to 20 years: Girls
Body mass index-for-age percentiles 3rd to 97th

NAME _____

RECORD # _____

Date	Age	Weight	Stature	BMI*	Comments

***To Calculate BMI:** Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



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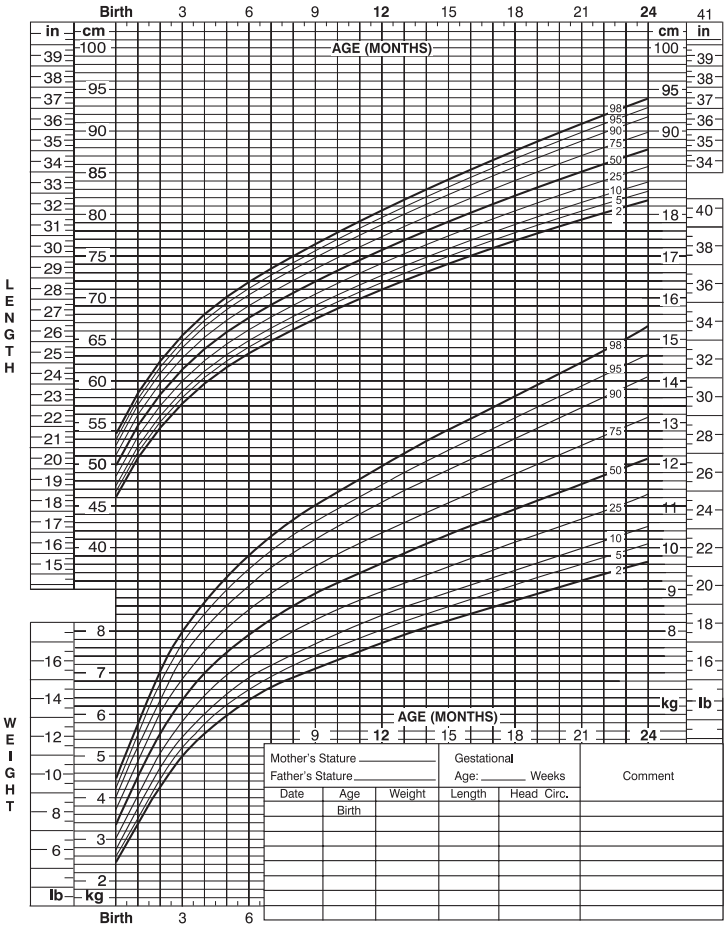
CDC

Birth to 24 months: Boys
Length-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____



Published by the Centers for Disease Control and Prevention, November 1, 2009
SOURCE: WHO Child Growth Standards (http://www.who.int/childgrowth/en)

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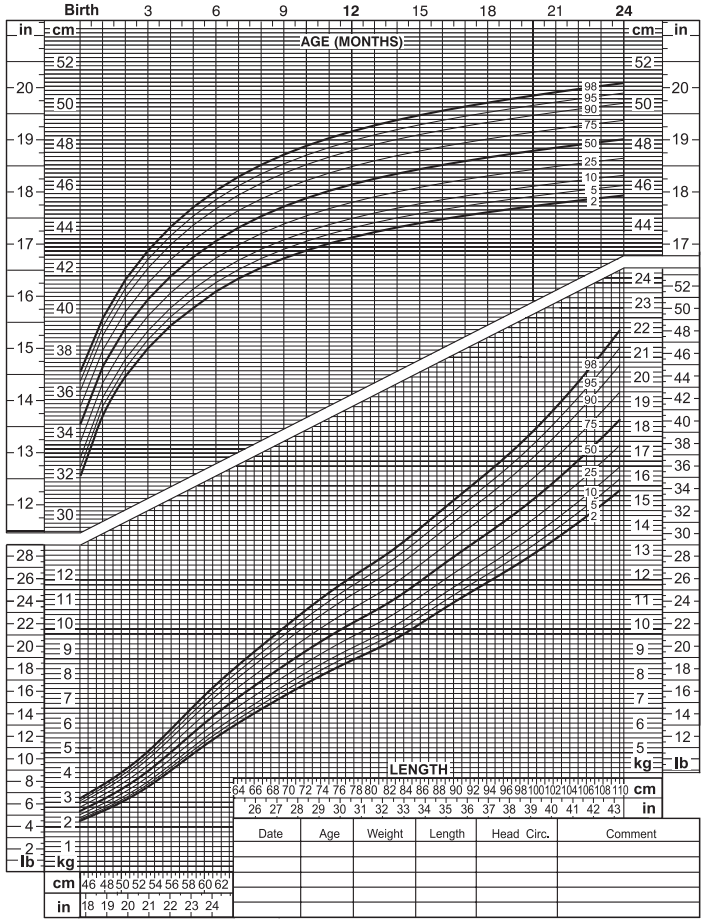
GROWTH CHARTS, continued

Birth to 24 months: Boys
Head circumference-for-age and
Weight-for-length percentiles

NAME _____

RECORD # _____



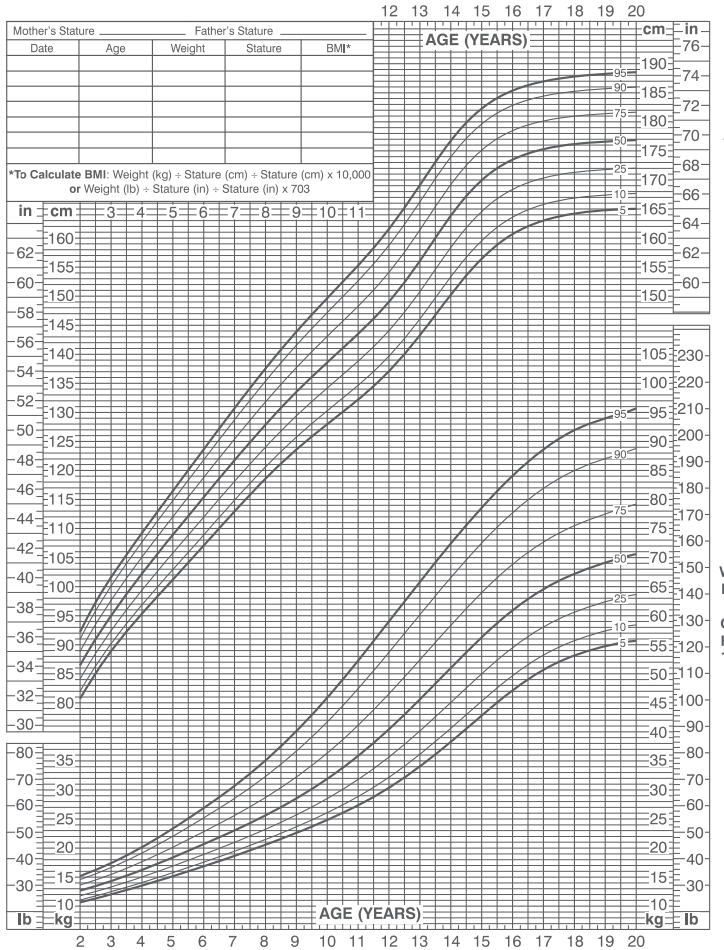
Date	Age	Weight	Length	Head Circ.	Comment

Published by the Centers for Disease Control and Prevention, November 1, 2009
SOURCE: WHO Child Growth Standards (http://www.who.int/childgrowth/en)

2 to 20 years: Boys
Stature-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____



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GROWTH CHARTS, continued

2 to 20 years: Boys
Body mass index-for-age percentiles

NAME _____

RECORD # _____

Date	Age	Weight	Stature	BMI*	Comments

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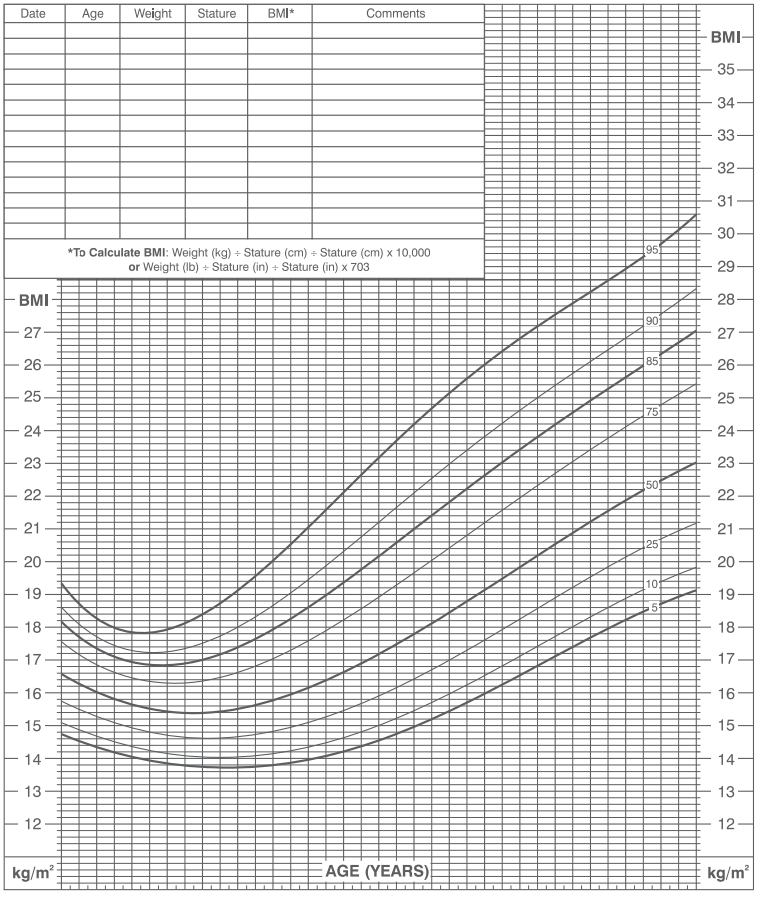

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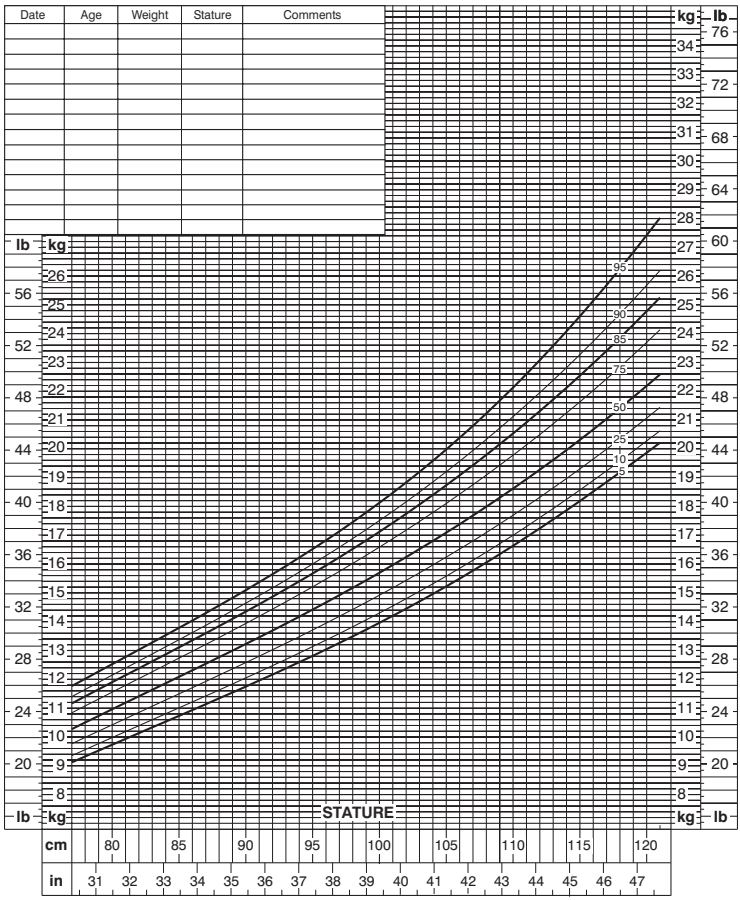
NAME _____

RECORD # _____

Weight-for-stature percentiles: Boys

Date	Age	Weight	Stature	Comments



SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

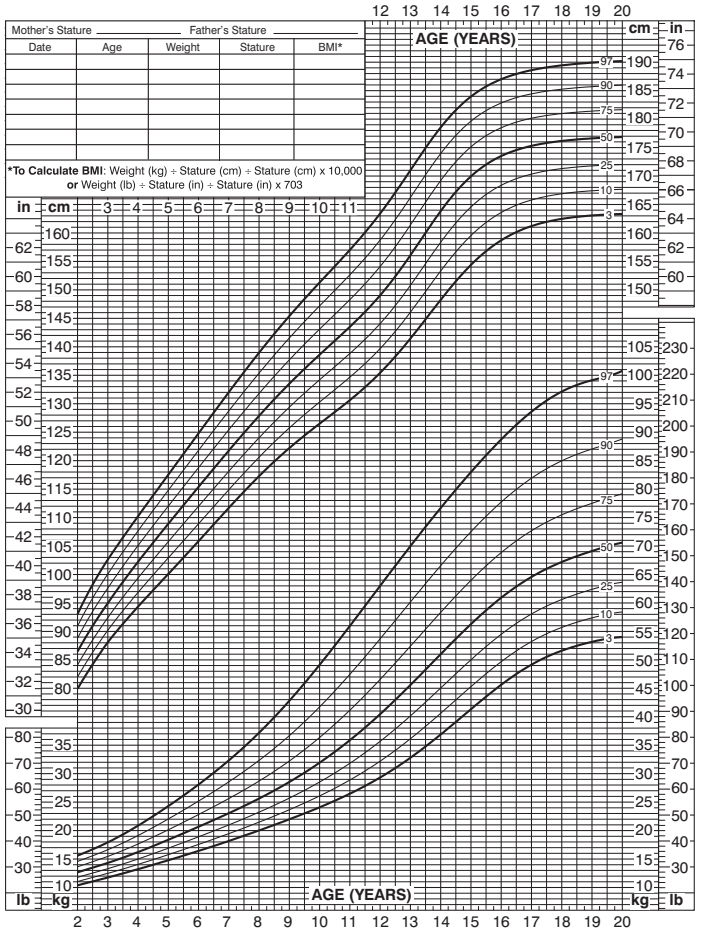
CDC

GROWTH CHARTS, continued

2 to 20 years: Boys
Stature-for-age and Weight-for-age percentiles 3rd to 97th

NAME _____

RECORD # _____



Revised and corrected November 21, 2000.

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

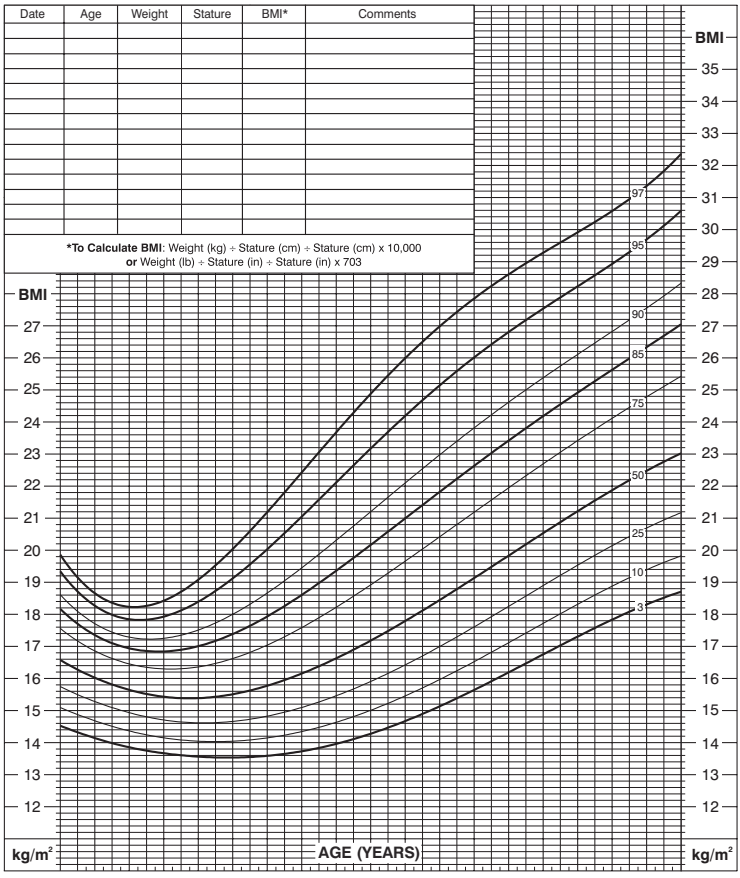
2 to 20 years: Boys
Body mass index-for-age percentiles 3rd to 97th

NAME _____

RECORD # _____

Date	Age	Weight	Stature	BMI*	Comments

***To Calculate BMI**: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703

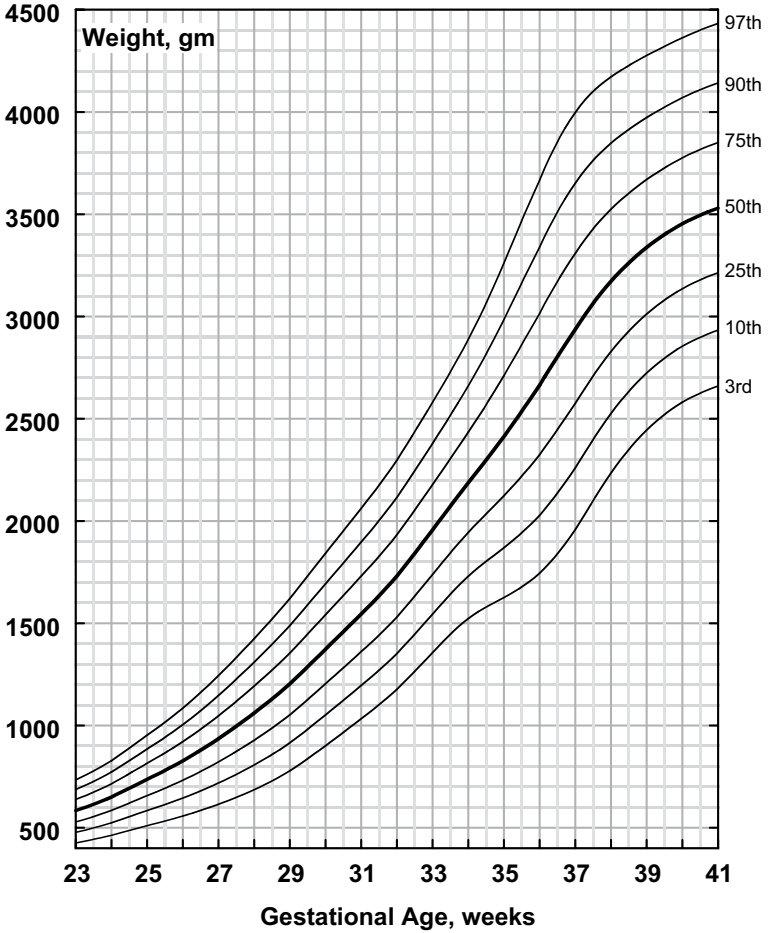


SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

CDC

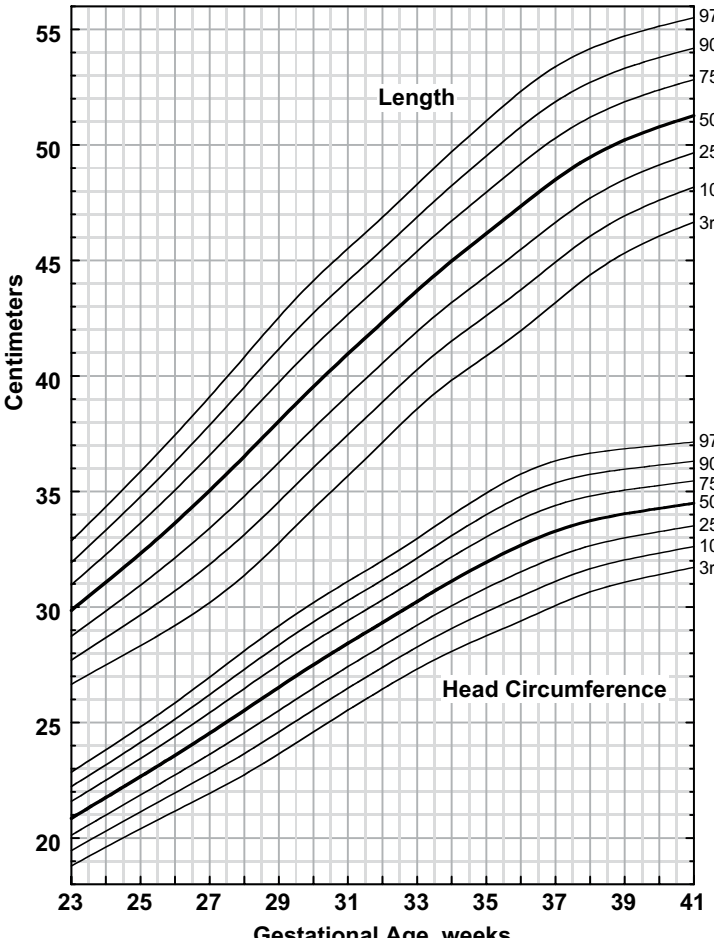
GROWTH CHARTS, continued

Neonatal Growth Curve—Girls, Weight



From Olsen IE, Groveman S, Lawson ML, Clark R, Zemel B. New intrauterine growth curves based on U.S. data. *Pediatrics.* 2010;125(2):e214–e244

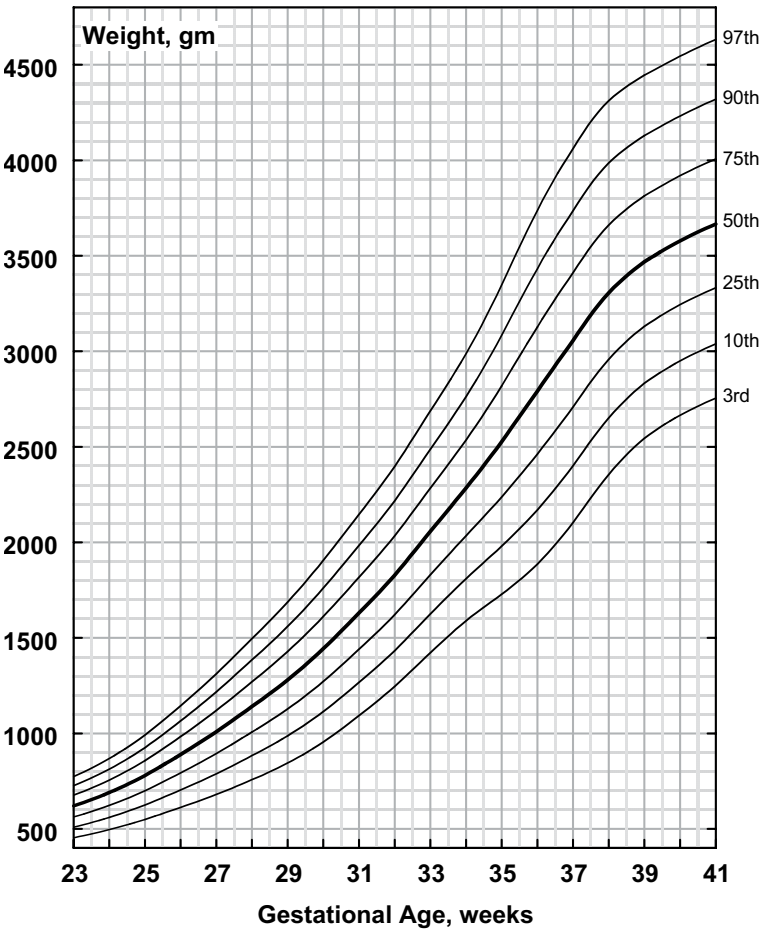
Neonatal Growth Curve—Girls, Length and Head Circumference



From Olsen IE, Groveman S, Lawson ML, Clark R, Zemel B. New intrauterine growth curves based on U.S. data. *Pediatrics.* 2010;125(2):e214–e244

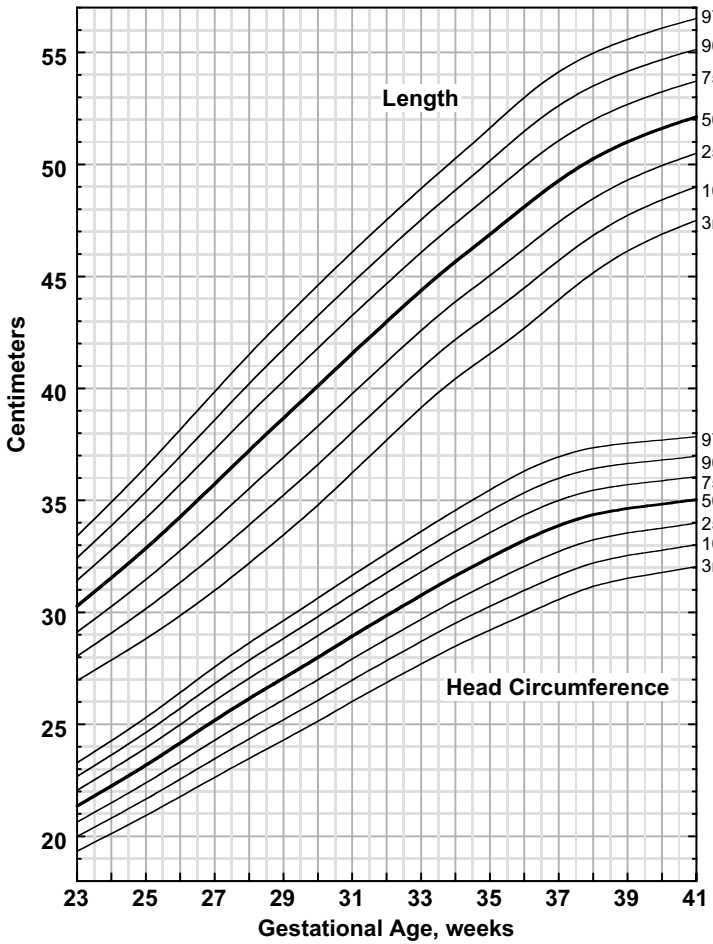
GROWTH CHARTS, continued

Neonatal Growth Curve — Boys, Weight



From Olsen IE, Groveman S, Lawson ML, Clark R, Zemel B. New intrauterine growth curves based on U.S. data. *Pediatrics.* 2010;125(2):e214–e244

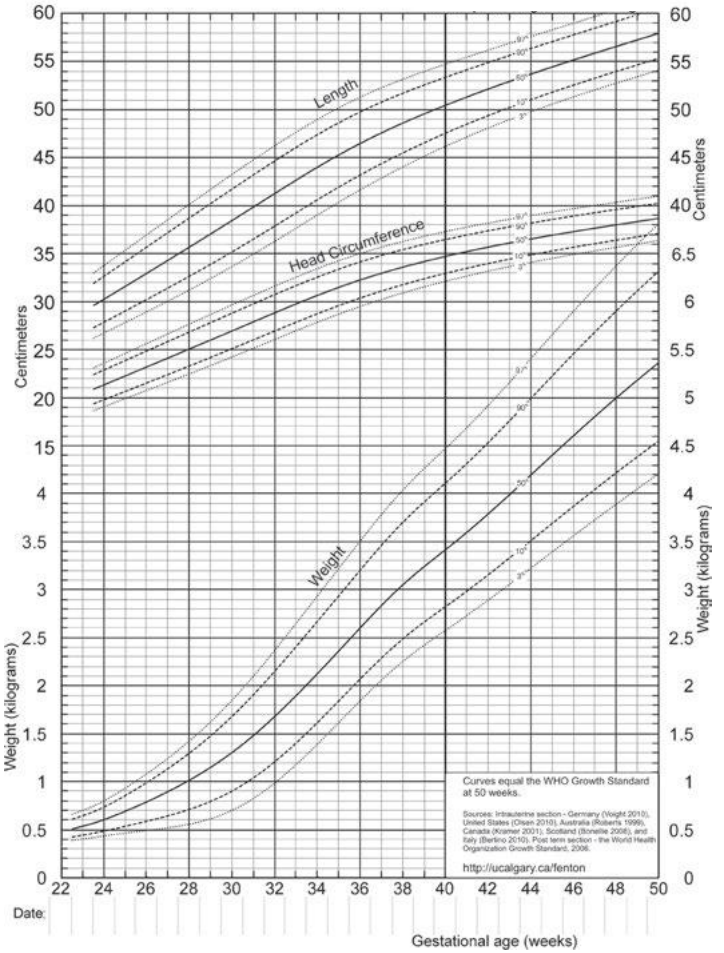
Neonatal Growth Curve—Boys, Length and Head Circumference



From Olsen IE, Groveman S, Lawson ML, Clark R, Zemel B. New intrauterine growth curves based on U.S. data. *Pediatrics.* 2010;125(2):e214–e244

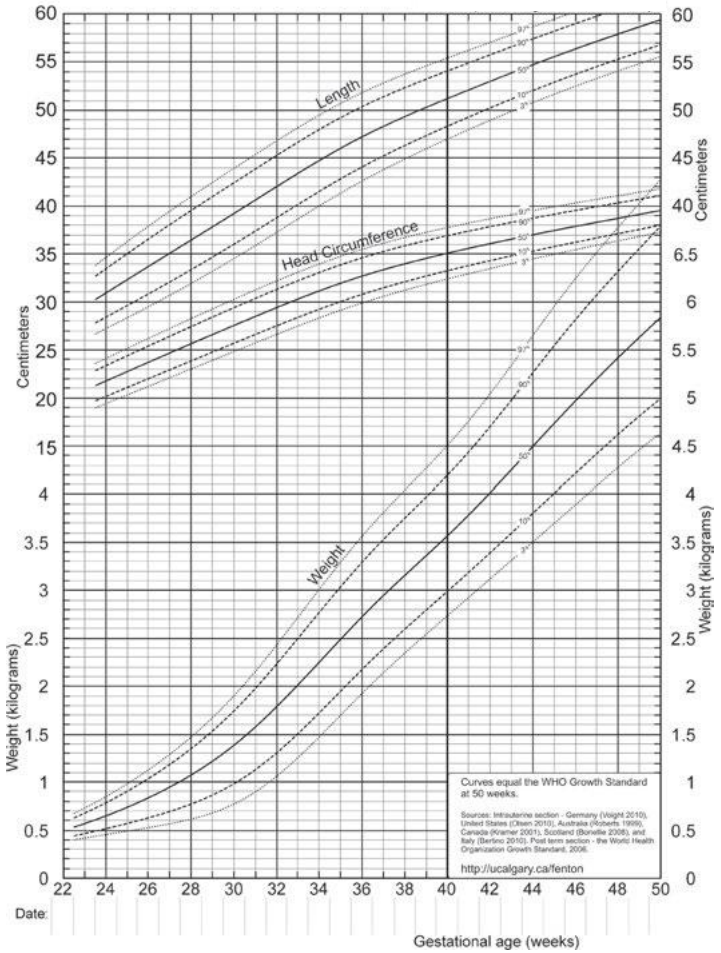
GROWTH CHARTS, continued

Fenton Preterm Growth Chart — Girls



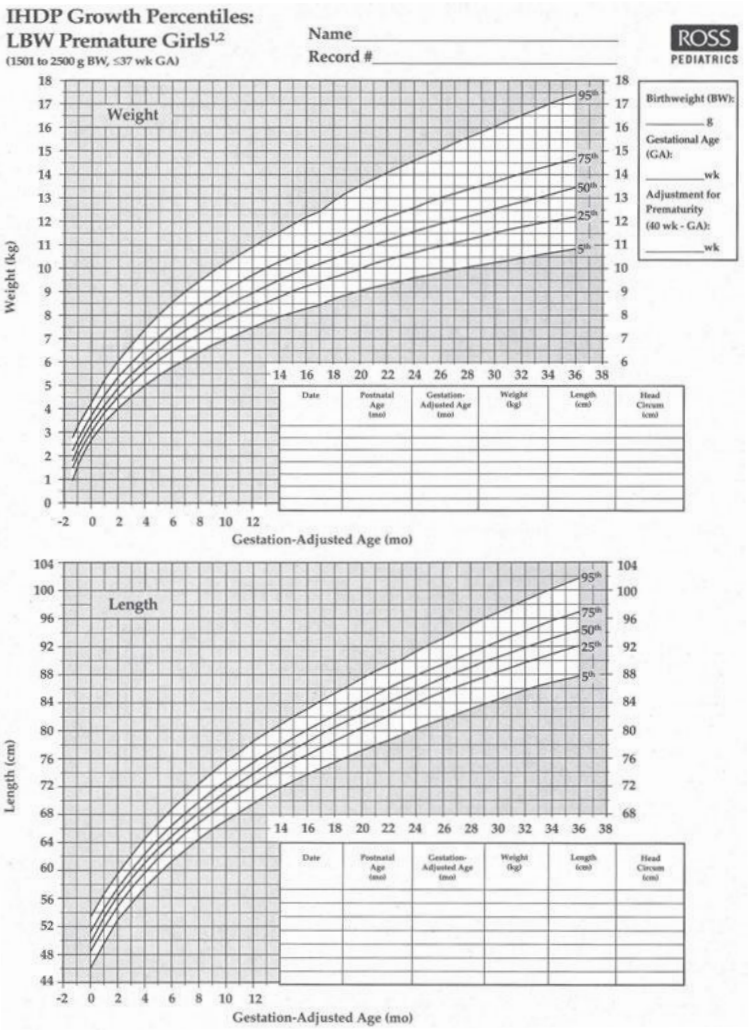
Reproduced with permission from Fenton TR, Kim JH. A systematic review and meta-analysis to revise the Fenton growth chart for preterm infants. *BMC Pediatr.* 2013;13:59. © 2013 Fenton and Kim; licensee BioMed Central Ltd.

Fenton Preterm Growth Chart—Boys

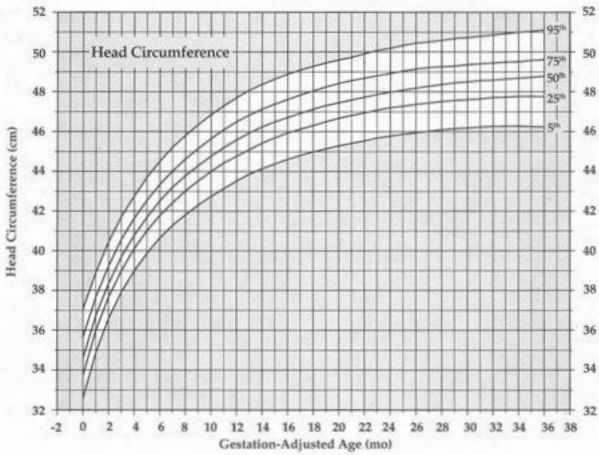


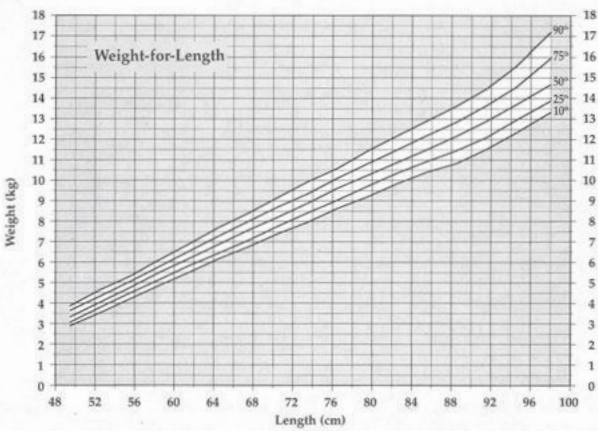
GROWTH CHARTS, continued

IHDP Low Birth Weight and Very Low Birth Weight Growth Charts



IHDP Growth Percentiles: LBW Premature Girls[1,2]





References

1. Guo SS, Roche AF, Chumlea WC, et al: Growth in weight, recumbent length, and head circumference for preterm low-birthweight infants during the first three years of life using gestation-adjusted ages. *Early Hum Dev* 1995;47:305-325.
2. Guo SS, Wholihan K, Roche AF, et al: Weight-for-length reference data for preterm, low-birth-weight infants. *Arch Pediatr Adolesc Med* 1996;150:964-970. Copyright 1996, American Medical Association.

Acknowledgment

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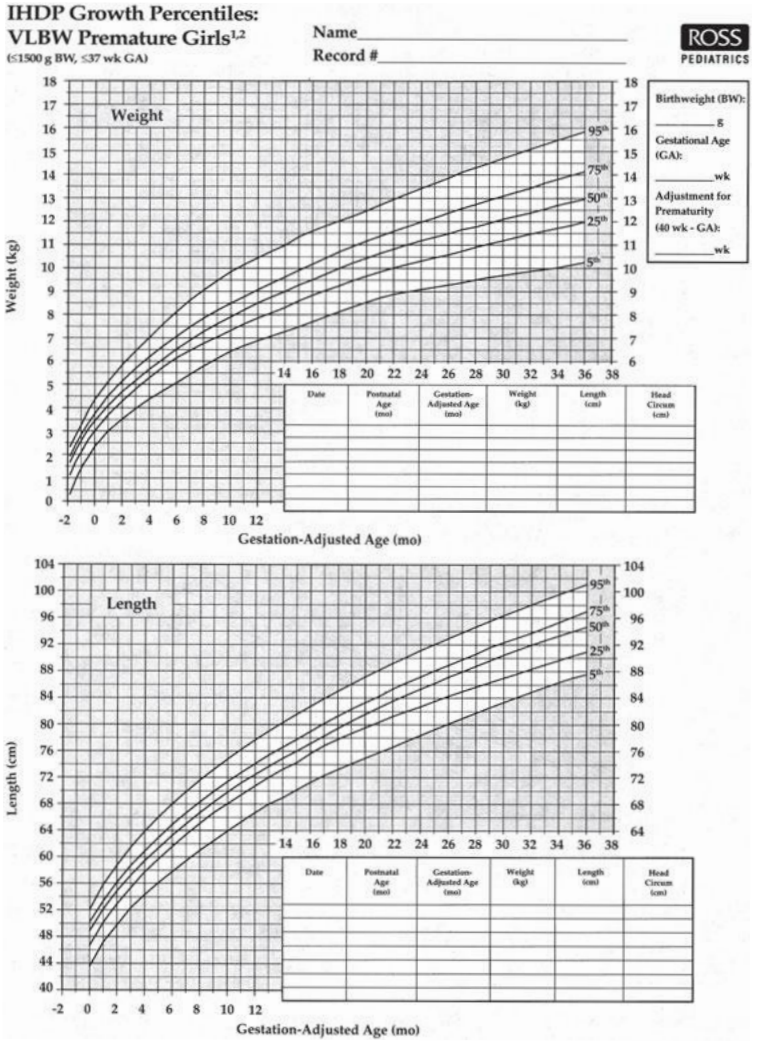
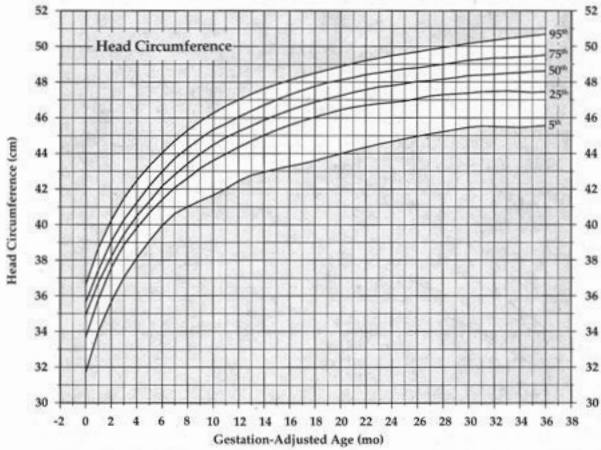
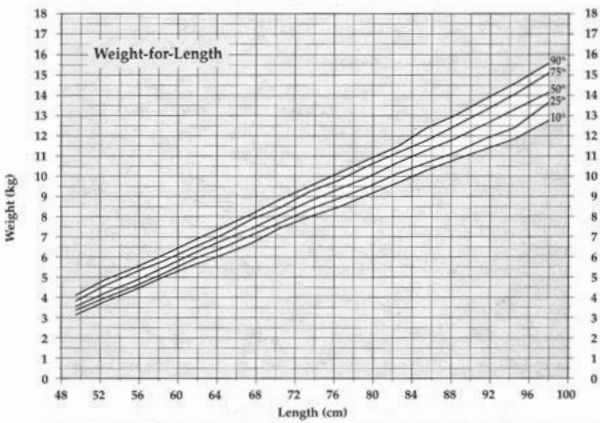
GROWTH CHARTS, continued



IHDP Growth Percentiles: VLBW Premature Girls[1,2]





References

1. Guo SS, Roche AF, Chumlea WC, et al: Growth in weight, recumbent length, and head circumference for preterm low-birthweight infants during the first three years of life using gestation-adjusted ages. *Early Hum Dev* 1997;47:305-325.
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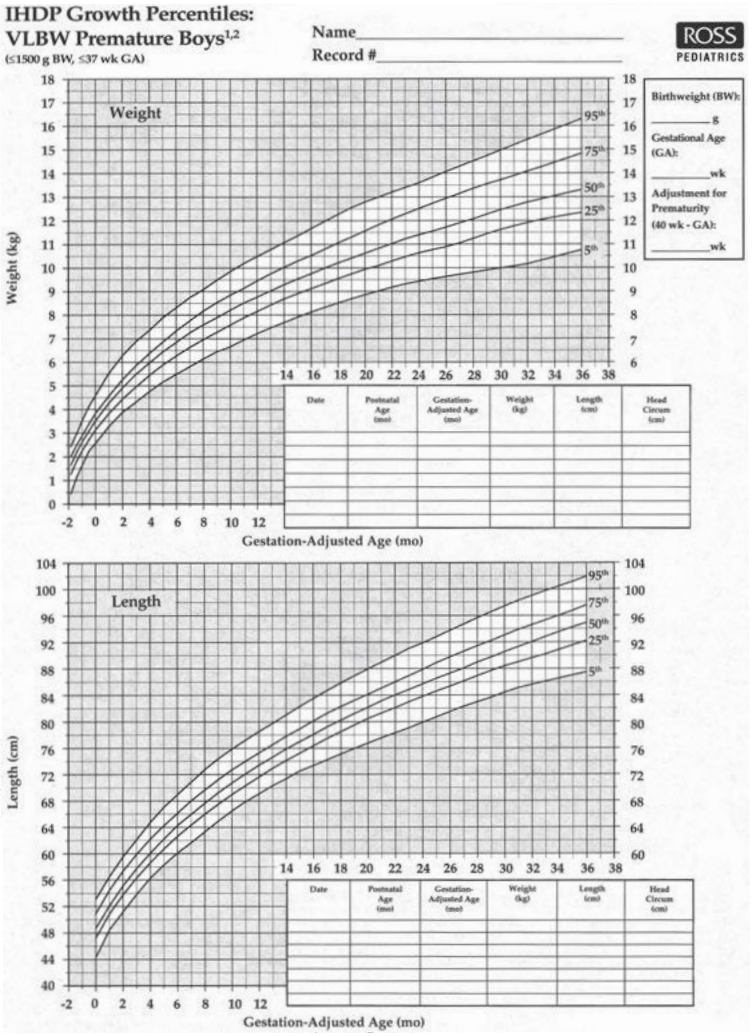
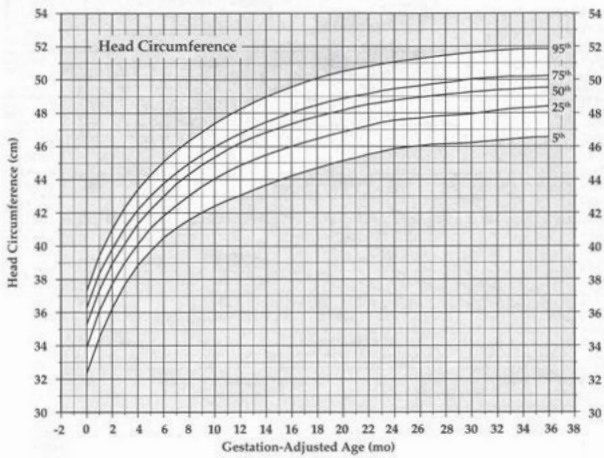
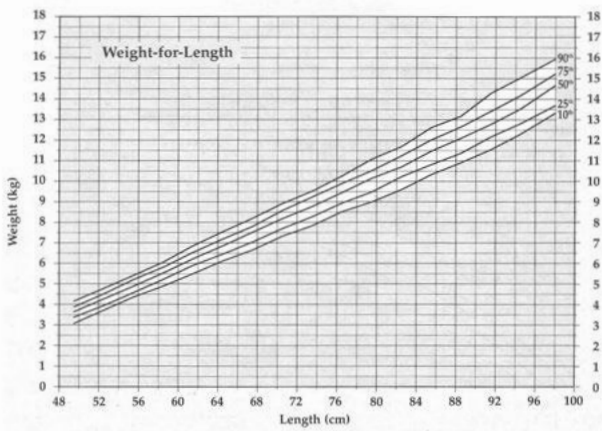
GROWTH CHARTS, continued



IHDP Growth Percentiles: VLBW Premature Boys[1,2]





References

1. Guo SS, Roche AF, Chumlea WC, et al: Growth in weight, recumbent length, and head circumference for preterm low-birthweight infants during the first three years of life using gestation-adjusted ages. *Early Hum Dev* 1997;47:305-325.
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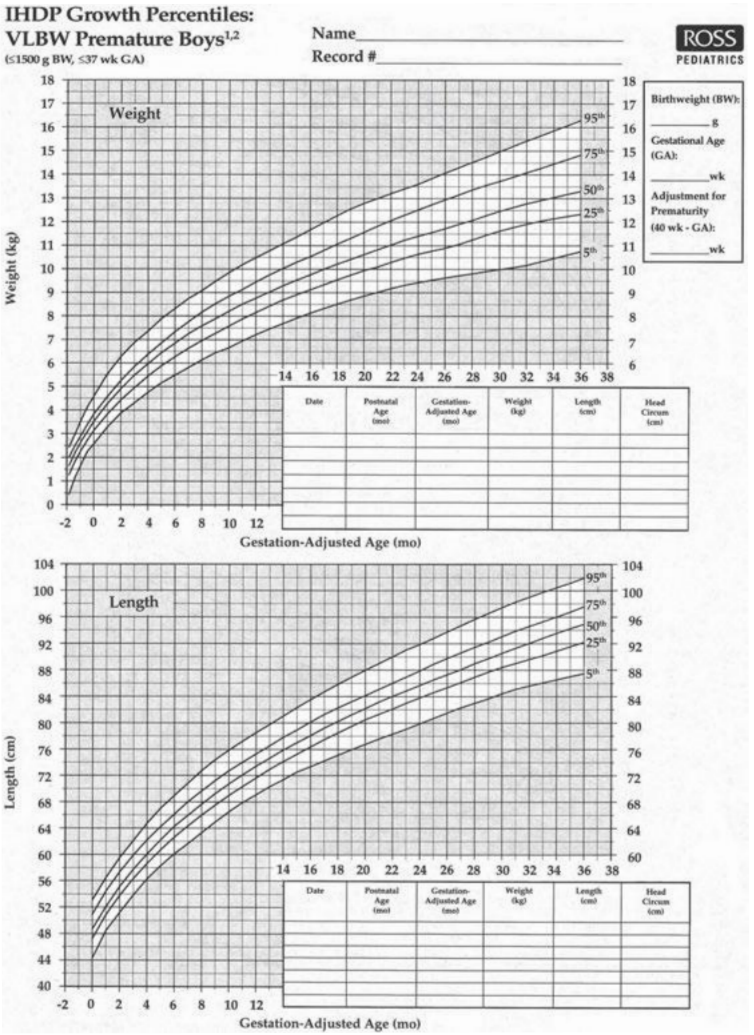
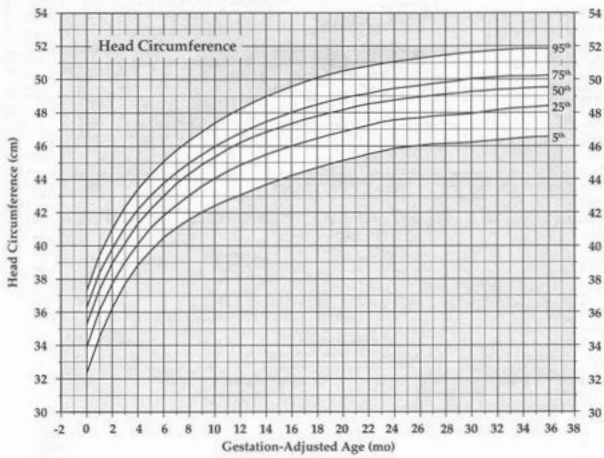
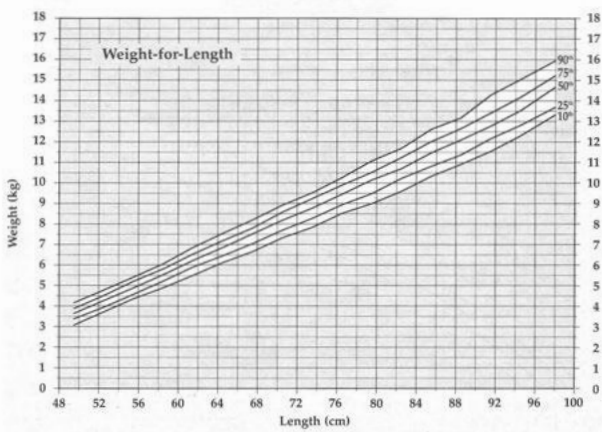
GROWTH CHARTS, continued



IHDP Growth Percentiles: VLBW Premature Boys[1,2]





References

1. Guo SS, Roche AF, Chumlea WC, et al: Growth in weight, recumbent length, and head circumference for preterm low-birthweight infants during the first three years of life using gestation-adjusted ages. *Early Hum Dev* 1997;47:305-325.
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GROWTH CHARTS FOR CHILDREN WITH SPECIAL HEALTH CARE NEEDS

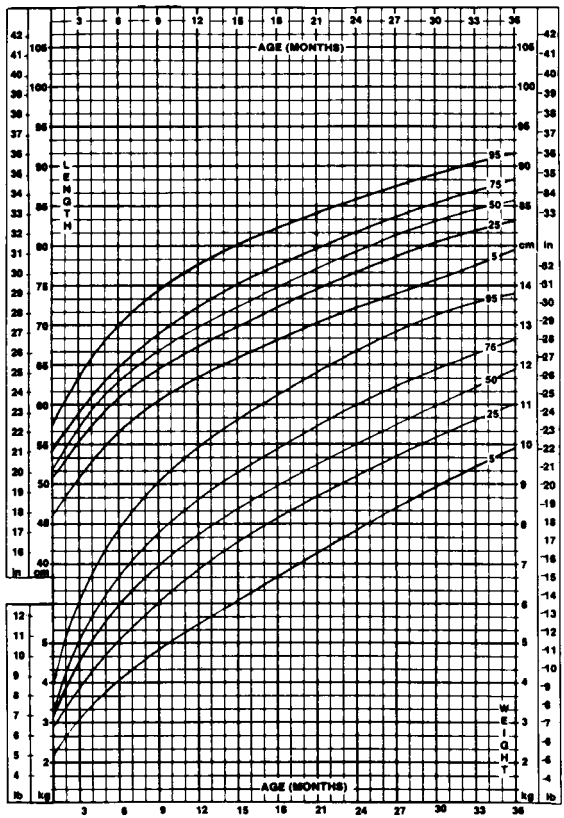
Several growth charts are available for children with special health care needs. Listed below are some charts for children with genetic conditions that can alter growth.

- Trisomy 21 (Down syndrome) (Cronk, 1988)
- Prader-Willi syndrome (Holm, 1995)
- Williams syndrome (Morris, 1988)
- Cornelia de Lange syndrome (Kline, 1993)
- Turner syndrome (Ranke, 1983; Lyon, 1985)
- Rubinstein-Taybi syndrome (Stevens, 1990)
- Marfan syndrome (Pyeritz, 1983; Pyertiz, 1985)
- Achondroplasia (Horton, 1978)

Currently, the CDC recommends that clinicians use the regular CDC growth charts for assessment of all these children. The inherent limitations of studies performed in each of these specific populations (eg, small sample size, retrospective nature of data, presence of other congenital anomalies such as cardiac conditions, inability to ascertain the nutritional status of these children, lack of ethnic diversity, and old data) may not afford the clinician an accurate assessment of growth in these children.

We have provided a sample of the Trisomy 21 growth chart, but clinicians should be aware of the inherent limitations of this study.

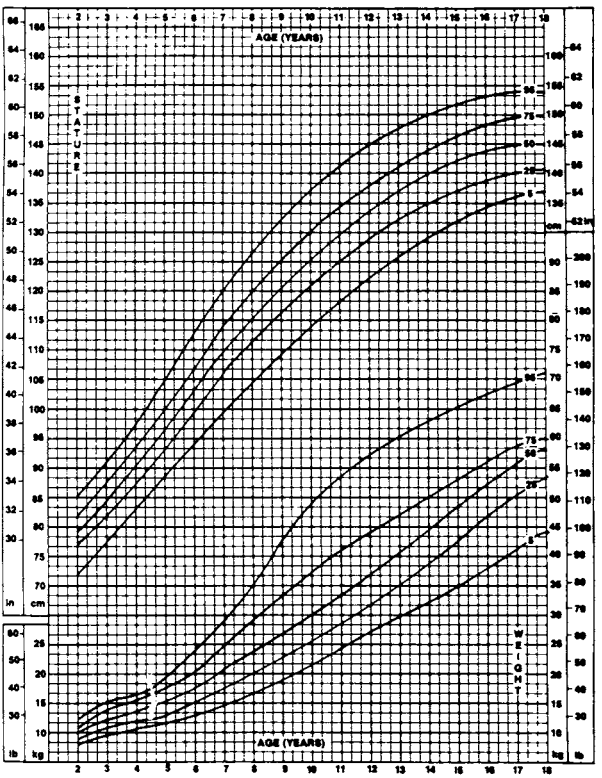
Height and Weight for Girls With Down Syndrome (1–36 mo)



From Cronk C, Crocker AC, Pueschel SM, et al. Growth charts for children with Down syndrome: 1 month to 18 years of age. *Pediatrics.* 1988;81(1):102–110.

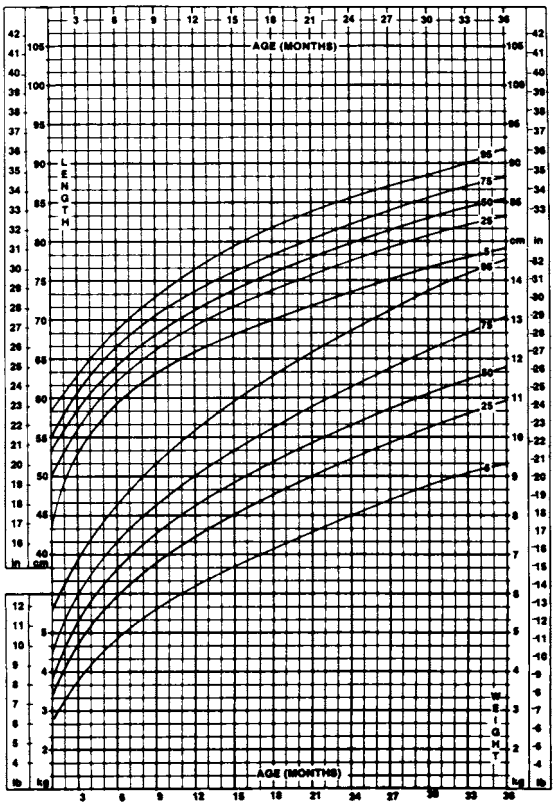
GROWTH CHARTS FOR CHILDREN WITH SPECIAL HEALTH CARE NEEDS, continued

Height and Weight for Girls With Down Syndrome (2–18 y)



From Cronk C, Crocker AC, Pueschel SM, et al. Growth charts for children with Down syndrome: 1 month to 18 years of age. *Pediatrics.* 1988;81(1):102–110.

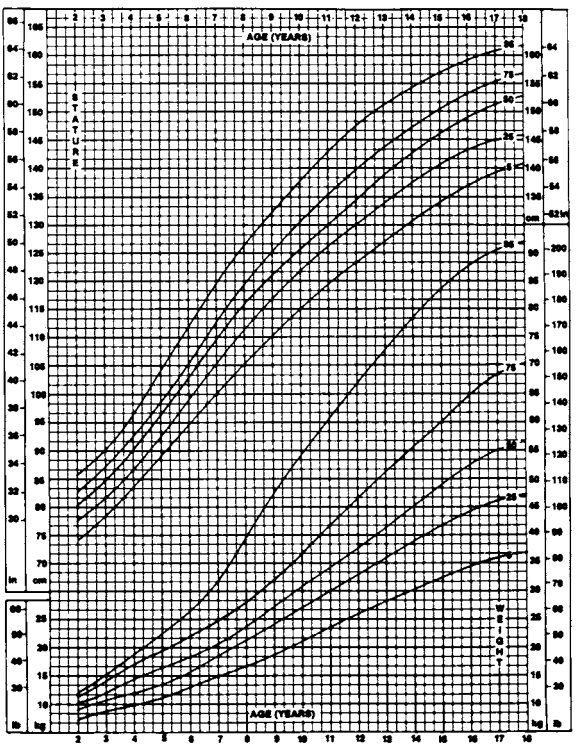
Height and Weight for Boys With Down Syndrome (1–36 mo)



From Cronk C, Crocker AC, Pueschel SM, et al. Growth charts for children with Down syndrome: 1 month to 18 years of age. *Pediatrics.* 1988;81(1):102–110.

GROWTH CHARTS FOR CHILDREN WITH SPECIAL HEALTH CARE NEEDS, continued

Height and Weight for Boys With Down Syndrome (2–18 y)



From Cronk C, Crocker AC, Pueschel SM, et al. Growth charts for children with Down syndrome: 1 month to 18 years of age. *Pediatrics.* 1988;81(1):102–110.

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Cronk C, Crocker AC, Pueschel SM, et al. Growth charts for children with Down syndrome: 1 month to 18 years of age. *Pediatrics*. 1988;81(1):102–110

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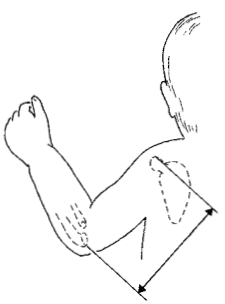
Stevens CA, Hennekam RC, Blackburn BL. Growth in the Rubinstein-Taybi syndrome. *Am J Med Genet Suppl*. 1990;6:51–55

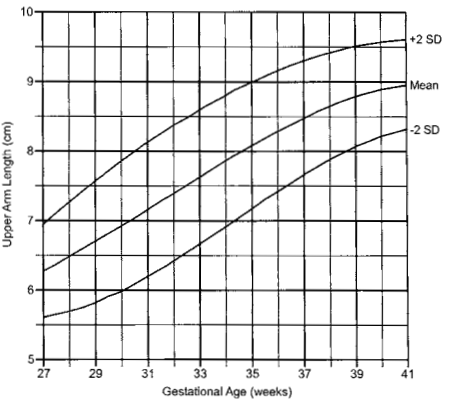
GROWTH MEASURES FOR EXTREMITIES/EAR ABOVE EYE LEVELS

The following measures show the normal ranges for upper and lower extremities and level of ears for newborns. They can be used to determine abnormalities (eg, newborns with suspected genetic anomalies or children with contractures where full limb length may not be feasible). The illustrations show the optimal method to measure. The graph can be used to plot measurements and determine percentiles.

Upper Arm Length

Mean ± 2 SD for length of the upper arm plotted against gestational age. Upper arm length is measured from the acromion to the olecranon with the elbow bent at 90 degrees. Measurements were made on 87 term (48 male and 39 female) and 111 preterm (55 male and 56 female) newborn Israeli infants between 27 and 41 weeks menstrual age. Measurements were made between 36 and 60 hours of age. No infants had congenital anomalies. Source: Merlob P, et al. *Birth Defects Orig Artic Ser.* 1984;20(7):1-52.

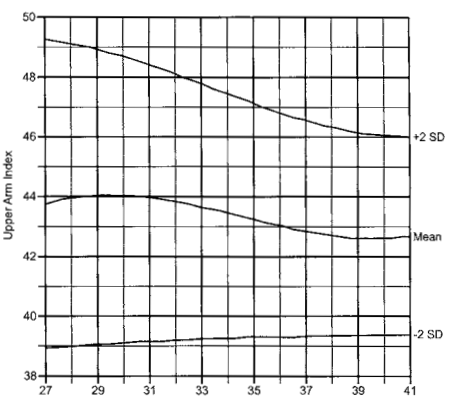




Mean ± 2 SD for arm index plotted against gestational age.

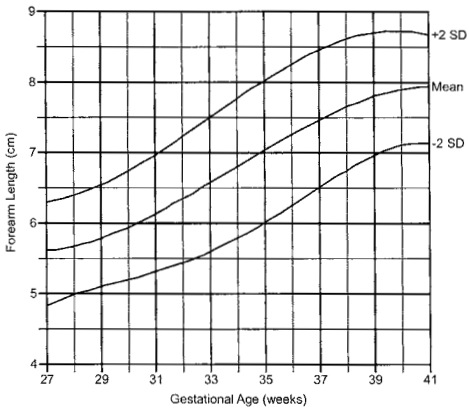
$$\text{Upper arm index} = 100 \times \frac{\text{Upper arm length}}{\text{Upper limb length}}$$

See above legend for sample information. Source: Merlob P, et al. *Birth Defects Orig Artic Ser.* 1984;20(7):1-52.

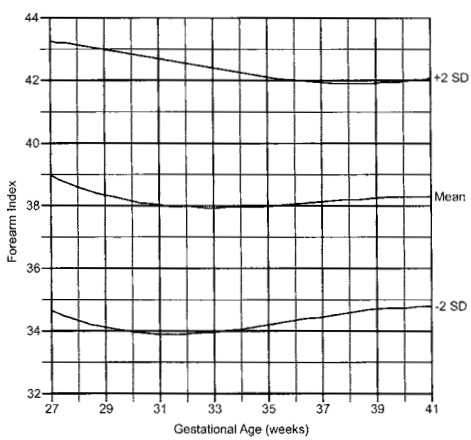


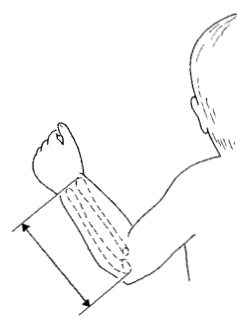
From Rollins JD, Tribble LM, Collins JS, et al, eds. *Growth References.* 3rd ed. Greenwood, SC: Greenwood Genetic Center, 2011.

Forearm Length



Mean ± 2 SD for forearm length plotted against gestational age. Forearm length is measured from the olecranon process to the distal end of the styloid process of the radius with the elbow bent at 90 degrees. Measurements were made on 87 term (48 male and 39 female) and 111 preterm (55 male and 56 female) newborn Israeli infants between 27 and 41 weeks gestational age. Measurements were made between 36 and 60 hours of age. No infants had congenital anomalies. Source: Merlob P, et al. *Birth Defects Orig Artic Ser.* 1984;20(7):1-52.





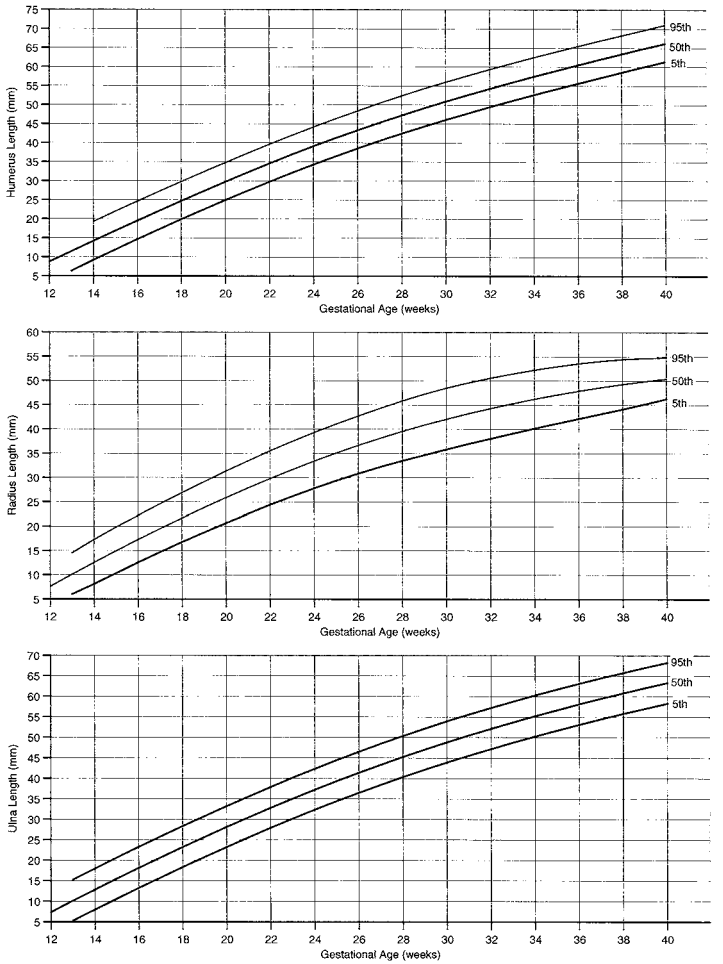
Mean ± 2 SD for forearm index plotted against gestational age.

$$\text{Forearm index} = 100 \times \frac{\text{Forearm length}}{\text{Upper limb length}}$$

See above legend for sample information. Source: Merlob P, et al. *Birth Defects Orig Artic Ser.* 1984;20(7):1-52.

From Rollins JD, Tribble LM, Collins JS, et al, eds. *Growth References.* 3rd ed. Greenwood, SC: Greenwood Genetic Center, 2011.

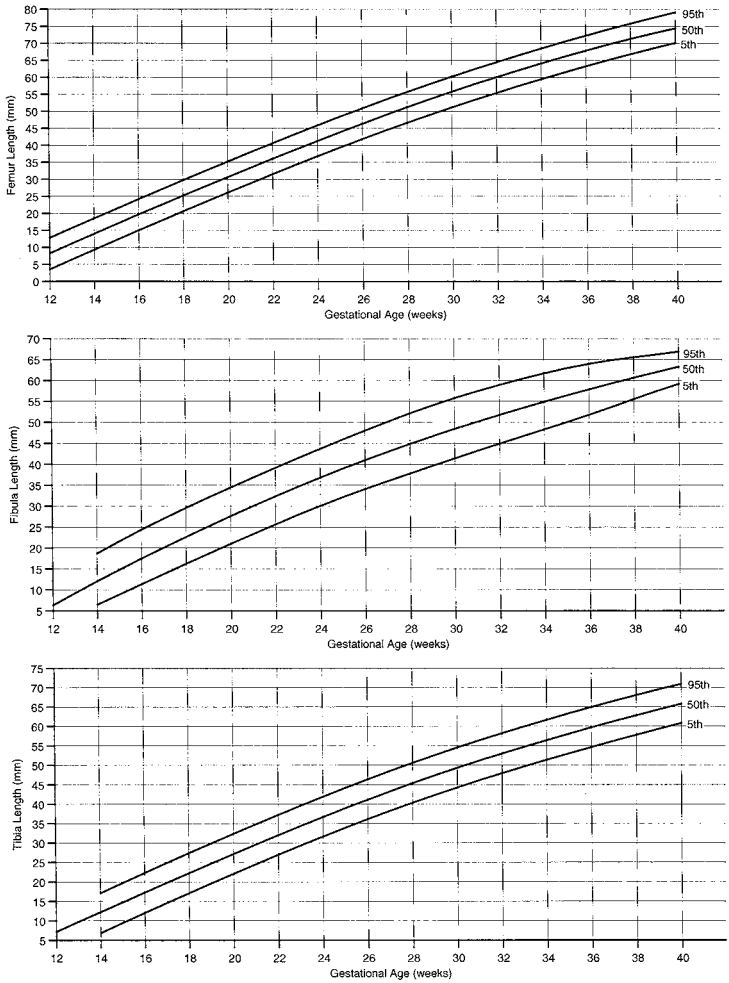
Long Bone Length–Upper Limb



Length of long bones of arm as assessed by ultrasound. Smoothed from tabulated values in: Hansmann, et al. *Ultrasound Diagnosis in Obstetrics and Gynecology*, Berlin: Springer-Verlag, 1986.

From Rollins JD, Tribble LM, Collins JS, et al, eds. *Growth References.* 3rd ed. Greenwood, SC: Greenwood Genetic Center, 2011.

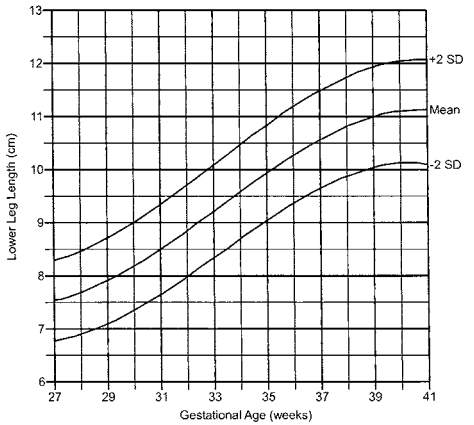
Long Bone Length–Lower Limb



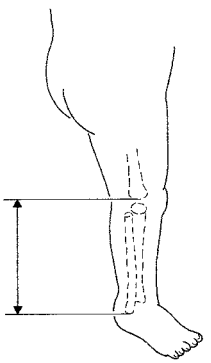
Length of the long bones of the leg as assessed by ultrasound. Derived from tabulated values in: Hansmann, et al. *Ultrasound Diagnosis in Obstetrics and Gynecology*. Berlin: Springer-Verlag, 1986.

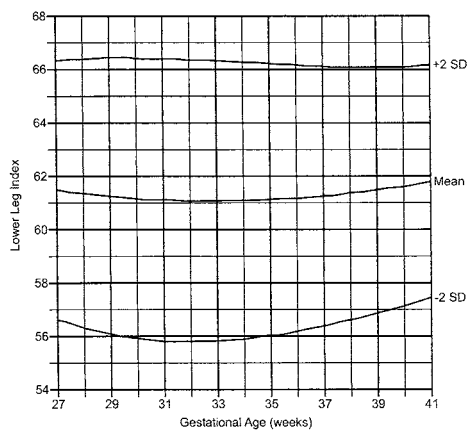
From Rollins JD, Tribble LM, Collins JS, et al, eds. *Growth References*. 3rd ed. Greenwood, SC: Greenwood Genetic Center, 2011.

Lower Leg Length



Mean ± 2 SD for lower leg length plotted against gestational age. Lower leg length is measured from the lateral femoral condyle to the lateral malleolus. Measurements were made on 87 term (48 male and 39 female) and 111 preterm (55 male and 56 female) newborn Israeli infants between 27 and 41 weeks gestational age. Measurements were made between 36 and 60 hours of age. No infants had congenital anomalies. Source: Merlob P, et al. *Birth Defects Orig Artic Ser*. 1984;20(7):1-52.





Mean ± 2 SD for lower leg index plotted against gestational age.

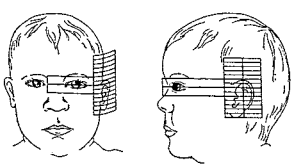
$$\text{Lower leg index} = 100 \times \frac{\text{Lower leg length}}{\text{Lower limb length}}$$

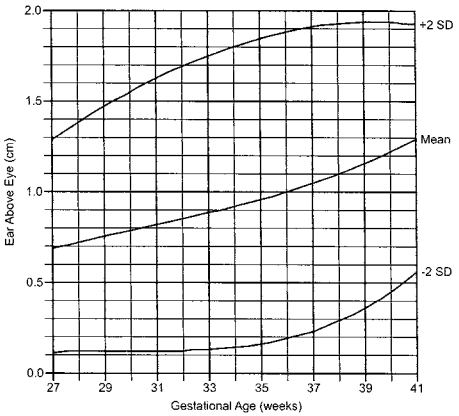
See above legend for sample information. Source: Merlob P, et al. *Birth Defects Orig Artic Ser*. 1984;20(7):1-52.

From Rollins JD, Tribble LM, Collins JS, et al, eds. *Growth References*. 3rd ed. Greenwood, SC: Greenwood Genetic Center, 2011.

Ear Above Eye Level (Gestational Age)

Mean ± 2 SD for ear above eyeline plotted against gestational age. Ear above eyeline is the measurement from the superior aspect of the ear to the inner canthal level. The inner canthal level is determined by a horizontal line between the two inner canthi. Measurements were made using a strip of x-ray film. A central horizontal line is placed at the inner canthal level. A millimeter scale covers the ear to measure between the inner canthal level and the superior aspect of the ear. The technique is from Feingold M, et al. *Birth Defects Orig Artic Ser.* 1974;X(13):1-16. See legend below for sample information. Source: Merlob P, et al. *Birth Defects Orig Artic Ser.* 1984;20(7):1-52.

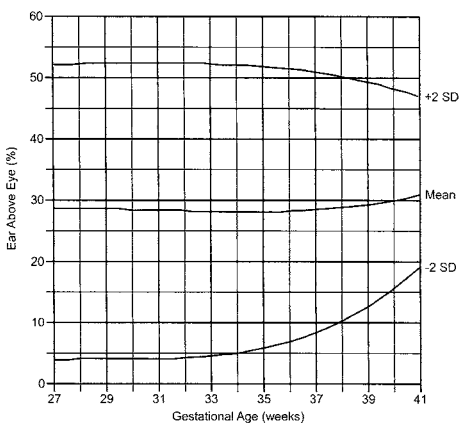




Mean ± 2 SD for percent of ear above eye plotted against gestational age.

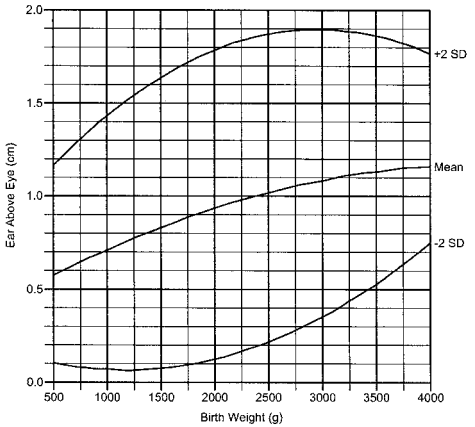
$$\text{Percent of ear above eyeline} = 100 \times \frac{\text{Ear above eyeline}}{\text{Total ear length}}$$

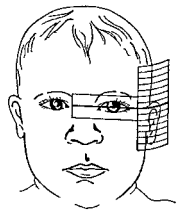
Measurements were made on 87 term (48 male and 39 female) and 111 preterm (55 male and 56 female) newborn Israeli infants between 27 and 41 weeks gestational age. Measurements were made between 36 and 60 hours of age. No infants had congenital anomalies. Source: Merlob P, et al. *Birth Defects Orig Artic Ser.* 1984;20(7):1-52. Graphs originally published by Sivan Y, et al. *J Med Genet.* 1983;20:213-215.

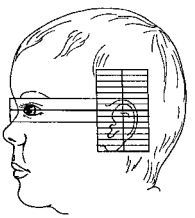


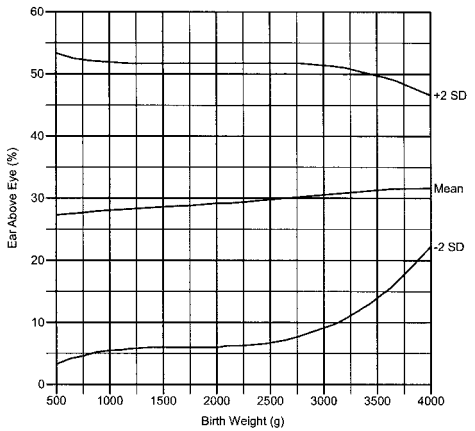
From Rollins JD, Tribble LM, Collins JS, et al, eds. *Growth References.* 3rd ed. Greenwood, SC: Greenwood Genetic Center, 2011.

Ear Above Eye Level (Birth Weight)





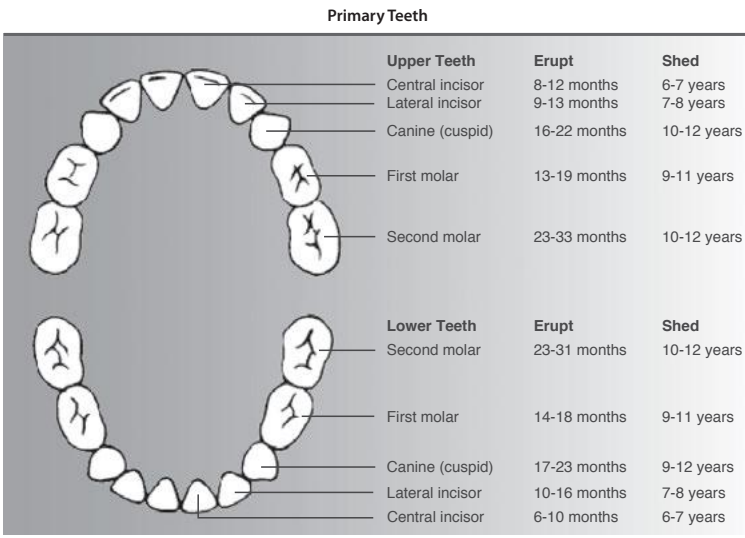




Upper graph shows mean ±2 SD for ear above eyeline plotted against birth weight. Lower graph shows mean ±2 SD for percent of ear above eyeline plotted against birth weight. Measurements were made on 87 term (48 male and 39 female) and 111 preterm (55 male and 56 female) newborn Israeli infants between 27 and 41 weeks of menstrual age. Measurements were made between 36 and 60 hours of age. No infants had congenital anomalies. Merlob P, et al. *Birth Defects Orig Artic Ser.* 1984;20(7):1-52. Sivan Y, et al. *J Med Genet.* 1985;22:414-415.

From Rollins JD, Tribble LM, Collins JS, et al, eds. *Growth References.* 3rd ed. Greenwood, SC: Greenwood Genetic Center, 2011.

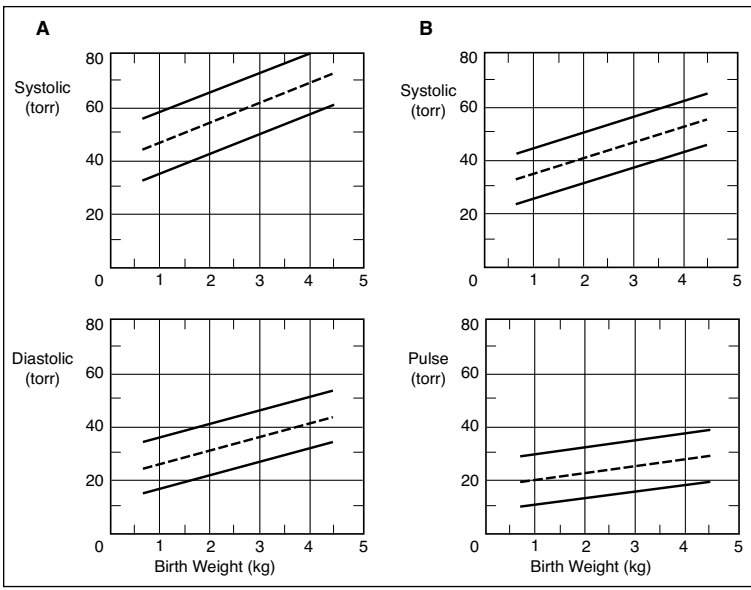
PRIMARY TEETH ERUPTION CHART



4. Blood Pressure

BLOOD PRESSURE NOMOGRAMS

Healthy Term Newborns During the First 12 Hours of Life

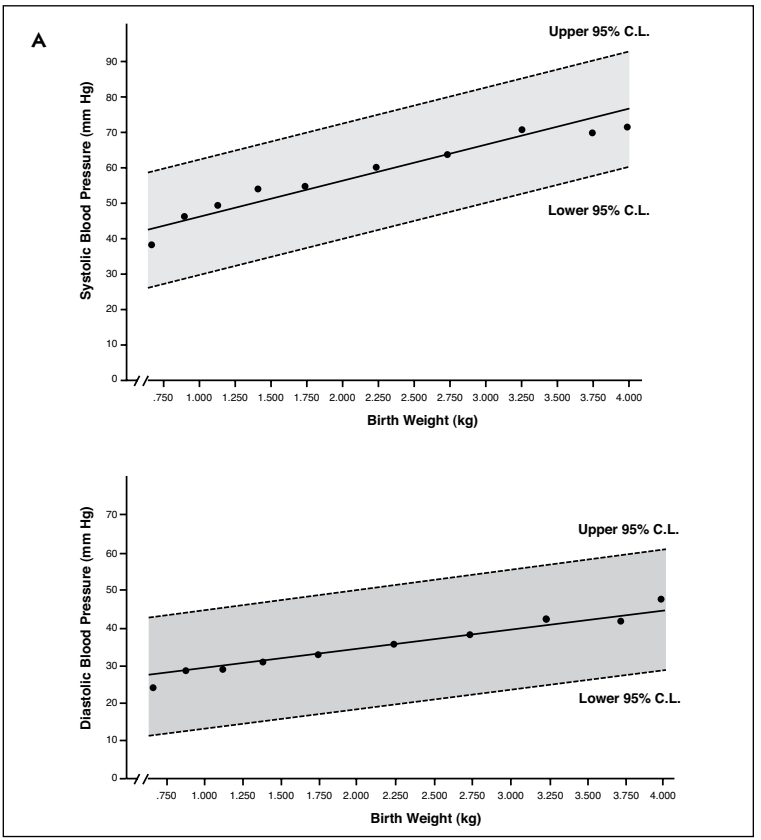


A, Linear regressions (broken lines) and 95% confidence limits (solid lines) of systolic (top) and diastolic (bottom) aortic blood pressures on birth weight in 61 healthy term newborns during the first 12 hours after birth. For systolic pressure, $y = 7.13x + 40.45$; $r = 0.79$. For diastolic pressure, $y = 4.81x + 22.18$; $r = 0.71$. For both, $n = 413$ and $p < .001$. **B,** Linear regressions (broken lines) and 95% confidence limits (solid lines) of mean pressure (top) and pulse pressure (systolic-diastolic pressure amplitude) (bottom) on birth weight in 61 healthy term newborns during the first 12 hours after birth. For mean pressure, $y = 5.16x + 29.80$; $n = 443$; $r = 0.80$. For pulse pressure, $y = 2.31x + 18.27$; $n = 413$; $r = 0.45$. For both, $p < .001$.

From Versmold HT, Kitterman JA, Phibbs RH, Gregory GA, Tooley WH. Aortic blood pressure during the first 12 hours of life in infants with birth weight 610 to 4,220 grams. *Pediatrics.* 1981;67(5):607–613.

BLOOD PRESSURE NOMOGRAMS, continued

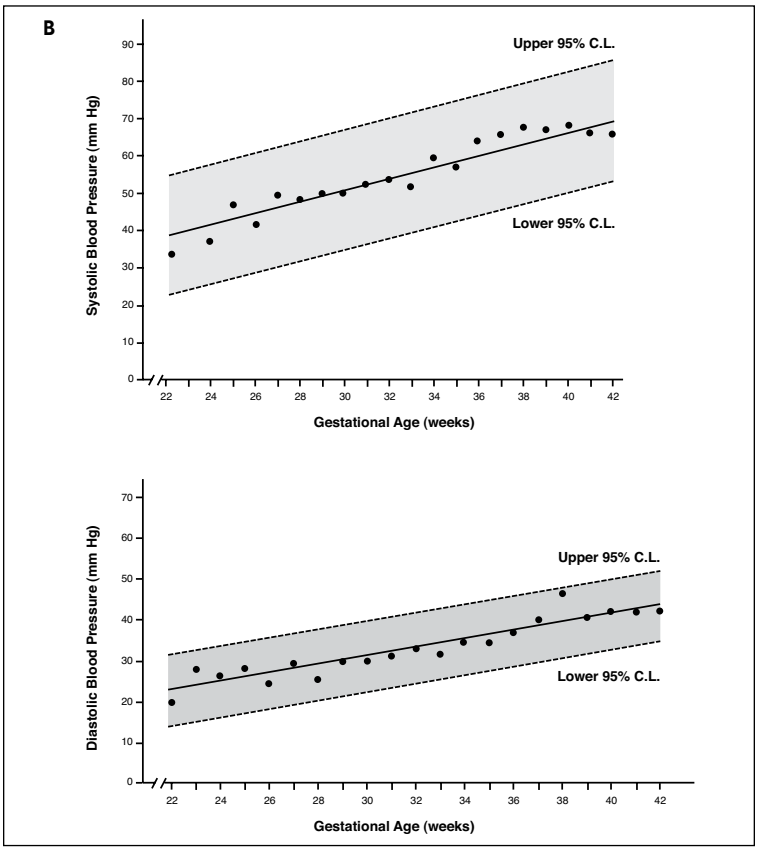
Preterm and Full-term Newborns During the First Day of Life (According to Birth Weight)



A, Linear regression of mean systolic and diastolic blood pressures by birth weight on day 1 of life, with 95% confidence limits (CLs) *(upper and lower dashed lines).*

From Zubrow AB, Hulman S, Kushner H, Falkner B. Determinants of blood pressure in infants admitted to neonatal intensive care units: a prospective multicenter study. Philadelphia Neonatal Blood Pressure Study Group. *J Perinatol.* 1995;15(6):470–479. Reproduced with permission.

Preterm and Full-term Newborns During the First Day of Life (According to Gestational Age)

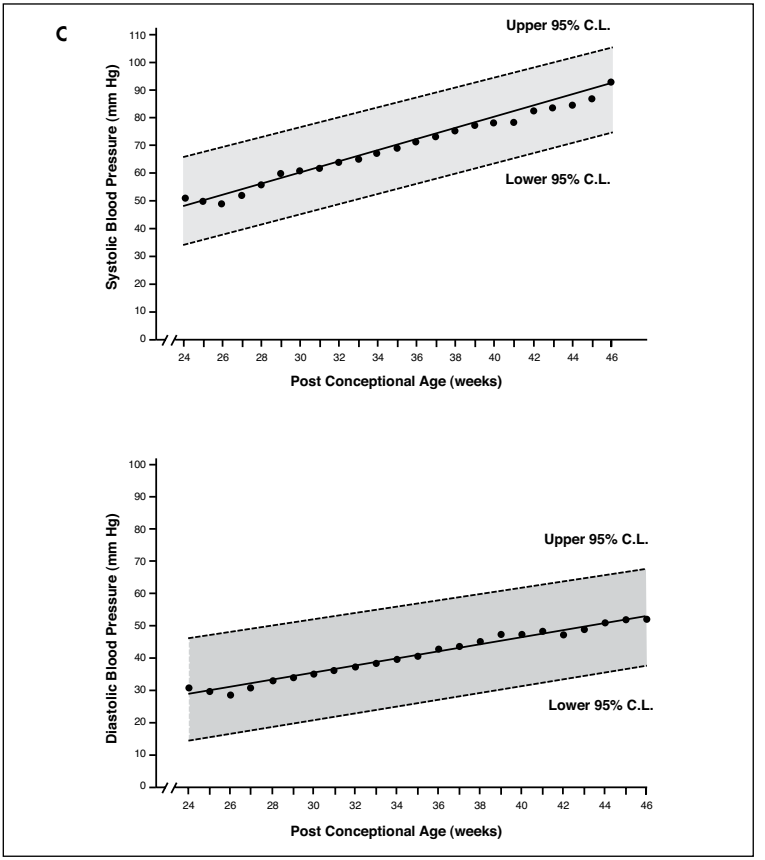


B, Linear regression of mean systolic and diastolic blood pressures by gestational age on day 1 of life, with 95% confidence limits (CLs) *(upper and lower dashed lines).*

From Zubrow AB, Hulman S, Kushner H, Falkner B. Determinants of blood pressure in infants admitted to neonatal intensive care units: a prospective multicenter study. Philadelphia Neonatal Blood Pressure Study Group. *J Perinatol.* 1995;15(6):470–479. Reproduced with permission.

BLOOD PRESSURE NOMOGRAMS, continued

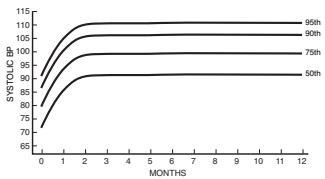
Preterm and Full-term Newborns According to Post-conceptional Age

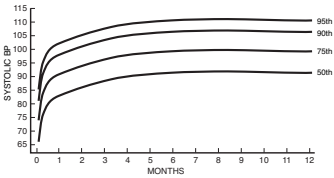


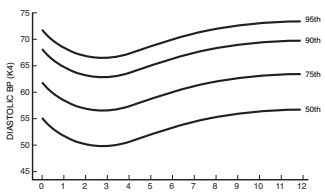
C, Linear regression of mean systolic and diastolic blood pressures by postconceptual age in weeks, with 95% confidence limits *(upper and lower dashed lines).*

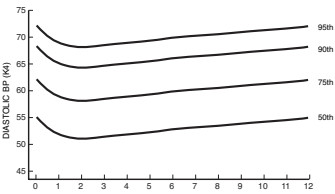
From Zubrow AB, Hulman S, Kushner H, et al. Determinants of blood pressure in infants admitted to neonatal intensive care units: a prospective multicenter study. Philadelphia Neonatal Blood Pressure Study Group. *J Perinatol.* 1995;15(6):470–479. Reproduced with permission.

Children Younger Than 1 Year









90th Percentile													
Systolic BP	87	101	106	106	106	105	105	106	105	105	105	105	105
Diastolic BP	68	65	63	63	63	65	66	67	68	68	69	69	69
Height CM	51	59	63	66	68	70	72	73	74	75	77	78	80
Weight KG	4	4	5	5	6	7	8	9	9	10	10	11	11

	76	98	101	104	105	106	106	106	106	106	108	105	105
	68	65	64	64	65	66	66	66	66	67	67	67	67
	54	55	56	58	51	63	66	68	70	72	74	75	77
	4	4	4	5	5	6	7	8	9	9	10	10	11

A, Age-specific percentiles of blood pressure (BP) measurements in boys—birth to 12 months of age; Korotkoff phase IV (K4) used for diastolic BP. **B,** Age-specific percentiles of blood pressure (BP) measurements in girls—birth to 12 months of age; Korotkoff phase IV (K4) used for diastolic BP.

From Task Force on Blood Pressure Control in Children. Report of the Second Task Force on Blood Pressure Control in Children—1987. *Pediatrics.* 1987;79(1):1–25.

BLOOD PRESSURE LEVELS FOR BOYS BY AGE AND HEIGHT PERCENTILE

		Systolic BP (mm Hg) ← Percentile of Height →							Diastolic BP (mm Hg) ← Percentile of Height →						
Age (Year)	BP Percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50th	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50th	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50th	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50th	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50th	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50th	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50th	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90th	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95th	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99th	119	120	122	123	125	127	127	83	84	85	86	87	87	88

		Systolic BP (mm Hg) ← Percentile of Height →							Diastolic BP (mm Hg) ← Percentile of Height →						
Age (Year)	**BP Percentile**	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**
9	50th	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90th	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95th	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99th	120	121	123	125	127	128	129	84	85	86	87	88	88	89
10	50th	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90th	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95th	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99th	122	123	125	127	128	130	130	85	86	86	88	88	89	90
11	50th	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90th	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95th	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99th	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50th	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90th	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95th	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99th	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50th	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90th	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95th	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99th	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50th	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90th	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95th	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99th	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	50th	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50th	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	91	92	93	94	94

BLOOD PRESSURE LEVELS FOR BOYS BY AGE AND HEIGHT PERCENTILE, continued

		Systolic BP (mm Hg) ← Percentile of Height →							Diastolic BP (mm Hg) ← Percentile of Height →						
Age (Year)	BP Percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
17	50th	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90th	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

Abbreviation: BP, blood pressure.

Note: The 90th percentile is 1.28 SD, the 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.

BLOOD PRESSURE LEVELS FOR GIRLS BY AGE AND HEIGHT PERCENTILE

		Systolic BP (mm Hg) ← Percentile of Height →							Diastolic BP (mm Hg) ← Percentile of Height →						
Age (Year)	BP Percentile	5th	10th	25th	50th	75th	90th	95th	10th	25th	50th	75th	90th	95th	95th
1	50th	83	84	85	86	88	89	90	38	39	39	40	41	41	42
	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	50th	85	85	87	88	89	91	91	43	44	44	45	46	46	47
	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	50th	86	87	88	89	91	92	93	47	48	48	49	50	50	51
	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	50th	88	88	90	91	92	94	94	50	50	51	52	52	53	54
	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	50th	89	90	91	93	94	95	96	52	53	53	54	55	55	56
	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	50th	91	92	93	94	96	97	98	54	54	55	56	56	57	58
	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86

BLOOD PRESSURE LEVELS FOR GIRLS BY AGE AND HEIGHT PERCENTILE, continued

		Systolic BP (mm Hg) ← Percentile of Height →							Diastolic BP (mm Hg) ← Percentile of Height →						
Age (Year)	**BP Percentile**	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**	**95th**
9	*50th*	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87
10	*50th*	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88
11	*50th*	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	*50th*	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	*50th*	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	*50th*	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92
15	50th	107	108	109	110	111	113	113	64	64	64	65	66	67	67
	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93

		Systolic BP (mm Hg) ← Percentile of Height →							Diastolic BP (mm Hg) ← Percentile of Height →						
Age (Year)	BP Percentile	5th	10th	25th	50th	75th	90th	95th	10th	25th	50th	75th	90th	95th	95th
16	50th	108	108	110	111	112	114	114	64	64	65	66	66	67	68
	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	50th	108	109	110	111	113	114	115	64	65	65	66	67	67	68
	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

Abbreviation: BP, blood pressure.

Note: The 90th percentile is 1.28 SD, the 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.

5. Reference Range Values

CEREBROSPINAL FLUID

Component	Preterm Newborn	Full Term 1–7 Days	Full Term 8–30 Days	1–3 Months	4 Months–16 Years	Adult
Note: Entries listed in alphabetical order.						
Color	Clear or xantho-chromic	Clear or xanthochromic	Clear or xantho-chromic	Clear	Clear	Clear
Red blood cells (/mcL)		3–23 (0–1070)				
White blood cells (/mcL)	<22–28	<30	<12	<6	<1	<5
Polymorpho-nuclear cells (/mcL)	<20%–60%	<38–60%	<10%	None (36%–71%)	None (26%–35%)	None
Lymphocytes (/mcL)		0–20 (if <24 h) 0–4 (if 7 days)	≤11	≤5	≤5	60%–70%
Monocytes (/mcL)		<4 (50%–99%)	≤4 (50%–99%)	<4 (33%–67%)	<4 (44%–90%)	30%–50%
Protein (mg/dL), mean ± SD (95th percen-tile)	65–150	79 ± 23 (132)	68 ± 20 (100)	58 ± 17 (89) up to 42 days; 53 ± 17 (83) up to 56 days; 5–45 after 56 days	5–45	5–45
Glucose (mg/dL)	24–63 (1.3–3.5 mmol/L)	>50 (>2.77 mmol/L)	>50% in serum ≥38 (2.1 mmol/L)	≥45 (≥2.5 mmol/L)	45–72 (2.5–4.0 mmol/L), 60% in serum	2.2–4.7 mmol/L
CSF glucose/ blood glucose	0.55–1.05	≥0.6	≥0.6	≥0.6	≥0.6	

Component	Preterm Newborn	Full Term 1–7 Days	Full Term 8–30 Days	1–3 Months	4 Months–16 Years	Adult
Note: Entries listed in alphabetical order.						
Lactate (mmol/L)	5–30 (approx 10% serum value)	<3.1 (if >2 days)	<3.1	<3.1	<2.4 (if 1–12 y)	
Opening pressure (mm H_2O) in lateral recumbent position		8–11	<28	<28	<28	50–180
CSF volume (mL)					60–100	100–160
Fluctuation with respiration		0.5–1.0	0.5–1.0	0.5–1.0	0.5–1.0	0.5–1.0

Abbreviation: CSF, Cerebral spinal fluid; SD, standard deviation.

Calculating the ratio of red blood cells (RBCs) to white blood cells (WBCs) in CSF
General rule: For every 500 RBCs in CSF, it is acceptable to have 1 WBC.
Normal ratio of RBCs to WBCs in peripheral blood is 1,000 RBCs: 1–2 WBCs × 10^6/L.

$$\text{Number of WBCs introduced into the CSF per L} = \frac{(\text{WBC}_{[\text{peripheral}]} \times \text{RBC}_{[\text{CSF}]})}{\text{RBC}_{(\text{peripheral})}} \times 10^6/\text{L}$$

Compare this number with the actual number of WBCs in the CSF.
1,000 × 10^6/L RBCs in CSF raises CSF protein by approximately 0.015 g/L.
Note: correction factors should not be used to reassure that meningitis is unlikely.

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CLINICAL CHEMISTRY

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Acid phosphate		
Newborn	7.4–19.4 U/L	7.4–19.4 U/L
2–13 y	6.4–15.2 U/L	6.4–15.2 U/L
Man	0.5–11.0 U/L	0.5–11.0 U/L
Woman	0.2–9.5 U/L	0.2–9.5 U/L
Alanine aminotransferase (ALT)		
<5 d	6–50 U/L	6–50 U/L
<12 mo	13–45 U/L	13–45 U/L
1–3 y	5–45 U/L	5–45 U/L
4–6 y	10–25 U/L	10–25 U/L
7–9 y	10–35 U/L	10–35 U/L
Girl 10–11 y	10–30 U/L	10–30 U/L
Boy 10–11 y	10–35 U/L	10–35 U/L
Girl 12–13 y	10–30 U/L	10–30 U/L
Boy 12–13 y	10–55 U/L	10–55 U/L
Girl 14–15 y	5–30 U/L	5–30 U/L
Boy 14–15 y	10–45 U/L	10–45 U/L
Girl >16 y	5–35 U/L	5–35 U/L
Boy >16 y	10–40 U/L	10–40 U/L
Man	10–40 U/L	10–40 U/L
Woman	7–35 U/L	7–35 U/L
Aldolase		
10–24 mo	3.4–11.8 U/L	3.4–11.8 U/L
2–16 y	1.2–8.8 U/L	1.2–8.8 U/L
Adult	1.7–4.9 U/L	1.7–4.9 U/L

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Alkaline phosphatase		
Infant	150–420 U/L	150–420 U/L
2–10 y	100–320 U/L	100–320 U/L
Adolescent boy	100–390 U/L	100–390 U/L
Adolescent girl	100–320 U/L	100–320 U/L
Adult	30–120 U/L	30–120 U/L
Ammonia		
Newborn	90–150 mcg/dL	64–107 mcmol/L
0–2 wk	79–129 mcg/dL	56–92 mcmol/L
>1 mo	29–70 mcg/dL	21–50 mcmol/L
Adult	15–45 mcg/dL	11–32 mcmol/L
Amylase		
0–3 mo	0–30 U/L	0–30 U/L
3–6 mo	0–50 U/L	0–50 U/L
6–12 mo	0–80 U/L	0–80 U/L
>1 y	30–100 U/L	30–100 U/L
Adult	27–131 U/L	27–131 U/L
Antinuclear antibody		
Negative	<1:40	
Patterns with clinical correlation:		
Centromere: CREST		
Nuclear: Scleroderma		
Homogeneous: Systemic Lupus Erythematosus (SLE)		

CLINICAL CHEMISTRY, continued

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Antistreptolysin O titer (ASOT) (fourfold rise in serial sample is significant)		
Newborn	Similar to mother's value	
6–24 mo	≤50 Todd units/mL	
2–4 y	≤160 Todd units/mL	
≥5 y	≤330 Todd units/mL	
Aspartate aminotransferase (AST)		
0–10 d	47–150 U/L	47–150 U/L
10 d–24 mo	9–80 U/L	9–80 U/L
Girl >24 mo	13–35 U/L	13–35 U/L
Boy >24 mo	15–40 U/L	15–40 U/L
Bicarbonate		
Newborn	17–24 mEq/L	17–24 mmol/L
Infant	19–24 mEq/L	19–24 mEq/L
2 mo–2 y	16–24 mEq/L	16–24 mmol/L
>2 y	22–26 mEq/L	22–26 mmol/L
Bilirubin (total)		
Cord		
Preterm and term	<2 mg/dL	<34 mcmol/L
0–1 d		
Preterm and term	<8 mg/dL	<137 mcmol/L
1–2 d		
Preterm	<12 mg/dL	<205 mcmol/L
Term	<11.5 mg/dL	<197 mcmol/L
3–5 d		
Preterm	<16 mg/dL	<274 mcmol/L
Term	<12 mg/dL	<205 mcmol/L

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Bilirubin (total), continued		
Older infants		
Preterm	<2 mg/dL	<34 mcmol/L
Term	<1.2 mg/dL	<21 mcmol/L
Adult	<1.5 mg/dL	<20.5 mcmol/L
Bilirubin (conjugated)		
Neonate	<0.6 mg/dL	<10 mcmol/L
Infant/children	<0.2 mg/dL	<3.4 mcmol/L

	pH	Pao_2 (mm Hg)	$Paco_2$ (mm Hg)	Hco_3^- (mEq/L)
Blood gas, arterial (breathing room air)				
Cord blood	7.28 ± 0.05	18.0 ± 6.2	49.2 ± 8.4	14–22
Newborn (birth)	**7.11–7.36**	**8–24**	**27–40**	**13–22**
5–10 min	7.09–7.30	33–75	27–40	13–22
30 min	7.21–7.38	31–85	27–40	13–22
60 min	7.26–7.49	55–80	27–40	13–22
1 d	7.29–7.45	54–95	27–40	13–22
Child/adult	**7.35–7.45**	**83–108**	**32–48**	**20–28**

Note: Venous blood gases can be used to assess acid-base status, not oxygenation. Pco_2 averages 6 to 8 mm Hg higher than $Paco_2$, and pH is slightly lower. Peripheral venous samples are strongly affected by the local circulatory and metabolic environment. Capillary blood gases correlate best with arterial pH and moderately well with $Paco_2$.

CLINICAL CHEMISTRY, continued

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Calcium		
Total		
Preterm	6.2–11 mg/dL	1.55–2.75 mmol/L
Term <10 d	7.6–10.4 mg/dL	1.9–2.6 mmol/L
10 d–24 mo	9.0–11 mg/dL	2.25-2.75 mmol/L
2–12 y	8.8–10.8 mg/dL	2.2–2.7 mmol/L
12–18 y	8.4–10.2 mg/dL	2.1–2.55 mmol/L
Ionized		
0–1 mo	3.9–6.0 mg/dL	1.0–1.5 mmol/L
1–6 mo	3.7–5.9 mg/dL	0.95–1.5 mmol/L
1–18 y	4.9–5.5 mg/dL	1.22–1.37 mmol/L
Adult	4.75–5.3 mg/dL	1.18–1.32 mmol/L
Carbon dioxide (CO_2 content) (see "Blood gas, arterial")		
Carbon monoxide (carboxyhemoglobin)		
Nonsmoker	0.5%–1.5% of total hemoglobin	
Smoker	4%–9% of total hemoglobin	
Toxic	20%–50% of total hemoglobin	
Lethal	>50% of total hemoglobin	
Chloride (serum)		
0–6 mo	97–108 mEq/L	97–108 mmol/L
6–12 mo	97–106 mEq/L	97–106 mmol/L
Child/adult	97–107 mEq/L	97–107 mmol/L
C-reactive protein	0–0.5 mg/d	

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Creatine kinase (creatine phosphokinase)		
Newborn	145–1,578 U/L	145–1,578 U/L
>6 wk–man	20–200 U/L	20–200 U/L
>6 wk–woman	20–180 U/L	20–180 U/L
Creatinine (serum)		
Cord	0.6–1.2 mg/dL	53–106 mcmol/L
Newborn	0.3–1.0 mg/dL	27–88 mcmol/L
Infant	0.2–0.4 mg/dL	18–35 mcmol/L
Child	0.3–0.7 mg/dL	27–62 mcmol/L
Adolescent	0.5–1.0 mg/dL	44–88 mcmol/L
Man	0.9–1.3 mg/dL	80–115 mcmol/L
Woman	0.6–1.1 mg/dL	53–97 mcmol/L
Erythrocyte sedimentation rate (ESR)		
Child	0–10 mm/h	
Man	0–15 mm/h	
Woman	0–20 mm/h	
Ferritin		
Newborn	25–200 ng/mL	56–450 pmol/L
1 mo	200–600 ng/mL	450–1350 pmol/L
2–5 mo	50–200 ng/mL	112–450 pmol/L
6 mo–15 y	7–140 ng/mL	16–350 pmol/L
Man	20–250 ng/mL	45–562 pmol/L
Woman	10–120 ng/mL	22–270 pmol/L
Folate (serum)		
Newborn	16–72 ng/mL	16–72 nmol/L
Child	4–20 ng/mL	4–20 nmol/L
Adult	10–63 ng/mL	10–63 nmol/L

CLINICAL CHEMISTRY, continued

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Folate (red blood cells)		
Newborn	150–200 ng/mL	340–453 nmol/L
Infant	74–995 ng/mL	168–2,254 nmol/L
2–16 y	>160 ng/mL	>362 nmol/L
>16 y	140–628 ng/mL	317–1422 nmol/L
Galactose		
Newborn	0–20 mg/dL	0–1.11 mmol/L
Older child	<5 mg/dL	<0.28 mmol/L
γ-Glutamyl transferase (GGT)		
Cord	37–193 U/L	37–193 U/L
0–1 mo	13–147 U/L	13–147 U/L
1–2 mo	12–123 U/L	12–123 U/L
2–4 mo	8–90 U/L	8–90 U/L
4 mo–10 y	5–32 U/L	5–32 U/L
10–15 y	5–24 U/L	5–24 U/L
Man	11–49 U/L	11–49 U/L
Woman	7–32 U/L	7–32 U/L
Glucose (serum)		
Preterm	20–60 mg/dL	1.1–3.3 mmol/L
Newborn <1 day	40–60 mg/dL	2.2–3.3 mmol/L
Newborn >1 day	50–90 mg/dL	2.8–5.0 mmol/L
Child	60–100 mg/dL	3.3–5.5 mmol/L
>16 y	70–105 mg/dL	3.9–5.8 mmol/L
Haptoglobin		
Newborn	5–48 mg/dL	50–480 mg/dL
>30 d	26–185 mg/dL	260–1850 mg/dL

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Hemoglobin A_{1c}		
Normal	4.5%–5.6%	
At risk for diabetes	5.7%–6.4%	
Diabetes mellitus	≥6.5%	
Hemoglobin F, % total hemoglobin [mean (SD)]		
1 d	77.0 (7.3)	
5 d	76.8 (5.8)	
3 wk	70.0 (7.3)	
6–9 wk	52.9 (11)	
3–4 mo	23.2 (16)	
6 mo	4.7 (2.2)	
8–11 mo	1.6 (1.0)	
Adult	<2.0	
Iron		
Newborn	100–250 mcg/dL	17.9–44.8 mcmol/L
Infant	40–100 mcg/dL	7.2–17.9 mcmol/L
Child	50–120 mcg/dL	9.0–21.5 mcmol/L
Man	65–175 mcg/dL	11.6–31.3 mcmol/L
Woman	50–170 mcg/dL	9.0–30.4 mcmol/L
Ketones (serum)		
Quantitative	0.5–3.0 mg/dL	5–30 mg/L

CLINICAL CHEMISTRY, continued

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Lactate		
Capillary blood		
0–90 d	9–32 mg/dL	1.1–3.5 mmol/L
3–24 mo	9–30 mg/dL	1.0–3.3 mmol/L
2–18 y	9–22 mg/dL	1.0–2.4 mmol/L
Venous	4.5–19.8 mg/dL	0.5–2.2 mmol/L
Arterial	4.5–14.4 mg/dL	0.5–1.6 mmol/L
Lactate dehydrogenase (at 37°C)		
0–4 d	290–775 U/L	290–775 U/L
4–10 d	545–2000 U/L	545–2000 U/L
10 d–24 mo	180–430 U/L	180–430 U/L
24 mo–12 y	110–295 U/L	110–295 U/L
>12 y	100–190 U/L	100–190 U/L
Lead		
Child	<10 mcg/dL	<0.48 mcmol/L
Lipase		
0–30 d	6–55 U/L	6–55 U/L
1–6 mo	4–29 U/L	4–29 U/L
6–12 mo	4–23 U/L	4–23 U/L
>1 y	3–32 U/L	3–32 U/L

	Desirable	Borderline	High
Lipids			
Cholesterol (mg/dL)			
Child/adolescent	<170	170–199	>200
Adult	<200	200–239	>240

	Desirable	Borderline	High
Lipids, continued			
Low-density lipoprotein (mg/dL)			
Child/adolescent	<110	110–129	>130
Adult	100 (Near/ Above optimal = 100–129)	130–159	>160
High-density lipoprotein (mg/dL)			
Child/adolescent	>35		
Adult	40–60		

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Magnesium	1.26–2.1 mEq/L	0.63–1.05 mmol/L
Methemoglobin	0.78 (± 0.37%) of total hemoglobin	
Osmolality	275–295 mOsm/kg	275–295 mmol/kg
Phenylalanine		
Preterm	2.0–7.5 mg/dL	121–454 mcmol/L
Newborn	1.2–3.4 mg/dL	73–206 mcmol/L
Adult	0.8–1.8 mg/dL	48–109 mcmol/L
Phosphorus		
0–9 d	4.5–9.0 mg/dL	1.45–2.91 mmol/L
10 d–24 mo	4.5–6.5 mg/dL	1.29–2.10 mmol/L
3–9 y	3.2–5.8 mg/dL	1.03–1.87 mmol/L
10–15 y	3.3–5.4 mg/dL	1.07–1.74 mmol/L
>15 y	2.4–4.4 mg/dL	0.78–1.42 mmol/L
Porcelain	9.0–25.04 mg/dL	5.0–31.03 mmol/L

CLINICAL CHEMISTRY, continued

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Potassium		
Preterm	3.0–6.0 mEq/L	3.0–6.0 mmol/L
Newborn	3.7–5.9 mEq/L	3.7–5.9 mmol/L
Infant	4.1–5.3 mEq/L	4.1–5.3 mmol/L
Child	3.4–4.7 mEq/L	3.4–4.7 mmol/L
Adult	3.5–5.1 mEq/L	3.5–5.1 mmol/L
Prealbumin		
Newborn	7–39 mg/dL	
1–6 mo	8–34 mg/dL	
6 mo–4 y	12–36 mg/dL	
4–6 y	12–30 mg/dL	
6–19 y	12–42 mg/dL	

	TP	Albumin	α-1	α-2	β	γ
Proteins (protein electrophoresis) (g/dL)						
Cord	4.8–8					
Preterm	3.6–6.0					
Newborn	4.6-7.0					
0–15 d	4.4–7.6	3.0–3.9	0.1–0.3	0.3–0.6	0.4–0.6	0.7–1.4
15 d–1 y	5.1–7.3	2.2–4.8	0.1–0.3	0.5–0.9	0.5–0.9	0.5–1.3
1–2 y	5.6–7.5	3.6–5.2	0.1–0.4	0.5–1.2	0.5–1.1	0.5–1.7
3–16 y	6.0–8.0	3.6–5.2	0.1–0.4	0.5–1.2	0.5–1.1	0.5–1.7
≥16 y	6.0–8.3	3.9–5.1	0.2–0.4	0.4–0.8	0.5–1.0	0.6–1.2

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Pyruvate	0.7–1.32 mg/dL	0.08–0.15 mmol/L
Rheumatoid Factor	<30 U/mL	
Sodium		
<1 y	130–145 mEq/L	130–145 mmol/L
>1 y	135–147 mEq/L	135–147 mmol/L
Total iron-binding capacity (TIBC)		
Infant	100–400 mcg/dL	17.9–71.6 mcmol/L
Adult	250–425 mcg/dL	44.8–76.1 mcmol/L
Transferrin		
Newborn	130–275 mg/dL	1.30–2.75 g/L
3 mo–16 y	203–360 mg/dL	2.03–3.6 g/L
Adult	215–380 mg/dL	2.15–3.8 g/L

Determination	Male (mg/dL)	Female (mg/dL)
Total triglycerides		
0–7 d	21–182	28–166
8 d–1 mo	30–184	30–165
1–3 mo	40–175	35–282
3–6 mo	45–291	50–355
6 mo–1 y	45–501	36–431
1–3 y	27–125	27–125
4–6 y	32–116	32–116
7–9 y	28–129	28–129
10–19 y	24–145	37–140

CLINICAL CHEMISTRY, continued

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Troponin-I		
0–30 d	<4.8 mcg/L	
1–3 mo	<0.4 mcg/L	
3–6 mo	<0.3 mcg/L	
7–12 mo	<0.2 mcg/L	
1–18 y	<0.1 mcg/L	
Urea nitrogen		
Premature (<1 wk)	3–25 mg/dL	1.1–8.9 mmol/L
Newborn	2–19 mg/dL	0.7–6.7 mmol/L
Infant/children	5–18 mg/dL	1.8–6.4 mmol/L
Adult	6–20 mg/dL	2.1–7.1 mmol/L
Uric acid		
0–30 d	1.0–4.6 mg/dL	0.059–0.271 mmol/L
1–12 mo	1.1–5.6 mg/dL	0.065–0.33 mmol/L
1–5 y	1.7–5.8 mg/dL	0.1–0.35 mmol/L
6–11 y	2.2–6.6 mg/dL	0.13–0.39 mmol/L
Boy 12–19 y	3.0–7.7 mg/dL	0.18–0.46 mmol/L
Girl 12–19 y	2.7–5.7 mg/dL	0.16–0.34 mmol/L
Vitamin A (retinol)		
Preterm	13–46 mcg/dL	0.46–1.61 mcmol/L
Term	18–50 mcg/dL	0.63–1.75 mcmol/L
1–6 y	20–43 mcg/dL	0.7–1.5 mcmol/L
7–12 y	20–49 mcg/dL	0.9–1.7 mcmol/L
13–19 y	26–72 mcg/dL	0.9–2.5 mcmol/L
Vitamin B_1 (thiamine)	4.5–10.3 mcg/dL	106–242 mcmol/L
Vitamin B_2 (riboflavin)	4–24 mcg/dL	106–638 nmol/L

Determination	Conventional Units	SI Units
Note: Entries listed in alphabetical order.		
Vitamin B_{12} (cobalamin)		
Newborn	160–1300 pg/mL	118–959 pmol/L
Child/adult	200–835 pg/mL	148–616 pmol/L
Vitamin C (ascorbic acid)	0.4–2.0 mg/dL	23–114 mcmol/L
Vitamin D_3 (1,25-dihydroxy-vitamin D)	16–65 pg/mL	42–169 pmol/L
25-hydroxy-vitamin D		
Normal level	30–60 ng/mL[a]	
Insufficiency	21–29 ng/mL	
Deficiency	<20 ng/mL	
Vitamin E		
Preterm	0.5–3.5 mg/L	1–8 mmol/L
Term	1.0–3.5 mg/L	2–8 mmol/L
1–12 y	3–9 mg/L	7–21 mcmol/L
13–19 y	6–10 mg/L	14–23 mcmol/L
Zinc	70–120 mg/dL	10.7–18.4 mmol/L

Abbreviation: CREST, Calcinosis/Raynaud's syndrome/Esophageal dysmotility/Sclerodactyly/Telangectasis

[a]Controversy exists as to the optimal level of 25-hydroxy-vitamin D level.

From Arcara KM, Tschudy MM, eds. *The Harriet Lane Handbook.* 19th ed. St Louis, MO: Mosby; 2012.

NEWBORN CLINICAL CHEMISTRY

Descriptive Statistics of Measured Variables in Samples Obtained From Cord and Venous Blood at 2 to 4 Hours of Life

	Cord Blood			2 to 4 Hour Blood			
	Mean ± SD	Range of Values	95% CI	Mean ± SD	Range of Values	95% CI	P Value
pH	7.35 ± 0.05	7.19–7.42	7.25–7.45	7.36 ± 0.04	7.27–7.45	7.28–7.44	NS
Pco_2	40 ± 6	24.5–56.7	28–52	43 ± 7	30–65	29–57	0.034
Hct (%)	48 ± 5	37–60	38–58	57 ± 5	42–67	47–67	<0.001
Hgb (g/L)	1.65 ± 0.16	1.29–2.06	1.33–1.97	1.90 ± 0.22	0.88–2.3	1.46–2.34	<0.001
Na^+ (mmol/L)	138 ± 3	129–144	132–144	137 ± 3	130–142	131–143	NS
K^+ (mmol/L)	5.3 ± 1.3	3.4–9.9	2.7–7.9	5.2 ± 0.5	4.4–6.4	4.2–6.2	NS
Cl^- (mmol/L)	107 ± 4	100–121	99–115	111 ± 5	105–125	101–121	0.002
ICa (mmol/L)	1.15 ± 0.35	0.21–1.5	0.4–1.85	1.13 ± 0.08	0.9–1.3	0.97–1.29	NS
IMg (mmol/L)	0.28 ± 0.06	0.09–0.39	0.12–0.4	0.30 ± 0.05	0.23–0.46	0.2–0.4	0.0005
Glucose (mmol/L)	4.16 ± 1.05	0.16–6.66	2.05–6.27	3.50 ± 0.67	5.11–16.10	2.16–4.82	
Glucose (mg/dL)	75 ± 19	2.9–120	37–113	63 ± 12	29–92	39–87	0.0005
Lactate (mmol/L)	4.6 ± 1.9	1.1–9.6	0.8–8.4	3.9 ± 1.5	1.6–9.8	0.9–6.9	0.033

Descriptive Statistics of Measured Variables in Samples Obtained From Cord and From Venous Blood at 2 to 4 Hours of Life, continued

	Cord Blood			2 to 4 Hour Blood			
	Mean ± SD	Range of Values	95% CI	Mean ± SD	Range of Values	95% CI	P Value
BUN (mmol/L)	2.14 ± 0.61	1.07–3.57	0.93–3.36	2.53 ± 0.71	1.43–4.28	1.11–3.96	
BUN (mg/dL)	6.0 ± 1.7	3.0–10.0	2.6–9.4	7.1 ± 2.0	4–12	3.1–11.1	0.0029

Abbreviations: BUN, blood urea nitrogen; CI, confidence interval; Hct, hematocrit; Hgb, hemoglobin; ICa, ionized calcium; IMg, ionized magnesium; P_{CO_2}, partial pressure of carbon dioxide.

Data were derived from Dollberg S, Bauer R, Lubetzky R, Mimouni FB. A reappraisal of neonatal blood chemistry reference ranges using the Nova M electrodes. *Am J Perinatol.* 2001;18(8):433–440.

Hematologic Values

Age	Hemoglobin (g, %) Mean (± 2 SD)	Hematocrit (%) Mean (± 2 SD)	Mean Cell Volume (fL) Mean (± 2 SD)	Mean Corpuscular Hemoglobin Concentration (g/dL RBC) Mean (± 2 SD)	Reticu-locytes (%)	WBC/10^3 Mean (± 2 SD)	Platelets (10^3 mm^3) Mean (± 2 SD)
26–30 wk, gestation[a]	13.4 (11)	41.5 (34.9)	118.2 (106.7)	37.9 (30.6)		4.4 (2.7)	254 (180–327)
28 wk	14.5	45	120	31	5–10		275
32 wk	15.0	47	118	32	3–10		290
Term (cord)[b]	16.5 (13.5)	51 (42)	108 (98)	33 (30)	3–7	18.1 (9–30)	290
1–3 d	18.5 (14.5)	56 (45)	108 (95)	33 (29)	1.8-4.6	18.9 (9.4–34)	192
2 wk	16.6 (13.4)	53 (41)	105 (88)	31.4 (28.1)		11.4 (5–20)	252
1 mo	13.9 (10.7)	44 (33)	101 (91)	31.8 (28.1)	0.1–1.7	10.8 (4–19.5)	
2 mo	11.2 (9.4)	35 (28)	95 (84)	31.8 (28.3)			
6 mo	12.6 (11.1)	36 (31)	76 (68)	35 (32.7)	0.7-2.3	11.9 (6–17.5)	
6 mo–2 y	12.0 (10.5)	36 (33)	78 (70)	33 (30)		10.6 (6–17)	(150–350)
2–6 y	12.5 (11.5)	37 (34)	81 (75)	34 (31)	0.5–1.0	8.5 (5–15.5)	(150–350)
6–12 y	13.5 (11.5)	40 (35)	86 (77)	34 (31)	0.5–1.0	8.1 (4.5–13.5)	(150–350)

Hematologic Values

Age	Hemoglobin (g, %) Mean (± 2 SD)	Hematocrit (%) Mean (± 2 SD)	Mean Cell Volume (fL) Mean (± 2 SD)	Mean Corpuscular Hemoglobin Concentration (g/dL RBC) Mean (± 2 SD)	Reticu-locytes (%)	WBC/10^3 Mean (± 2 SD)	Platelets (10^3 mm^3) Mean (± 2 SD)
12–18 y							
Male	14.5 (13)	43 (36)	88 (78)	34 (31)	0.5–1.0	7.8 (4.5–13.5)	(150–350)
Female	14.0 (12)	41 (37)	90 (78)	34 (31)	0.5–1.0	7.8 (4.5–13.5)	(150–350)
Adult							
Male	15.5 (13.5)	47 (41)	90 (80)	34 (31)	0.8–2.5	7.4 (4.5–11)	(150–350)
Female	14.0 (12)	41 (36)	90 (80)	34 (31)	0.8–4.1	7.4 (4.5–11)	(150–350)

[a]Values are from fetal samplings.

[b]In newborns younger than 1 month, capillary hemoglobin exceeds venous hemoglobin: 1 hour of age—by 3.6 grams; 5 days of age—by 2.2 grams; 3 weeks of age—by 1.1 gram.

Mean (95% confidence limits)

Adapted from Arcara KM, Tschudy MM, eds. *The Harriet Lane Handbook.* 19th ed. St Louis, MO; Mosby; 2012. Reproduced with permission.

COAGULATION TESTS

Healthy Full-term Infant During the First 6 Months of Life

Tests	Day 1 (n)	Day 5 (n)	Day 30 (n)	Day 90 (n)	Day 180 (n)	Adult (n)
PT (s)	13.0 ± 1.43 (61)[a]	12.4 ± 1.46 (77)[a,b]	11.8 ± 1.25 (67)[a,b]	11.9 ± 1.15 (62)[a]	12.3 ± 0.79 (47)[a]	12.4 ± 0.78 (29)
aPTT (s)	42.9 ± 5.80 (61)	42.6 ± 8.62 (76)	40.4 ± 7.42 (67)	37.1 ± 6.52 (62)[a]	35.5 ± 3.71 (47)[a]	33.5 ± 3.44 (29)
TCT (s)	23.5 ± 2.38 (58)[a]	23.1 ± 3.07 (64)[b]	24.3 ± 2.44 (53)[a]	25.1 ± 2.32 (52)[a]	25.5 ± 2.86 (41)[a]	25.0 ± 2.66 (19)
Fibrinogen (g/L)	2.83 ± 0.58 (61)[a]	3.12 ± 0.75 (77)[a]	2.70 ± 0.54 (67)[a]	2.43 ± 0.68 (60)[a,b]	2.51 ± 0.68 (47)[a,b]	2.78 ± 0.61 (29)
II (U/mL)	0.48 ± 0.11 (61)	0.63 ± 0.15 (76)	0.68 ± 0.17 (67)	0.75 ± 0.15 (62)	0.88 ± 0.14 (47)	1.08 ± 0.19 (29)
V (U/mL)	0.72 ± 0.18 (61)	0.95 ± 0.25 (76)	0.98 ± 0.18 (67)	0.90 ± 0.21 (62)	0.91 ± 0.18 (47)	1.06 ± 0.22 (29)
VII (U/mL)	0.66 ± 0.19 (60)	0.89 ± 0.27 (75)	0.90 ± 0.24 (67)	0.91 ± 0.26 (62)	0.87 ± 0.20 (47)	1.05 ± 0.19 (29)
VIII (U/mL)	1.00 ± 0.39 (60)[a,b]	0.88 ± 0.33 (75)[a,b]	0.91 ± 0.33 (67)[a,b]	0.79 ± 0.23 (62)[a,b]	0.73 ± 0.18 (47)[b]	0.99 ± 0.25 (29)
vWF (U/mL)	1.53 ± 0.67 (40)[b]	1.40 ± 0.57 (43)[b]	1.28 ± 0.59 (40)[b]	1.18 ± 0.44 (40)[b]	1.07 ± 0.45 (46)[b]	0.92 ± 0.33 (29)[b]
IX (U/mL)	0.53 ± 0.19 (59)	0.53 ± 0.19 (75)	0.51 ± 0.15 (67)	0.67 ± 0.23 (62)	0.86 ± 0.25 (47)	1.09 ± 0.27 (29)
X (U/mL)	0.40 ± 0.14 (60)	0.49 ± 0.15 (76)	0.59 ± 0.14 (67)	0.71 ± 0.18 (62)	0.78 ± 0.20 (47)	1.06 ± 0.23 (29)
XI (U/mL)	0.38 ± 0.14 (60)	0.55 ± 0.16 (74)	0.53 ± 0.13 (67)	0.69 ± 0.14 (62)	0.86 ± 0.24 (47)	0.97 ± 0.15 (29)
XII (U/mL)	0.53 ± 0.20 (60)	0.47 ± 0.18 (75)	0.49 ± 0.16 (67)	0.67 ± 0.21 (62)	0.77 ± 0.19 (47)	1.08 ± 0.28 (29)
PK (U/mL)	0.37 ± 0.16 (45)[b]	0.48 ± 0.14 (51)	0.57 ± 0.17 (48)	0.73 ± 0.16 (46)	0.86 ± 0.15 (43)	1.12 ± 0.25 (29)
HMWK (U/mL)	0.54 ± 0.24 (47)	0.74 ± 0.28 (63)	0.77 ± 0.22 (50)[a]	0.82 ± 0.32 (46)[a]	0.82 ± 0.23 (48)[a]	0.92 ± 0.22 (29)
XIIIa (U/mL)	0.79 ± 0.26 (44)	0.94 ± 0.25 (49)[a]	0.93 ± 0.27 (44)[a]	1.04 ± 0.34 (44)[a]	1.04 ± 0.29 (41)[a]	1.05 ± 0.25 (29)[b]

Tests	Day 1 (n)	Day 5 (n)	Day 30 (n)	Day 90 (n)	Day 180 (n)	Adult (n)
XIIIb (U/mL)	0.76 ± 0.23 (44)	1.06 ± 0.37 (47)[a]	1.11 ± 0.36 (45)[a]	1.16 ± 0.34 (44)[a]	1.10 ± 0.30 (41)[a]	0.97 ± 0.20 (29)
Plasminogen (CTA, U/mL)	1.95 ± 0.35 (44)	2.17 ± 0.38 (60)	1.98 ± 0.36 (52)	2.48 ± 0.37 (44)	3.01 ± 0.40 (47)	3.36 ± 0.44 (29)

Note: All factors except fibrinogen and plasminogen are expressed as units per milliliter, where pooled plasma contains 1.0 U/mL. Plasminogen units are those recommended by the Committee on Thrombolytic Agents (CTA). All values are expressed as mean ± 1 SD.

Abbreviations: aPTT, activated partial thromboplastin time; HMWK, high molecular–weight kininogen; PK, prekallikrein; PT, prothrombin time; TCT, thrombin clotting time; vWF, von Willebrand factor.

[a] Values that do not differ statistically from the adult values.

[b] These measurements are skewed because of a disproportionate number of high values. The lower limit that excludes the lower 2.5th percentile of the population has been given in the respective figures. The lower limit for factor VIII was 0.50 U/mL at all time points for the infant.

Data were derived from Andrew M, Paes B, Milner R, et al. Development of the human coagulation system in the full-term infant. *Blood.* 1987;70(1):165.

Inhibition of Coagulation in the Healthy Full-term Infant During the First 6 Months of Life

Inhibitors	Day 1 (n)	Day 5 (n)	Day 30 (n)	Day 90 (n)	Day 180 (n)	Adult (n)
AT-III	0.63 ± 0.12 (58)	0.67 ± 0.13 (74)	0.78 ± 0.15 (66)	0.97 ± 0.12 (60)[a]	1.04 ± 0.10 (56)[a]	1.05 ± 0.13 (28)
a2-M	1.39 ± 0.22 (54)	1.48 ± 0.25 (73)	1.50 ± 0.22 (61)	1.76 ± 0.25 (55)	1.91 ± 0.21 (55)	0.86 ± 0.17 (29)
a2-AP	0.85 ± 0.15 (55)	1.00 ± 0.15 (75)[a]	1.00 ± 0.12 (62)[a]	1.08 ± 0.16 (55)[a]	1.11 ± 0.14 (53)[a]	1.02 ± 0.17 (29)
C1E-INH	0.72 ± 0.18 (59)	0.90 ± 0.15 (76)[a]	0.89 ± 0.21 (63)	1.15 ± 0.22 (55)	1.41 ± 0.26 (55)	1.01 ± 0.15 (29)
a3-AT	0.93 ± 0.22 (57)[a]	0.89 ± 0.20 (75)[a]	0.62 ± 0.13 (61)	0.72 ± 0.15 (56)	0.77 ± 0.15 (55)	0.93 ± 0.19 (29)
HCII	0.43 ± 0.25 (56)	0.48 ± 0.24 (72)	0.47 ± 0.20 (58)	0.72 ± 0.37 (58)	1.20 ± 0.35 (55)	0.96 ± 0.15 (29)
Protein C	0.35 ± 0.09 (41)	0.42 ± 0.11 (44)	0.43 ± 0.11 (43)	0.54 ± 0.13 (44)	0.59 ± 0.11 (52)	0.96 ± 0.16 (28)
Protein S	0.36 ± 0.12 (40)	0.50 ± 0.14 (48)	0.63 ± 0.15 (41)	0.86 ± 0.16 (46)[a]	0.87 ± 0.16 (49)[a]	0.92 ± 0.16 (29)

Note: All values are expressed in units per milliliter as the mean ± 1 SD.

[a]Values that do not differ statistically from the adult values.

Data were derived from Andrew M, Paes B, Milner R, et al. Development of the human coagulation system in the full-term infant. *Blood.* 1987;70(1):165.

Healthy Preterm Infants (30 to 36 Weeks' Gestation) During the First 6 Months of Life

	Day 1 (n)		Day 5 (n)		Day 30 (n)		Day 90 (n)		Day 180 (n)		Adult (n)	
	M	B	M	B	M	B	M	B	M	B	M	B
PT (s)	13.0	(10.6–16.2)[a]	12.5	(10.0–15.3)[a,b]	11.8	(10.0–13.6)[a]	12.3	(10.0–14.6)[a]	12.5	(10.0–15.0)[a]	12.4	(10.8–13.9)
APTT (s)	53.6	(27.5–79.4)[b]	50.5	(26.9–74.1)[c]	44.7	(26.9–62.5)	39.5	(28.3–50.7)	37.5	(21.7–53.3)[a]	33.5	(26.8–40.3)
TCT (s)	24.8	(19.2–30.4)[a]	24.1	(18.8–29.4)[a]	24.4	(18.8–29.9)[a]	25.1	(19.4–30.8)[a]	25.2	(18.9–31.5)[a]	25.0	(19.7–30.3)
Fibrinogen (g/L)	2.43	(1.50–3.73)[a–c]	2.80	(1.60–4.18)[a–c]	2.54	(1.50–4.14)[a,b]	2.46	(1.50–3.52)[a,b]	2.28	(1.50–3.80)[b]	2.78	(1.58–4.00)
II (U/mL)	0.45	(0.20–0.77)[b]	0.57	(0.29–0.85)[c]	0.57	(0.36–0.95)[b,c]	0.68	(0.30–1.06)	0.87	(0.51–1.23)	1.08	(0.70–1.46)
V (U/mL)	0.88	(0.41–1.44)[a–c]	1.00	(0.46–1.54)	1.02	(0.48–1.56)	0.99	(0.59–1.39)	1.02	(0.58–1.46)	1.06	(0.62–1.50)
VII (U/mL)	0.67	(0.21–1.13)	0.84	(0.30–1.38)	0.83	(0.21–1.45)	0.87	(0.31–1.43)	0.99	(0.47–1.51)[a]	1.05	(0.67–1.43)
VIII (U/mL)	1.11	(0.50–2.13)[a,b]	1.15	(0.53–2.05)[a–c]	1.11	(0.50–1.99)[a–c]	1.06	(0.58–1.88)[a,c]	0.99	(0.50–1.87)[a–c]	0.99	(0.50–1.49)
vWF (U/mL)	1.36	(0.78–2.10)[b]	1.33	(0.72–2.19)[b]	1.36	(0.66–2.16)[b]	1.12	(0.75–1.84)[a,b]	0.98	10.54–1.58)[a,b]	0.92	(0.50–1.58)
IX (U/mL)	0.35	(0.19–0.65)[c]	0.42	(0.14–0.74)[b,c]	0.44	(0.13–0.80)[b]	0.59	(0.25–0.93)	0.81	(0.50–1.20)[b]	1.09	(0.55–1.83)
X (U/mL)	0.41	(0.11–0.71)	0.51	(0.19–0.83)	0.56	(0.20–0.92)	0.67	(0.35–0.99)	0.77	(0.35–1.19)	1.06	(0.70–1.52)
XI (U/mL)	0.30	(0.08–0.52)[b,c]	0.41	(0.13–0.69)[c]	0.43	(0.15–0.71)[c]	0.59	(0.25–0.93)[c]	0.78	(0.46–1.10)	0.97	(0.87–1.27)
XII (U/mL)	0.38	(0.10–0.66)[c]	0.39	(0.09–0.69)[c]	0.43	(0.11–0.75)	0.61	(0.15–1.07)	0.82	(0.22–1.42)	1.08	(0.52–1.84)
PK (U/mL)	0.33	(0.09–0.57)	0.45	(0.26–0.75)[b]	0.59	(0.31–0.87)	0.79	(0.37–1.21)	0.78	(0.40–1.16)	1.12	(0.82–1.82)
HMWK (U/mL)	0.49	(0.09–0.89)	0.62	(0.24–1.00)[c]	0.64	(0.16–1.12)[c]	0.78	(0.32–1.24)	0.83	(0.41–1.25)[a]	0.92	(0.50–1.38)
XIIIa (U/mL)	0.70	(0.32–1.08)	1.01	(0.57–1.45)[a]	0.99	(0.51–1.47)[a]	1.13	(0.71–1.55)[a]	1.13	(0.65–1.61)[a]	1.05	(0.55–1.55)
XIIIb (U/mL)	0.81	(0.35–1.27)	1.10	(0.68–1.58)[a]	1.07	(0.57–1.57)[a]	1.21	(0.75–1.67)	1.15	(0.67–1.63)	0.97	(0.57–1.37)
Plasminogen ICTA (U/mL)	1.70	(1.12–2.48)[b,c]	1.91	(1.21–2.61)[c]	1.81	(1.09–2.53)	2.38	(1.58–3.18)	2.75	(1.91–3.59)[c]	3.38	(2.46–4.24)

Note: All factors except fibrinogen and plasminogen are expressed as U/mL, where pooled plasma contains 1.0 U/mL. Plasminogen units are those recommended by the Committee on Thrombolytic Agents (CTA). All values are given as a mean (M) followed by lower and upper boundary encompassing 95% of the population (B). Between 40 and 96 samples were assayed for each value for newborns.

[a]Values indistinguishable from those of adults.

[b]Measurements are skewed owing to a disproportionate number of high values. Lower limit which excludes the lower 2.5% of the population is given (B).

[c]Values different from those of full-term infants.

From Andrew M, Paes B, Milner R, et al. Development of the human coagulation system in the healthy premature infant. *Blood*. 1988;72(5):1651–1657.

Inhibition of Coagulation in Healthy Preterm Infants (30 to 36 Weeks' Gestation) During the First 6 Months of Life

	Day 1 (n)		Day 5 (n)		Day 30 (n)		Day 90 (n)		Day 180 (n)		Adult (n)	
	M	B	M	B	M	B	M	B	M	B	M	B
AT-III (U/mL)	0.38	(0.14–0.62)[c]	0.56	(0.30–0.82)[a]	0.59	(0.37–0.81)[c]	0.83	(0.45–1.21)[c]	0.90	(0.52–1.28)[c]	1.05	(0.79–1.31)
α_2M (U/mL)	1.10	(0.56–1.82)[a,c]	1.25	(0.71–1.77)[a]	1.38	(0.72–2.04)	1.80	(1.20–2.66)[b]	2.09	(1.10–3.21)[b]	0.88	(0.52–1.20)
α_2AP (U/mL)	0.78	(0.40–1.16)	0.81	(0.49–1.13)[a]	0.89	(0.55–1.23)[c]	1.06	(0.64–1.46)[a]	1.15	(0.77–1.53)	1.02	(0.68–1.36)
C$_1$INH (U/mL)	0.65	(0.31–0.99)	0.83	(0.45–1.21)	0.74	(0.40–1.24)[a,c]	1.14	(0.60–1.68)[a]	1.40	(0.96–2.04)[b]	1.01	(0.71–1.31)
α_1AT (U/mL)	0.90	(0.36–1.44)[a]	0.94	(0.42–1.46)[c]	0.76	(0.38–1.12)[c]	0.81	(0.49–1.13)[a,c]	0.82	(0.48–1.16)[a]	0.93	(0.55–1.31)
HCII (U/mL)	0.32	(0.00–0.60)[c]	0.34	(0.00–0.69)[a]	0.43	(0.15–0.71)	0.61	(0.20–1.11)[b]	0.89	(0.45–1.40)[a,c]	0.96	(0.66–1.28)
Protein C (U/mL)	0.28	(0.12–0.44)[a,c]	0.31	(0.11–0.51)[a]	0.37	(0.15–0.59)[a]	0.45	(0.23–0.67)[c]	0.57	(0.31–0.83)	0.96	(0.84–1.28)
Protein S (U/mL)	0.26	(0.14–0.38)[c]	0.37	(0.13–0.61)[a]	0.56	(0.22–0.90)	0.76	(0.40–1.12)[c]	0.82	(0.44–1.20)	0.92	(0.80–1.94)

Note: All factors are expressed as U/mL, where pooled plasma contains 1.0 U/mL. All values are given as a mean (M) followed by lower and upper boundary encompassing 95% of the population (B). Between 40 and 75 samples were assayed for each value for newborns.

[a]Values indistinguishable from those of adults.

[b]Measurements are skewed owing to a disproportionate number of high values. Lower limit which excludes the lower 2.5% of the population is given (B).

[c]Values different from those of fullterm infants.

From Andrew M, Paes B, Milner R, et al. Development of the human coagulation system in the healthy premature infant. *Blood*. 1988;72(5):1651–1657.

Healthy Children Aged 1 to 16 Years Compared With Adults

	Age			
	1 to 5 y	6 to 10 y	11 to 16 y	Adult
Coagulation Tests	Mean (boundary)	Mean (boundary)	Mean (boundary)	Mean (boundary)
PT (s)	11 (10.6–11.4)	11.1 (10.1–12.1)	11.2 (10.2,12.0)	12 (11.0–14.0)
INR	1.0 (0.96–1.04)	1.01 (0.91–1.11)	1.02 (0.93–1.10)	1.10 (1.0–1.3)
APTI (s)	30 (24–36)	31 (26–36)	32 (26–37)	33 (27–40)
Fibrinogen (g/L)	2.76 (1.70–4.05)	2.79 (1.57–4.0)	3.0 (1.54–4.48)	2.78 (1.56–4.0)
Bleeding time (min)	6 (2.5–10)[a]	7 (2.5–13)[a]	5 (3–8)[a]	4(1–7)
II (U/mL)	0.94 (0.71–1.16)[a]	0.88 (0.67–1.07)[a]	0.83 (0.61–1.04)[a]	1.08 (0.70–1.46)
V (U/mL)	1.03 (0.79–1.27)	0.90 (0.63–1.16)[a]	Q.77 (0,55–0.99)	1.06 (0.62–1.50)
VII (U/mL)	0.82 (0.55–1.16)[a]	0.85 (0.52–1.20)[a]	0.83 (0.58–1.15)[a]	1.05 (0.67–1.43)
VIII (U/mL)	0.90 (0.59–1.42)	0.95 (0.58–1.32)	0.92 (0.53–1.31)	0.99 (0.50–1.49)
vWF (U/mL)	0.82 (0.60–1.20)	0.95 (0.44–1.44)	1.00 (0.46–1.53)	0.92 (0.50–1.58)
IX (U/mL)	0.73 (0.47–1.04)[a]	0.75 (0.63–0.89)[a]	0.82 (0.59–1.22)[a]	1.09 (0.55–1.63)
X (U/mL)	0.88 (0.58–1.16)[a]	0.75 (0.55–1.01)[a]	0.79 (0.50–1.17)[a]	1.06 (0.70–1.52)
XI (U/mL)	0.97 (0.56–1.50)	0.86 (0.52–1.20)	0.74 (0.50–0.97)[a]	0.97 (0.67–1.27)
XII (U/mL)	0.93 (0.64–1.29)	0.92 (0.60–1.40)	0.81 (0.34–1.37)[a]	1.08 (0.52–1.64)
PK (U/mL)	0.95 (0.65–1.30)	0.99 (0.66–1.31)	0.99 (0.53–1.45)	1.12 (0.62–1.62)
HMWK (U/mL)	0.98 (0.64–1.32)	0.93 (0.60–1.30)	0.91 (0.63–1.19)	0.92 (0.50–1.36)
XIIIa (U/mL)	1.08 (0.72–1.43)[a]	1.09 (0.65–1.51)[a]	0.99 (0.57–1.40)	1.05 (0.55–1.55)
XIIIs (U/mL)	1.13 (0.69–1.56)[a]	1.16 (0.77–1.54)[a]	1.02 (0.60–1.43)	0.97 (0.57–1.37)

Note: All factors except fibrinogen are expressed as units per milliliter, where pooled plasma contains 1.0 U/mL. All data are expressed as the mean, followed by the upper and lower boundary encompassing 95% of the population. Between 20 and 50 samples were assayed for each value for each age group. Some measurements were skewed due to a disproportionate number of high values. The lower limit, which excludes the lower 2.5% of the population, is given.

Abbreviations: APTT, activated partial thromboplastin time; HMWK, high molecular weight kininogen; PK, prekallikrein; PT, prothrombin time; VIII, factor VIII procoagulant; vWF, von Willebrand factor.

[a]Values that are significantly different from adults.

From Andrew M, Vegh P, Johnston M, Bowker J, Ofosu F, Mitchell L. Maturation of the hemostatic system during childhood. *Blood.* 1992;80(8):1998–2005.

Inhibition of Coagulation in Healthy Children Aged 1 to 16 Years Compared With Adults

	Age			
	1 to 5 y	6 to 10 y	11 to 16 y	Adult
Coagulation Inhibitors	**Mean (boundary)**	**Mean (boundary)**	**Mean (boundary)**	**Mean (boundary)**
ATIII (U/mL)	1.11 (0.82–1.39)	1.11 (0.90–1.31)	1.05 (0.77–1.32)	1.0 (0.74–1.26)
a_2M (U/mL)	1.69 (1.14–2.23)[a]	1.69 (1.28–2.09)[a]	1.56 (0.98–2.12)[a]	0.86 (0.52–1.20)
C_1-Inh (U/mL)	1.35 (0.85–1.83)[a]	1.14 (0.88–1.54)	1.03 (0.68–1.50)	1.0 (0.71–1.31)
a_1AT (U/mL)	0.93 (0.39–1.47)	1.00 (0.69–1.30)	1.01 (0.65–1.37)	0.93 (0.55–1.30)
HCII (U/mL)	0.88 (0.48–1.28)[a]	0.86 (0.40–1.32)[a]	0.91 (0.53–1.29)[a]	1.08 (0.66–1.26)
Protein C (U/mL)	0.66 (0.40–0.92)[a]	0.69 (0.45–0.93)[a]	0.83 (0.55–1.11)[a]	0.96 (0.64–1.28)
Protein S				
Total (U/mL)	0.86 (0.54–1.18)	0.78 (0.41–1.14)	0.72 (0.52–0.92)	0.81 (0.60–1.13)
Free (U/mL)	0.45 (0.21–0.69)	0.42 (0.22–0.62)	0.38 (0.26–0.55)	0.45 (0.27–0.61)

Note: All values are expressed in units per milliliter, where for all factors pooled plasma contains 1.0 U/mL, with the exception of free protein S, which contains a mean of 0.4 U/ml. All values are given as a mean, followed by the lower and upper boundary encompassing 95% of the population. Between 20 and 30 samples were assayed for each value for each age group. Some measurements were skewed due to a disproportionate number of high values. The lower limits, which exclude the lower 2.5% of the population, are given.

[a]Values that are significantly different from adults.

From Andrew M, Vegh P, Johnston M, Bowker J, Ofosu F, Mitchell L. Maturation of the hemostatic system during childhood. *Blood.* 1992;80(8):1998–2005.

Fibrinolytic System in Healthy Children Aged 1 to 16 Years Compared With Adults

	Age			
	1 to 5 y	6 to 10 y	11 to 16 y	Adult
	Mean (boundary)	Mean (boundary)	Mean (boundary)	Mean (boundary)
Plasminogen (U/mL)	0.98 (0.78–1.18)	0.92 (0.75–1.08)	0.86 (0.68–1.03)[a]	0.99 (0.77–1.22)
TPA (ng/mL)	2.15 (1.0–4.5)[a]	2.42 (1.0–5.0)[a]	2.16 (1.0–4.0)[a]	4.90 (1.40–8.40)
a_2AP (U/mL)	1.05 (0.93–1.17)	0.99 (0.89–1.10)	0.98 (0.78–1.18)	1.02 (0.68–1.36)
PAI (U/mL)	5.42 (1.0–10.0)	6.79 (2.0–12.0)[a]	6.07 (2.0–10.0)[a]	3.60 (0–11.0)

Note: For a_2AP, values are expressed as units per milliliter, where pooled plasma contains 1.0 U/ml. Values for TPA are given as nanograms per milliliter. Values for PAI are given as U/ml, where 1 U of PAI activity is defined as the amount of PAI that inhibits 1 IU of human single-chain TPA. All values are given as the mean, followed by the lower and upper boundary encompassing 95% of the population (boundary).

[a]Values that are significantly different from adults.

From Andrew M, Vegh P, Johnston M, Bowker J, Ofosu F, Mitchell L. Maturation of the hemostatic system during childhood. *Blood.* 1992;80(8):1998–2005.

LYMPHOCYTE SUBSET COUNTS IN PERIPHERAL BLOOD

Subset	N	0–3 Months	3–6 Months	6–12 Months	1–2 Years	2–6 Years	6–12 Years	12–18 Years
White Blood Cells	800	10.60 (7.20–18.00)	9.20 (6.70–14.00)	9.10 (6.40–13.00)	8.80 (6.40–12.00)	7.10 (5.20–11.00)	6.50 (4.40–9.50)	6.00 (4.40–8.10)
Lymphocytes	800	5.40 (3.40–7.60)	6.30 (3.90–9.00)	5.90 (3.40–9.00)	5.50 (3.60–8.90)	3.60 (2.30–5.40)	2.70 (1.90–3.70)	2.20 (1.40–3.30)
3	699	3.68 (2.50–5.50)	3.93 (2.50–5.60)	3.93 (1.90–5.90)	3.55 (2.10–6.20)	2.39 (1.40–3.70)	1.82 (1.20–2.60)	1.48 (1.00–2.20)
19	699	0.73 (0.30–2.00)	1.55 (0.43–3.00)	1.52 (0.61–2.60)	1.31 (0.72–2.60)	0.75 (0.39–1.40)	0.48 (0.27–0.86)	0.30 (0.11–0.57)
16/56	770	0.42 (0.17–1.10)	0.42 (0.17–0.83)	0.40 (0.16–0.95)	0.36 (0.18–0.92)	0.30 (0.13–0.72)	0.23 (0.10–0.48)	0.19 (0.07–0.48)
4	699	2.61 (1.60–4.00)	2.85 (1.80–4.00)	2.67 (1.40–4.30)	2.16 (1.30–3.40)	1.38 (0.70–2.20)	0.98 (0.65–1.50)	0.84 (0.53–1.30)
8	699	0.98 (0.56–1.70)	1.05 (0.59–1.60)	1.04 (0.50–1.70)	1.04 (0.62–2.00)	0.84 (0.49–1.30)	0.68 (0.37–1.10)	0.53 (0.33–0.92)
4/45RA/62L	694	2.25 (1.20–3.60)	2.23 (1.30–3.60)	2.10 (1.10–3.60)	1.64 (0.95–2.80)	0.96 (0.42–1.50)	0.56 (0.31–1.00)	0.39 (0.21–0.75)
8/45RA/62L	696	0.73 (0.38–1.30)	0.74 (0.45–1.20)	0.70 (0.33–1.20)	0.76 (0.40–1.40)	0.54 (0.26–0.85)	0.41 (0.20–0.65)	0.30 (0.17–0.56)
4/45RA	694	2.27 (1.20–3.70)	2.32 (1.30–3.70)	2.21 (1.10–3.70)	1.65 (1.00–2.90)	0.98 (0.43–1.50)	0.57 (0.32–1.00)	0.40 (0.23–0.77)
8/45RA	696	0.87 (0.45–1.50)	0.91 (0.55–1.40)	0.87 (0.48–1.50)	0.94 (0.49–1.70)	0.67 (0.38–1.10)	0.54 (0.31–0.90)	0.40 (0.24–0.71)

Subset	N	0–3 Months	3–6 Months	6–12 Months	1–2 Years	2–6 Years	6–12 Years	12–18 Years
4/DR/38	694	0.08 (0.03–0.18)	0.11 (0.05–0.26)	0.10 (0.04–0.22)	0.10 (0.05–0.25)	0.06 (0.03–0.14)	0.04 (0.02–0.08)	0.03 (0.01–0.06)
8/DR/38	697	0.05 (0.02–0.16)	0.07 (0.03–0.17)	0.09 (0.04–0.27)	0.15 (0.05–0.54)	0.11 (0.05–0.34)	0.06 (0.03–0.18)	0.04 (0.02–0.13)
4/DR	694	0.10 (0.04–0.18)	0.15 (0.06–0.28)	0.12 (0.05–0.26)	0.13 (0.07–0.28)	0.09 (0.05–0.18)	0.07 (0.04–0.12)	0.06 (0.03–0.10)
8/DR	697	0.05 (0.02–0.16)	0.08 (0.03–0.17)	0.09 (0.04–0.29)	0.18 (0.06–0.60)	0.14 (0.07–0.42)	0.09 (0.04–0.27)	0.07 (0.03–0.18)
4/38	694	2.54 (0.16–3.90)	2.77 (1.60–4.00)	2.55 (1.20–4.10)	2.02 (1.20–3.30)	1.21 (0.59–2.00)	0.75 (0.48–1.20)	0.57 (0.33–1.00)
8/38	697	0.93 (0.55–1.60)	0.94 (0.53–1.50)	0.93 (0.45–1.60)	0.95 (0.57–1.90)	0.67 (0.39–1.10)	0.48 (0.24–0.74)	0.31 (0.16–5.70)
4/28	695	2.56 (1.60–3.80)	2.65 (1.60–4.00)	2.58 (1.20–4.20)	2.12 (1.30–3.40)	1.33 (0.69–2.00)	0.94 (0.63–1.50)	0.79 (0.49–1.20)
8/28	696	0.71 (0.35–1.30)	0.73 (0.35–1.20)	0.67 (0.28–1.10)	0.72 (0.40–1.30)	0.50 (0.28–0.87)	0.40 (0.21–0.70)	0.29 (0.16–0.52)
4/95	695	0.29 (0.16–0.58)	0.41 (0.23–0.62)	0.51 (0.29–0.82)	0.50 (0.27–0.91)	0.42 (0.27–0.65)	0.36 (0.25–0.62)	0.40 (0.25–0.66)
8/95	696	0.12 (0.05–0.31)	0.16 (0.06–0.39)	0.22 (0.08–0.66)	0.34 (0.10–0.85)	0.30 (0.11–0.58)	0.25 (0.08–0.53)	0.21 (0.08–0.45)

LYMPHOCYTE SUBSET COUNTS IN PERIPHERAL BLOOD, continued

Subset	N	0–3 Months	3–6 Months	6–12 Months	1–2 Years	2–6 Years	6–12 Years	12–18 Years
3/4/45RO	644	0.32 (0.06–0.90)	0.33 (0.12–0.63)	0.34 (0.16–0.80)	0.40 (0.21–0.85)	0.36 (0.22–0.66)	0.35 (0.23–0.63)	0.38 (0.24–0.70)
3/4^{-}/45RO	644	0.10 (0.03–0.33)	0.12 (0.03–0.29)	0.12 (0.04–0.33)	0.23 (0.06–0.57)	0.19 (0.09–0.44)	0.21 (0.07–0.39)	0.16 (0.06–0.31)
3/45RO	644	0.48 (0.09–1.20)	0.46 (0.15–0.86)	0.47 (0.22–1.10)	0.65 (0.30–1.30)	0.57 (0.33–1.00)	0.59 (0.32–0.95)	0.56 (0.34–0.97)
3^{-}/19/38	655	0.60 (0.12–2.00)	1.20 (0.00–2.80)	1.29 (0.02–2.20)	1.04 (0.00–2.20)	0.56 (0.01–1.20)	0.28 (0.00–0.67)	0.03 (0.00–0.35)
3^{-}/19	655	0.62 (0.12–2.10)	1.26 (0.00–2.80)	1.33 (0.02–2.30)	1.10 (0.00–2.30)	0.67 (0.02–1.40)	0.34 (0.00–0.74)	0.04 (0.00–0.39)

Note: Values are presented as medians (10th and 90th percentiles). Subset counts (numbers of cells per microliter × 10^{-3}) were obtained by multiplying subset percentages times anchor marker percentages (ie, CD3CD4 or CD3CD8) of total CD45 lymphocyte population times the absolute lymphocyte count (white blood cells × lymphocyte percentage).

Adapted from Shearer WT, Rosenblatt HM, Gelman RS, et al; Pediatric AIDS Clinical Trials Group. Lymphocyte subsets in healthy children from birth through 18 years of age: the Pediatric AIDS Clinical Trials Group P1009 study. *J Allergy Clin Journal.* 2003;112(5):973–980. Reproduced with permission.

THYROID FUNCTION TESTS

Very Low Birth Weight Infants

Postnatal days	Screening T4 Levels by Birth Weight and Postnatal Age (mcg/dL)		
	VLBW (<1500 g)	LBW (<2500 g)	Term
1–3	7.9 ± 3.3	11.4 ± 2.5	12 ± 1.9
4–6	6.5 ± 2.9	9.9 ± 2.5	11 ± 2.5
7–10	6.3 ± 3.0	9.5 ± 2.3	
11–14	5.7 ± 2.8	9.2 ± 2.1	
15–18	7.0 ± 2.5	9.1 ± 2.3	
29–56	7.8 ± 2.5	9.3 ± 3.3	

Abbreviations: LBW, low birth weight; T4, thyroxine; VLBW, very low birth weight. Data expressed as ± SD.

From Frank JE, Faix JE, Hermos RJ, et al. Thyroid function in very low birth weight infants: effects on neonatal hypothyroidism screening. *J Pediatr.* 1996;128(4):548. Reproduced with permission. Copyright © 1996 Elsevier.

Preterm Infants

Gestational Age	Free T4 (ng/dL)	Thyroid-Stimulating Hormone (mcU/mL)
25–27 wk	0.6–2.2	0.2–30.3
28–30 wk	0.6–3.4	0.2–20.6
31–33 wk	1.0–3.8	0.7–27.9
34–36 wk	1.2–4.4	1.2–21.6
Term 37–42 wk	2.0–5.3	1.0–39
PCA	Concentrations after the first week of life[a]	
Preterm 28–40 wk	0.8–2.6	0.8–12.0
Term 42–60 wk	0.9–2.3	1.7–9.1

Abbreviations: PCA, postconceptional age (gestational age + postnatal age); T4, thyroxine.

[a]Clark SJ, Deming DD, Emery JR, Adams LM, Carlton EI, Nelson JC. Reference ranges for thyroid function tests in premature infants beyond the first week of life. *J Perinatol.* 2001;21(8):531–536.

From Adams LM, Emery JR, Clark SJ, et al. Reference ranges for newer thyroid function tests in premature infants. *J Pediatr.* 1995;126(1):122. Reproduced with permission. Copyright © 1995 Elsevier.

THYROID FUNCTION TESTS, continued

Infants, Children, and Adults

Age	Thyroxine (mcg/dL)	Free Thyroxine (ng/dL)	Triiodothyronine (ng/dL)	Free Triiodothyronine (ng/dL)	Thyroxine-Binding Globulin (mg/dL)	Thyroid-Stimulating Hormone (mcU/mL)
Cord blood	6.6–17.5	1.03–1.73	14–86	0.09–0.36	0.7–4.7	<2.5–17.4
1–3 d	11.0–21.5	0.6–2.0 (1–10 d)	100–380	0.17–0.57[a]		<2.5–13.3
1–4 wk	8.2–16.6	0.7–1.7 (>10 days)	99–310	0.17–0.65[a]	0.5–4.5	0.6–10.0
1–12 mo	7.2–15.6	0.8–1.8 (5–24 mo)[b]	102–264	0.24–0.65[a]	1.6–3.6	0.6–6.3
1–5 y	7.3–15	1.0–2.1 (2–7 y)[b]	105–269	0.29–0.8[a]	1.3–2.8	0.6–6.3
6–10 y	6.4–13.3	0.8–1.9 (8–20 y)[b]	94–241	0.34–0.72[a]	1.4–2.6	
11–15 y	5.6–11.7	0.59–2.45[c]	83–213	0.37–0.7[a]	1.4–2.6	0.6–6.3
16–20 y	4.2–11.8	0.54–2.23[c]	80–210	0.42–0.68 (16–18 y)[a]	1.4–2.6	0.2–7.6
21–45 y	4.3–12.5	0.9–2.5	70–204		1.2–2.4	0.2–7.6

[a] Soldin SJ, Morales A, Albalos F, Albalos F, Lenherr S, Rifai N. Pediatric reference ranges on the Abbott Imx for FSH, LH, prolactin, TSH, T4, T3, free T4, free T3, T-uptake, IgE and ferritin. *Clin Biochem.* 1995;28(6):603–606.

[b] Nelson JC, Clark SJ, Borut DL, Tomei RT, Carlton EI. Age-related changes in serum free thyroxine during childhood and adolescence. *J Pediatr.* 1993;123(6):899–905.

[c] Zurakowski D, DiCanzio J, Majzoub JA. Pediatric reference intervals for serum thyroxine, triiodothyronine, thyrotropin and free thyroxine. *Clin Chem.* 1999;45(7):1087–1091.

ENDOCRINE LABORATORY VALUES

Growth Hormone Values

In children: Spontaneous growth hormone secretion is pulsatile and unpredictable throughout the day with more peaks overnight in children who have an established diurnal rhythm. Therefore, random growth hormone values are generally not helpful.

Stimulated growth hormone values (arginine, insulin-induced hypoglycemia, levodopa, or clonidine) are often useful, and growth hormone deficiency can be ruled out with a value of >10 ng/mL or μg/L.

In neonates: A growth hormone level should always be measured in the presence of neonatal hypoglycemia in the absence of a metabolic disorder. A random growth hormone measurement in a polyclonal radioimmunoassay of less than 20 μg/L would suggest growth hormone deficiency.

These values may differ according to the method used by the laboratory. Please refer to your local laboratory values when interpreting test results.

Reference

Growth Hormone Research Society. Consensus guidelines for the diagnosis and treatment of growth hormone (GH) deficiency in childhood and adolescence: summary statement of the GH Research Society. GH Research Society. *J Clin Endocrinol Metab.* 2000;85(11):3990–3993

8 am Cortisol Levels

Interpretation	Cortisol (mcg/dL)
Suggestive of adrenal insufficiency	<5 mcg/dL
Indeterminate	5–14 mcg/dL
Adrenal insufficiency unlikely	>14 mcg/dL

Note: Post ACTH stimulation test Cortisol level of 16 to 36 mcg/dL is reassuring.

ENDOCRINE LABORATORY VALUES, continued

Serum 17 Hydroxyprogesterone

Age	Baseline (ng/dL)	60-Min Post-ACTH Stimulation (ng/dL)
Term infants (3 d)	≤420	
1–12 mo	11–170	85–465
1–5 y	4–115	50–350
6–12 y	7–69	75–220
Males, Tanner II-III	12–130	69–310
Females, Tanner II-III	18–220	80–420
Male, Tanner IV-V	51–190	105–230
Females, Tanner IV-V	36–200	80–225
Male (18–30 y)	32–307	
Adult Female		
Follicular phase	≤185	
Midcycle phase	≤225	
Luteal phase	≤285	

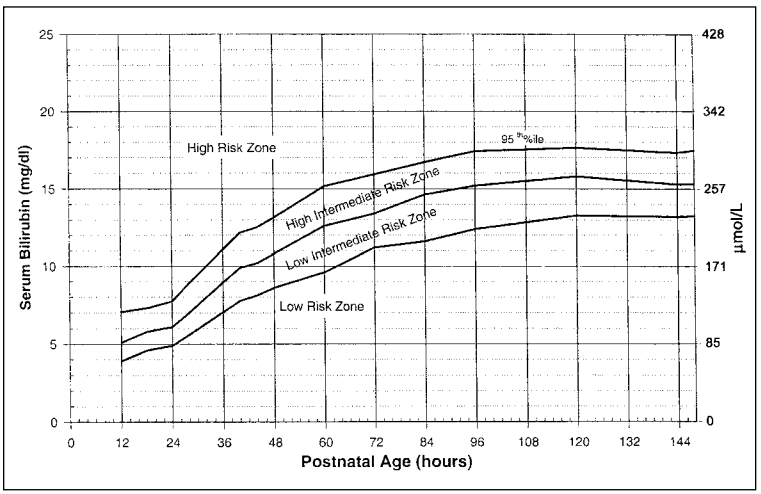
Abbreviation: ACTH, adrenocorticotropic hormone.

Note: 8 am level is most accurate given diurnal variation. Levels are normally increased in newborns for the first few days of life. Be aware that infant serum contains substances that may cross-react in the assay for 17-hydroxyprogesterone and artificially elevate the level, unless they are separated by chromatography. Before interpreting results on infants, be sure that the laboratory has prepared samples appropriately.

For preterm infants or infants born small for gestational age, see: Olgemöller et al. Screening for congenital adrenal hyperplasia: adjustment of 17-hydroxyprogesterone cut-off values to both age and birth weight markedly improves the predictive value. *J Clin Endocrinol Metab.* 2003;88: 5790–5794.

6. Hyperbilirubinemia Management

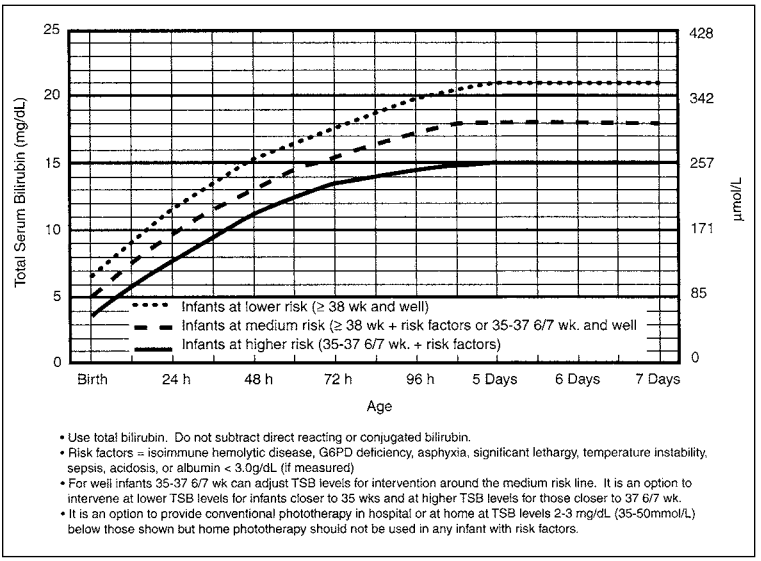
RISK NOMOGRAM



Nomogram for designation of risk in 2840 well newborns at 36 or more weeks' gestational age with birth weight of 2000 g or more or 35 or more weeks' gestational age and birth weight of 2500 g or more based on the hour-specific serum bilirubin values.

From Bhutani VK, Johnson L, Sivieri EM. Predictive ability of a predischarge hour-specific serum bilirubin for subsequent significant hyperbilirubinemia in healthy term and near-term newborns. *Pediatrics.* 1999;103(1):6–14.

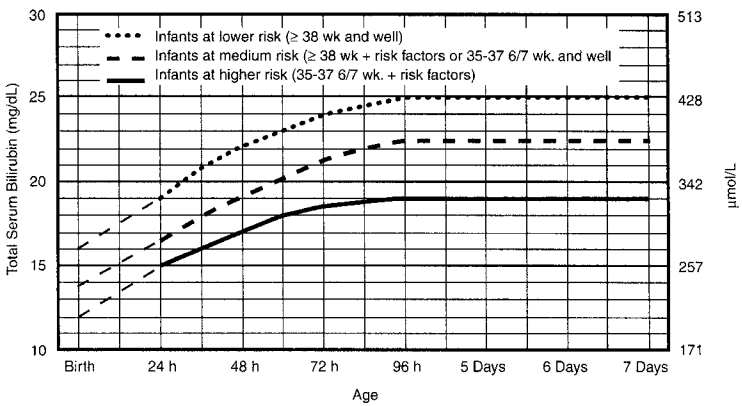
PHOTOTHERAPY NOMOGRAM



Guidelines for phototherapy in hospitalized infants of 35 or more weeks' gestation.

From American Academy of Pediatrics Subcommittee on Hyperbilirubinemia. Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. *Pediatrics.* 2004; 114(1):297–316.

EXCHANGE TRANSFUSION NOMOGRAM



- The dashed lines for the first 24 hours indicate uncertainty due to a wide range of clinical circumstances and a range of responses to phototherapy.
- Immediate exchange transfusion is recommended if infant shows signs of acute bilirubin encephalopathy (hypertonia, arching, retrocollis, opisthotonos, fever, high pitched cry) or if TSB is ≥5 mg/dL (85 µmol/L) above these lines.
- Risk factors - isoimmune hemolytic disease, G6PD deficiency, asphyxia, significant lethargy, temperature instability, sepsis, acidosis.
- Measure serum albumin and calculate B/A ratio (See legend)
- Use total bilirubin. Do not subtract direct reacting or conjugated bilirubin
- If infant is well and 35-37 6/7 wk (median risk) can individualize TSB levels for exchange based on actual gestational age.

Guidelines for exchange transfusion in infants 35 or more weeks' gestation.

From American Academy of Pediatrics Subcommittee on Hyperbilirubinemia. Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. *Pediatrics.* 2004;114(1):297–316.

7. Rate and Gap Calculations

GLUCOSE INFUSION RATE

The glucose infusion rate (GIR) can be calculated using the following formula:

$$\text{GIR} = \frac{\text{IV Rate (mL/h)} \times \text{Dextrose Concentration (g/dL)} \times 0.167}{\text{Weight (kg)}}$$

- A GIR of 5 to 8 mg/kg/min is typical.
- The maximal GIR needed to optimize nutrition is 14 mg/kg/min.

CALCULATED SERUM OSMOLALITY

The serum osmolality can be calculated using the following formula:

(2 × serum [Na]) + [glucose, in mg/dL]/18 + [blood urea nitrogen, in mg/dL]/2.8

- Reference Range Value: 275 to 295 mOsm/L

Osmolal Gap = Measured Osmolality by Laboratory – Calculated Osmolality

- Gap should be less than 10 mOsm.

ANION GAP

The anion gap is the difference between the positive ions in the serum (sodium – Na) and the negative ions (chloride [CI] and bicarbonate [HCO_3^-]. It can be calculated using the following formula:

Anion Gap: Na – (HCO_3^- + CI)

- Normal Anion Gap = 8 to 12 mEq/L.This varies according to local laboratories. Please check your specific lab because new analyzers produce higher chloride levels.
- Elevated Anion Gap is greater than 14 mEq/L in children.

8. Nutrition, Formula Preparation, and Caloric Counts

PREPARATION OF INFANT FORMULA FOR STANDARD AND SOY FORMULAS[a]

Formula Type	Caloric Concentration (kcal/oz)	Amount of Formula	Water (oz)
Liquid concentrates (40 kcal/oz)	20	13 oz	13
	24	13 oz	8.5
	27	13 oz	6.3
	30	13 oz	4.3
Powder (44 kcal/scoop)	20	1 scoop	2
	24	3 scoops	5
	27	3 scoops	4.25
	30	3 scoops	4

[a]Does not apply to Enfacare LIPIL, Neocate Infant, Neosure Advance, EleCare; Enfamil AR should not be concentrated greater than 24 kcal/oz. Use a packed measure for Nutramigen LIPIL and Pregestimil LIPIL and unpacked powder for all others.

Adapted from Arcara KM, Tschudy MM, eds. *The Harriet Lane Handbook.* 19th ed. St Louis, MO: Mosby; 2012. Reproduced with permission.

COMMON CALORIC SUPPLEMENTS[a]

Component		Calories
Protein	Resource Beneprotein (powder)	25 kcal/scoop (6 g protein)
	ProSource Protein Powder	30 kcal/scoop (6 g protein)
	Complete Amino Acid Mix	3.28 kcal/g (0.82 g protein)
Carbohydrate	Polycose	Powder: 3.8 kcal/g, 8 kcal/5 mLl
Fat	MCT oil[b]	7.7 kcal/mL
	Vegetable oil	8.3 kcal/mL
	Microlipid	4.5 kcal/mL
Fat and Carbohydrate	Duocal	42 kcal/15 mL; 25 kcal/scoop (59% carbohydrates, 41% fat; 35% fat as MCT oil)

Abbreviations: MCT, medium-chain triglyceride.

[a] Use these caloric supplements when you want to increase protein or when you have reached the maximum concentration tolerated and wish to further increase caloric density.

[b] MCT oil is unnecessary unless there is fat malabsorption.

From Arcara KM, Tschudy MM, eds. *The Harriet Lane Handbook.* 19th ed. St Louis, MO: Mosby; 2012.

ENTERAL FORMULAS, INCLUDING THEIR MAIN NUTRIENT COMPONENTS

	Kcal/oz	Protein (g)	Fat (g)	Carbs (g)	Na (mEq)	K (mEq)	Ca (mg)	P (mg)	Fe (mg)	Osmolality
A. INFANTS										
Human Milk										
Term	20	11	39	72	8	14	279	143	0.3	286
Preterm	20	14	39	66	11	15	248	128	1.2	290
Human Milk and Fortifiers Analysis										
Enfamil HMF+ preterm human milk (1 pkt/25 mL)	24	26	49	70	18	23	1148	628	15.6	325
Similac HMF+ preterm human milk (1 pkt/25 mL)	24	23	41	82	17	30	1381	777	4.6	N/A

	Kcal/ oz	Protein (g)	Fat (g)	Carbs (g)	Na (mEq)	K (mEq)	Ca (mg)	P (mg)	Fe (mg)	Osmo-lality
A. INFANTS, continued										
Preterm Formulas										
Enfamil Premature LIPIL	20	20	34	74	17	17	1100	553	3.4	240
Good Start Premature 24	24	24	42	84	19	25	1312	680	14.4	275
NeoSure	22	21	41	75	11	27	781	461	13.4	250
EnfaCare LIPIL	22	21	39	77	11	20	890	490	13.3	260
Similac Special Care 20	20	20	37	70	13	22	1217	676	12.2	235
Similac Special Care 24 High Protein	24	27	44	81	15	27	1461	811	14.6	280
Similac Special Care 30	30	30	67	78	19	34	1826	1014	18.3	325
Cow's Milk-Based Formulas										
Enfamil Premium Lipil	20	14	36	74	8	19	520	287	12	360
Enfamil LIPIL	20	14	36	73	8	19	520	287	12	300
Enfamil AR LIPIL	20	17	34	74	12	19	520	353	12	230 (240*)
Enfamil LactoFree LIPIL	20	14	36	73	9	19	547	307	12	200
Enfamil Restfull	20	17	34	74	12	19	520	353	12	230
Enfagrow Premium NextStep	20	18	36	70	10	23	1300	867	13.4	270
Evaporated Milk (13 oz + 19 oz water + 30 mL corn syrup)	20	27	31	72	21	32	1066	832	0.8	N/A
Organic Milk-Based Infant Formula	20	15	36	71	7	15	420	280	12	294
Parent's Choice Store Brand (also w/ARA/DHA)	20	14	36	72	8	19	520	287	12	295

*Liquid formulation

ENTERAL FORMULAS, INCLUDING THEIR MAIN NUTRIENT COMPONENTS, continued

	Kcal/ oz	Protein (g)	Fat (g)	Carbs (g)	Na (mEq)	K (mEq)	Ca (mg)	P (mg)	Fe (mg)	Osmo-lality
A. INFANTS, continued										
Cow's Milk-Based Formulas, continued										
Similac Advance Early Shield	20	14	37	76	7	18	528	284	12	310
Similac Go & Grow Milk-Based Formula	20	14	37	72	7	18	1014	548	13.5	300
Similac Sensitive	20	14	37	72	9	19	568	379	12.2	200
Similac Organic	20	14	37	71	7	18	528	284	12.2	225
Similac PM 60/40	20	15	38	69	7	14	379	189	4.7	280
Similac Sensitive RS	20	14	37	72	9	19	568	379	12.2	180
Soy-Based Formulas										
Good Start 2 Soy PLUS	20	19	34	73	12	20	1273	710	13.4	175
Good Start Soy PLUS	20	17	34	75	12	20	704	422	12.1	180
America's Store Brand Soy (also w/ARA/DHA)	20	17	36	68	11	21	700	460	12	164
SimilacGo & Grow Soy-Based Formula	20	17	37	70	13	19	1014	676	13.5	200
Isomil Advance	20	17	37	70	13	19	710	507	12.2	200
IsomilDF	20	18	37	68	13	19	710	507	12.2	240
Enfagrow Soy NextStep	20	22	30	79	11	21	1300	867	13.3	230
Enfamil Pro-SobeeLIPIL	20	17	36	71	11	21	700	460	12	170
Casein, Extensively Hydrolyzed										
Alimentum	20	19	37	69	13	20	710	507	12.2	370
Nutramigen LIPIL	20	19	36	69	14	19	627	347	12	300 (320*)

*Liquid formulation

	Kcal/ oz	Protein (g)	Fat (g)	Carbs (g)	Na (mEq)	K (mEq)	Ca (mg)	P (mg)	Fe (mg)	Osmo-lality
A. INFANTS, continued										
Casein, Extensively Hydrolyzed, continued										
Nutramigen with Enflora LGG	20	19	36	69	14	19	627	347	12	300
Pregestimil LiPiL	20	19	38	69	14	19	640	350	12.2	250
Whey, Partially Hydrolyzed										
Good Start Gentle PLUS	20	15	34	78	8	19	449	255	10.1	250
Good Start Protect PLUS	20	15	34	75	8	19	449	255	10.1	250
Good Start 2 Gentle PLUS	20	15	24	78	8	19	1273	710	13.4	180
Good Start 2 Protect PLUS	20	15	34	75	8	19	1273	710	13.4	250
Whey and Casein, Partially Hydrolyzed										
Enfamil Gentlease	20	15	36	72	10	19	547	307	12	230
Amino Acid-Based Formulas										
EleCare (also w/ DHA/ARA)	20	20	32	72	13	26	780	568	10	350
Neocate Infant (also w/ DHAIARA)	20	21	30	78	11	27	830	624	12.4	375
Nutramigen AA LIPIL	20	19	36	69	14	19	627	347	12	350
Specialized Formulas										
3232A	20	19	28	89	13	19	627	420	12.5	250
RCF	20	20	36	68	13	19	710	507	12.2	168
Enfaport LIPIL	30	35	54	102	13	29	940	520	18	280

ENTERAL FORMULAS, INCLUDING THEIR MAIN NUTRIENT COMPONENTS, continued

	Kcal/ oz	Protein (g)	Fat (g)	Carbs (g)	Na (mEq)	K (mEq)	Ca (mg)	P (mg)	Fe (mg)	Osmo-lality
B. TODDLERS AND YOUNG CHILDREN AGES 1–10 YEARS										
Cow's Milk-Based Formulas										
Boost Kid Essentials	30	30	38	135	24	30	1181	886	14	550/ 600/ 570
Boost Kid Essentials 1.5 (w/fiber)	45	42	75	165	30	33	1300	990	14	390 (405)
Carnation Instant Breakfast Lactose Free	30	35	37	133	38	32	500	1018	9	480/ 490
Carnation Instant Breakfast Lactose Free Plus	45	52	48	176	51	48	748	748	13.6	620
Carnation Instant Breakfast Lactose Free VHC	68	90	123	197	51	46	1232	1232	22.4	950
Carnation Instant Breakfast Essentials	24	43	16	105	24	27	1539	1539	13.8	N/A
Compleat Pediatric	30	38	39	126	33	42	1440	1000	13.2	380
Cow's milk, 2%	15	35	20	50	22	41	1258	979	0.5	N/A
Cow's milk, whole	19	34	34	48	22	40	1226	956	0.5	285
Ketocal 3:1	30	22	97	10	18	35	1140	801	16	180
KetoCal 4:1	43	30	144	6	26	55	1600	1300	22	197
Kindercal TF Vanilla	32	30	44	135	16	34	1010	850	10.6	345
Monogen	30	27	28	163	21	22	617	480	10.1	370
NutrenJunior with Fiber	30	30	50	110	20	34	1000	800	14	350
PediaSure Enteral (w/fiber)	30	30	40	133	17	34	972	845	14	335 (345)
PediaSure 1.5 with Fiber	45	59	69	160 (165)	17	42	1476	1054	11	379 (390)
PediaSure Vanilla	30	30	38	131	17	34	972	845	14	480

	Kcal/ oz	Protein (g)	Fat (g)	Carbs (g)	Na (mEq)	K (mEq)	Ca (mg)	P (mg)	Fe (mg)	Osmo-lality
B. TODDLERS AND YOUNG CHILDREN AGES 1–10 YEARS, continued										
Cow's Milk-Based Formulas, continued										
PediaSure with Fiber Vanilla	30	30	38	135	17	34	972	845	14	480
Portagen	30	32	44	104	22	29	850	642	17	350
Soy-Based Formulas										
Bright Beginnings Soy Pediatric Drink	30	30	50	109	17	40	970	800	14	350
Semi-Elemental, Hydrolyzed										
Peptamen Junior 1.5	45	45	68	180	30	35	1652	1352	20.8	450
Peptamen Junior Fiber	30	30	39	137	20	34	1000	800	14	365
Peptamen Junior with Prebio	30	30	39	137	20	34	1000	800	14	365
Peptamen Junior, Unflavored (w/fiber)	30	30	39	138	20	34	1000	800	14	260 (390)
Vital Junior	30	30	41	134	31	35	1055	844	13.9	390
Soy and Pork, Hydrolyzed										
Pepdite Junior, unflavored	30	31	50	106	18	35	1130	940	14	430
Amino Acid-Based Formulas										
EleCare (Unflavored and Vanilla)	30	31	49	109	20	39	1172	852	15	560
E028 Splash	30	25	35	146	9	24	620	620	7.7	820
NeocateJunior Flavored	30	35	47	110	19	36	1200	738	16	690
Neocate Junior Unflavored	30	33	50	104	18	35	1130	697	15	590
Vivonex Pediatric	24	24	24	130	17	31	970	800	10	360

ENTERAL FORMULAS, INCLUDING THEIR MAIN NUTRIENT COMPONENTS, continued

	Kcal/ oz	Protein (g)	Fat (g)	Carbs (g)	Na (mEq)	K (mEq)	Ca (mg)	P (mg)	Fe (mg)	Osmo-lality
C. OLDER CHILDREN AND ADULTS										
Cow's Milk-Based Formulas										
Boost	30	40	17	171	24	43	1250	1250	19	625
Boost High Protein	30	63	25	138	31	41	1459	1250	19	650
Boost Diabetic	32	59	50	84	48	29	1160	928	15	400
Boost High Protein	30	63	25	138	31	41	1459	1250	19	650
Boost Plus	45	59	59	188	31	41	1459	1250	19	670
Compleat	32	48	40	128	43	44	760	760	14	340
Crucial	45	94	68	134	51	48	1000	1000	18	490
Enlive	31	37	0	217	8	5	208	1166	11	825
Ensure	32	38	25	173	37	40	1266	1055	19	620
Ensure Plus	45	55	212	47	41	45	1266	2166	19	680
Glucerna 1.0 Cal	30	42	54	96	41	40	705	705	13	355
Jevity 1 Cal	32	44	35	155	40	40	910	760	14	300
Jevity 1.2 Cal	36	56	39	169	59	47	1200	1200	18	450
Jevity1.5 Cal	45	64	50	216	61	55	1200	1200	18	525
Nepro	53	81	96	167	46	27	1060	700	19	585
Novasource Renal	60	74	100	200	39	21	1300	650	18	700/ 960
Nutren 1.0 vanilla (w/fiber)	30	40	38	127	38	32	668	668	12	370 (410)
Nutren 1.5 unflavored	45	60	68	169	51	48	1000	1000	18	430
Nutren 2.0	60	80	104	196	57	49	1340	1340	24	745
Optimental	30	51	28	139	49	44	1055	1055	13	585
Osmolite 1 Cal	32	44	35	144	40	40	760	760	14	300
Osmolite 1.2 Cal	36	56	39	158	58	46	1200	1200	18	360
Osmolite 1.5 Cal	45	63	49	204	61	46	1000	1000	18	525
Promote (w/fiber)	30	63	26	130	44	51	1200	1200	18	340 (380)
Pulmocare	45	63	93	106	57	50	1060	1060	19	475
Renalcal	60	35	83	291	0	0	0	0	0	600

	Kcal/oz	Protein (g)	Fat (g)	Carbs (g)	Na (mEq)	K (mEq)	Ca (mg)	P (mg)	Fe (mg)	Osmolality
C. OLDER CHILDREN AND ADULTS, continued										
Cow's Milk-Based Formulas, continued										
Replete, Unflavored	30	63	34	113	38	39	1000	1000	18	300/350
Resource 2.0	60	84	88	217	35	39	1042	1042	18.8	790
Resource Breeze	32	38	0	230	15	1	42	633	11	750
Suplena	54	45	96	205	35	29	1055	717	19	600
TwoCal HN	60	84	91	219	64	63	1050	1050	19	725
Soy-Based Formulas										
Fibersource HN	36	53	39	160	52	51	1000	1000	17	490
Isosource 1.5 Cal	45	68	65	170	56	58	1070	1070	19	650/585
Isosource HN	36	53	39	160	48	49	1200	1200	15	490
Semi-Elemental Hydrolyzed										
Peptamen, Unflavored	30	40	39	127	25	39	800	700	18	270
Peptamen with Prebio	30	40	39	127	25	39	800	700	18	300
Peptamen 1.5, Unflavored	45	68	56	188	45	48	1000	1000	27	550
Peptamen AF	36	76	55	107	35	41	800	800	14.4	390
Perative	39	67	37	180	45	44	870	870	16	460
Pivot 1.5	45	94	51	172	61	51	1000	1000	18	595
Vital 1.0 Cal	30	40	38	130	46	36	705	705	13	390
Vital HN	30	42	11	185	25	36	667	667	12	500
Amino Acid-Based Formulas										
Tolerex	30	21	1.5	230	20	30	560	560	10	550
Vivonex RTF	30	50	12	175	29	31	670	670	12	630
Vivonex Plus	30	7	67	190	27	27	560	560	10	650
VivonexT.E.N.	30	38	3	210	26	24	500	500	9	630

COMPOSITION OF FLUIDS FREQUENTLY USED IN ORAL REHYDRATION[a]

Solution	Glucose/ CHO, g/L	Sodium, mEq/L	HCO_3^-, mEq/L	Potassium mEq/L	Osmolality, mmol/L	CHO/ Sodium
Pedialyte (Abbott Laboratories, Columbus, OH)	25	45	30	20	250	3.1
Pediatric Electrolyte (Pendo-Pharm, Montreal, Quebec)	25	45	20	30	250	3.1
Kaolectrolyte (Pfizer, New York, NY)	20	48	28	20	240	2.4
Rehydralyte (Abbott Laboratories, Columbus, OH)	25	75	30	20	310	1.9
WHO ORS, 2002 (reduced osmolarity)	75	75	10[b]	30	224	1.0
WHO ORS, 1975, (original formulation)	111	90	10[b]	20	311	1.2
Cola[a]	126	2	13	0.1	750	1944
Apple juice[a]	125	3	0	32	730	1278
Gatorade[a] (Gatorade, Chicago, IL)	45	20	3	3	330	62.5

Abbreviations: CHO indicates carbohydrate; HCO_3^-, bicarbonate; WHO, World Health Organization.

[a] Cola, juice, and Gatorade are shown for comparison only; they are not recommended for use. Mainly for maintenance therapy; may be used for rehydration therapy in mildly dehydrated patients.
[b] Citrate.

From Kleinman RE, ed. *Pediatric Nutrition Handbook*. Elk Grove Village, IL: American Academy of Pediatrics; 2009.

DIETARY REFERENCE INTAKES: RECOMMENDED INTAKES FOR INDIVIDUALS, FOOD AND NUTRITION BOARD, INSTITUTE OF MEDICINE

	Infants 0–6 mo	Infants 7–12 mo	Children 1–3 y	Children 4–8 y	Males 9–13 y	Males 14–18 y	Females 9–13 y	Females 14–18 y	Pregnancy ≤18 y	Lactation ≤18 y
Carbohydrate (g/day)	60[a]	95[a]	**130**	**130**	**130**	**130**	**130**	**130**	**175**	**210**
Total Fiber (g/day)	ND	ND	19[a]	25[a]	31[a]	38[a]	26[a]	26[a]	28[a]	29[a]
Fat (g/day)	31[a]	30[a]	ND	ND	ND	ND	ND	ND	ND	ND
n-6 Polyunsaturated Fatty Acids (g/day) (Linoleic Acid)	4.4[a]	4.6[a]	7[a]	10[a]	12[a]	16[a]	10[a]	11[a]	13[a]	13[a]
n-3 Polyunsaturated Fatty Acids (g/day) (α-Linolenic Acid)	0.5[a]	0.5[a]	0.7[a]	0.9[a]	1.2[a]	1.6[a]	1.0[a]	1.1[a]	1.4[a]	1.3[a]
Protein (g/kg/day)	1.52[a]	1.2[a]	1.05[a]	0.95[a]	0.95[a]	0.85[a]	0.95[a]	0.85[a]	1.1[a]	1.3[a]
Vitamin A (μg/day)[b]	400[a]	500[a]	**300**	**400**	**600**	**900**	**600**	**700**	**750**	**1200**
Vitamin C (mg/day)	40[a]	50[a]	**15**	**25**	**45**	**75**	**45**	**65**	**80**	**115**
Vitamin D (IU/day)[c,d]	400[a]	400[a]	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**
Vitamin E (mg/day)[e]	4[a]	5[a]	**6**	**7**	**11**	**15**	**11**	**15**	**15**	**19**
Vitamin K (μg/day)	2.0[a]	2.5[a]	30[a]	55[a]	60[a]	75[a]	60[a]	75[a]	75[a]	75[a]
Thiamin (mg/day)	0.2[a]	0.3[a]	**0.5**	**0.6**	**0.9**	**1.2**	**0.9**	**1.0**	**1.4**	**1.4**
Riboflavin (mg/day)	0.3[a]	0.4[a]	**0.5**	**0.6**	**0.9**	**1.3**	**0.9**	**1.0**	**1.4**	**1.6**
Niacin (mg/day)[f]	2[a]	4[a]	**6**	**8**	**12**	**16**	**12**	**14**	**18**	**17**
Vitamin B_6 (mg/day)	0.1[a]	0.3[a]	**0.5**	**0.6**	**1.0**	**1.3**	**1.0**	**1.2**	**1.9**	**2.0**
Folate (μg/day)[g]	65[a]	80[a]	**150**	**200**	**300**	**400**	**300**	**400[h]**	**600[i]**	**500**
Vitamin B_{12} (μg/day)	0.4[a]	0.5[a]	**0.9**	**1.2**	**1.8**	**2.4**	**1.8**	**2.4**	**2.6**	**2.8**
Pantothenic Acid (mg/day)	1.7[a]	1.8[a]	2[a]	3[a]	4[a]	5[a]	4[a]	5[a]	6[a]	7[a]
Biotin (μg/day)	5[a]	6[a]	8[a]	12[a]	20[a]	25[a]	20[a]	25[a]	30[a]	35[a]
Calcium (mg/day)	200[a]	260[a]	**700[a]**	**1000[a]**	**1300[a]**	**1300**	**1300**	**1300**	**1300**	**1300**
Choline (mg/day)	125[a]	150[a]	200[a]	250[a]	375[a]	550[a]	375[a]	400[a]	450[a]	550[a]
Chromium (μg/day)	0.2[a]	5.5[a]	11[a]	15[a]	25[a]	35[a]	21[a]	24[a]	29[a]	44[a]

DIETARY REFERENCE INTAKES: RECOMMENDED INTAKES FOR INDIVIDUALS, FOOD AND NUTRITION BOARD, INSTITUTE OF MEDICINE, continued

	Infants 0–6 mo	Infants 7–12 mo	Children 1–3 y	Children 4–8 y	Males 9–13 y	Males 14–18 y	Females 9–13 y	Females 14–18 y	Pregnancy ≤18 y	Lactation ≤18 y
Copper (µg/day)	200[a]	220[a]	**340**	**440**	**700**	**890**	**700**	**890**	**1000**	**1300**
Fluoride (mg/day)	0.01[a]	0.5[a]	0.7[a]	1[a]	2[a]	3[a]	3[a]	3[a]	3[a]	3[a]
Iodine (µg/day)	110[a]	130[a]	**90**	**90**	**120**	**150**	**120**	**150**	**220**	**290**
Iron (mg/day)	0.27[a]	**11**	**7**	**10**	**8**	**11**	**8**	**15**	**27**	**10**
Magnesium (mg/day)	30[a]	75[a]	**80**	**130**	**240**	**410**	**240**	**360**	**400**	**360**
Manganese (mg/day)	0.003[a]	0.6[a]	1.2[a]	1.5[a]	1.9[a]	2.2[a]	1.6[a]	1.6[a]	2.0[a]	2.6[a]
Molybdenum (µg/day)	2[a]	3[a]	**17**	**22**	**34**	**43**	**34**	**43**	**50**	**50**
Phosphorus (mg/day)	100[a]	275[a]	**460**	**500**	**1250**	**1250**	**1250**	**1250**	**1250**	**1250**
Selenium (µg/day)	15[a]	20[a]	**20**	**30**	**40**	**55**	**40**	**55**	**60**	**70**
Zinc (mg/day)	2[a]	**3**	**3**	**5**	**8**	**11**	**8**	**9**	**12**	**13**
Potassium (g/day)	0.4[a]	0.7[a]	3.0[a]	3.8[a]	4.5[a]	4.7[a]	4.5[a]	4.7[a]	4.7[a]	5.1[a]
Sodium (g/day)	0.12[a]	0.37[a]	1.0[a]	1.2[a]	1.5[a]	1.5[a]	1.5[a]	1.5[a]	1.5[a]	1.5[a]
Chloride (g/day)	0.18[a]	0.57[a]	1.5[a]	1.9[a]	2.3[a]	2.3[a]	2.3[a]	2.3[a]	2.3[a]	2.3[a]

Note: This table (taken from the DRI reports; see www.nas.edu) presents recommended dietary allowances (RDAs) in bold type, and adequate intakes (AIs) are in ordinary type followed by the symbol ([a]). ND indicates not determined.

[a] RDAs and AIs may both be used as goals for individual intake. RDAs are set to meet the needs of almost all (97%–98%) individuals in a group. For healthy breastfed infants, the AI is the mean intake. The AI for other life stage and gender groups is believed to cover needs of all individuals in the group, but lack of data or uncertainty in the data prevent being able to specify with confidence the percentage of individuals covered by this intake.

[b] As retinol activity equivalents (RAEs). 1 RAE = 1 µg retinol, 12 µg β-carotene, 24 µg α-carotene, or 24 µg β-cryptoxanthin in foods. The RAE for dietary provitamin A carotenoids is twofold greater than retinol equivalents (RE), whereas the RAE for preformed vitamin A is the same as RE.

[c] As cholecalciferol. 1 µg cholecalciferol = 40 IU vitamin D.

[d] In the absence of adequate exposure to sunlight.

[e] As α-tocopherol. α-Tocopherol includes RRR-α-tocopherol, the only form of α-tocopherol that occurs naturally in foods, and the 2R-stereoisomeric forms of α-tocopherol (RRR-, RSR-, RRS-, and RSS-α-tocopherol) that occur in fortified foods and supplements. It does not include the 2S-stereoisomeric forms of α-tocopherol (SRR-, SSR-, SRS-, and SSS-α-tocopherol), also found in fortified foods and supplements.

[f] As niacin equivalents (NEs). 1 mg of niacin = 60 mg of tryptophan; 0–6 mo = preformed niacin (not NEs).

[g] As dietary folate equivalents (DFEs). 1 DFE = 1 µg food folate = 0.6 µg of folic acid from fortified food or as a supplement consumed with food = 0.5 µg of a supplement taken on an empty stomach.

[h] In view of evidence linking folate intake with neural tube defects in the fetus, it is recommended that all women capable of becoming pregnant consume 400 µg from supplements or fortified foods in addition to intake of food folate from the diet.

[i] It is assumed that women will continue consuming 400 µg from supplements or fortified food until their pregnancy is confirmed and they enter prenatal care, which ordinarily occurs after the end of the periconceptional period—the critical time for formation of the neural tube.

[j] Although AIs have been set for choline, there are few data to assess whether a dietary supply of choline is needed at all stages of the life cycle, and it may be that the choline requirement can be met by endogenous synthesis at some of these stages.

FLUORIDE SOURCES AND SUPPLEMENTATION

Topical Fluoride Sources

Source	Availability	Concentration	Typical Dose
Toothpaste	OTC	1,000–1,500 ppm	Pea sized = 0.25 mg
Toothpaste	Prescription	5,000 ppm	Pea sized = 1.25 mg
Varnish	Professionally applied	22,600 ppm (NaF)	0.2 mL = 4.4 mg
Gel	Professionally applied	12,300 ppm (1.23%)	5 mL = 61.5 mg
Gel	Prescription	5,000 ppm (0.5% NaF)	Thin ribbon = 25 mg
Foam	Professionally applied	9,040 ppm (0.9%)	5 mL = 45 mg
Rinse	OTC	230 ppm (0.05% NaF)	5 mL = 2.5 mg

From Slayton R. Fluoride facts: what pediatricians need to know about fluoride agents for children, including supplementation. *AAP News.* 2010;31:30

Dietary Fluoride Supplementation Schedule

Age	<0.3 ppm F	0.3–0.6 ppm F	>0.6 ppm F
Birth–6 months	0	0	0
6 months–3 years	0.25 mg	0	0
3–6 years	0.50 mg	0.25 mg	0
6 years up to at least 16 years	1.00 mg	0.50 mg	0

From American Academy of Pediatric Dentistry Liaison with Other Groups Committee; American Academy of Pediatric Dentistry Council on Clinical Affairs. Guideline on fluoride therapy. *Pediatr Dent.* 2008–2009;30(7 suppl):121–124. Reproduced with permission. Copyright © 2008–2009 American Academy of Pediatric Dentistry.

9. Umbilical Vein and Artery Catheterization Measurements

USING BIRTH WEIGHT TO MEASURE CATHETER LENGTH

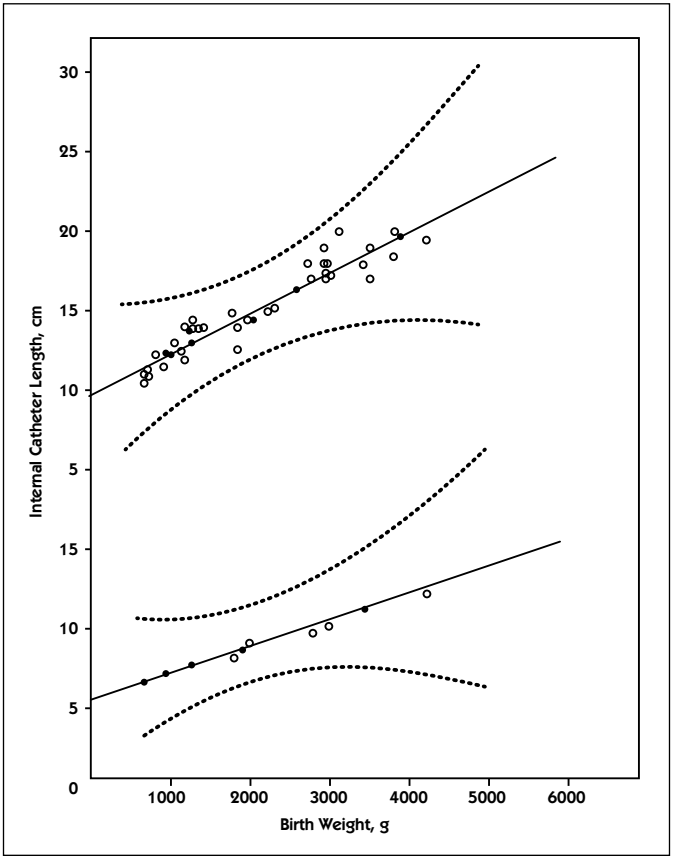
Prior to placing an umbilical vein or artery catheter in a newborn as an elective procedure, you can use the following regression formula to determine the catheter length in centimeters using birth weight:

$$\textbf{Umbilical Artery Catheter Length (cm)} = 3 \times \text{Birth Weight} + 9 \text{ cm}$$

$$\textbf{Umbilical Vein Catheter Length (cm)} = \frac{\text{Umbilical Artery Catheter Length (cm)} + 1 \text{ cm}}{2}$$

You can use this formula to approximate the length necessary for placement of a high-lying line between T6 and T10 for umbilical artery lines and umbilical vein lines above the level of the diaphragm in the inferior vena cava. Correct placement in small for gestational age (SGA) and large for gestational age (LGA) babies may vary because the formula is only an approximation. Radiographic confirmation of line positioning is important to avoid complications.

Estimate of Insertional Length of Umbilical Catheters Based on Birth Weight With 95% Confidence Intervals



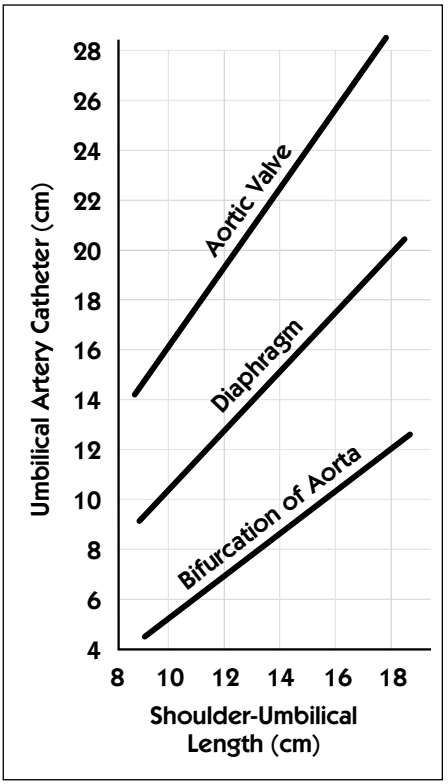
Umbilical catheters (umbilical artery catheter tip inserted between T-6 and T-10; umbilical vein catheter tip inserted above diaphragm in interior vena cava near or in right atrium). Modified estimating equations utilizing birth weight (BW) are as follows: umbilical artery length = 2.5*BW + 9.7 (top graph) and umbilical vein length = 1.5*BW + 5.6 (bottom graph), where BW is measured in kilograms and lengths in centimeters.

USING SHOULDER-UMBILICAL LENGTH TO MEASURE UMBILICAL ARTERY CATHETER LENGTH

The graph shows the length of catheter necessary to reach the aortic valve, diaphragm, or aortic bifurcation. Ideally, the umbilical artery catheter should reach the level of the diaphragm for a high-lying line.

Measure the shoulder-umbilical length by dropping a vertical line from the tip of the shoulder to a point vertically beneath it that is level with the center of the umbilicus. Plot this length on the x-axis of the graph. Where the line intersects the graph of the diaphram, plot a line to the y-axis.

Umbilical Artery Catheter Length

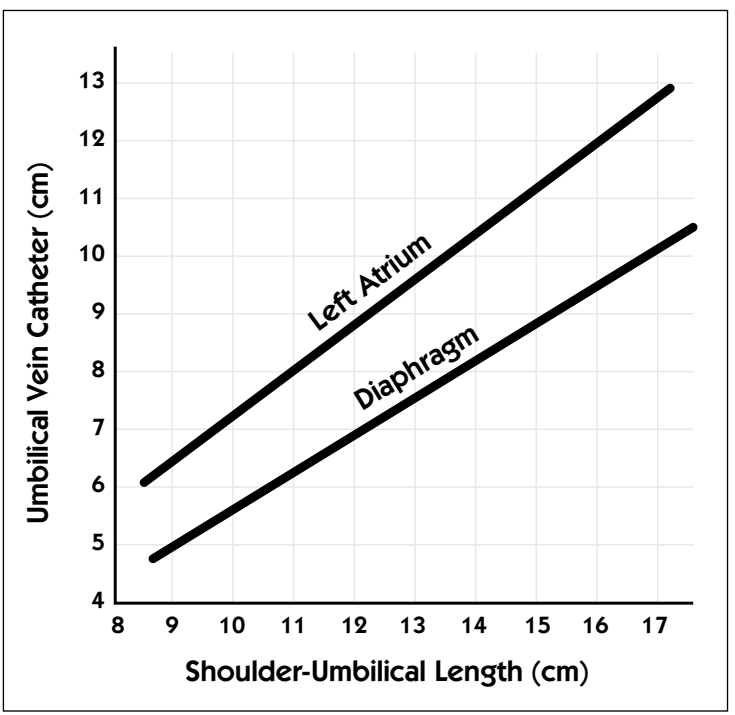


USING SHOULDER-UMBILICAL LENGTH TO MEASURE UMBILICAL VEIN CATHETER LENGTH

The graph shows the length of catheter necessary to reach the left side of the atrium and the diaphragm. Ideally, the umbilical vein catheter should reach the level of the diaphragm.

Measure the shoulder-umbilical length by dropping a vertical line from the tip of the shoulder to a point vertically beneath it that is level with the center of the umbilicus. Plot this length on the x-axis of the graph. Where the line intersects the graph of the diaphragm, plot a line to the y-axis.

Umbilical Vein Catheter Length



10. Doses and Levels of Common Antibiotic and Antiseizure Medications

ANTIBIOTICS

Amikacin

Neonatal Dosing

Dosing Table for IV Systemic Administration			
PMA (wk)	**Postnatal (d)**	**Dose (mg/kg)**	**Interval (h)**
≤29	0–7	18	48
	8–28	15	36
	≥29	15	24
30–34	0–7	18	36
	≥8	15	24
≥35	All	15	24

Abbreviation: PMA, postmenstrual age.

Infant, Children, and Adolescent Dosing

CONVENTIONAL DOSING: 5 to 7.5 mg/kg/dose every 8 hours
DOSAGE FOR RENAL IMPAIRMENT: Yes

Monitoring in neonates

WHEN TO DRAW LEVELS

- Peak: After second dose (see "Timing of Levels").
- Trough: After second dose (just before third dose).
- Levels are unnecessary if patient is on antibiotics for 48 to 72 hour rule-out sepsis protocol.
- Consider more frequent monitoring in hypothermia treatment.

TIMING OF LEVELS

- Peak: 30 minutes after end of 30-minute infusion
- Trough: 0 to 30 minutes before next dose

GOAL LEVELS

- Amikacin peak: 20 to 25 mcg/mL
- Amikacin trough: <5 mcg/mL

Monitoring in Infants, Children, and Adolescents

WHEN TO DRAW LEVELS

- Peak: After second dose (see "Timing of Levels").
- Trough: After second dose (just before third dose).
- Levels may be unnecessary if patient is on antibiotics for 48 to 72 hours sepsis protocol.

TIMING OF LEVELS

- Peak: 30 minutes after end of 30-minute infusion
- Trough: 0 to 30 minutes before next dose

GOAL LEVELS

- Amikacin peak: 20 to 30 mcg/mL
- Amikacin trough: 4 to 10 mcg/mL

Gentamicin

Neonatal Dosing

Dosing Table for IV Systemic Administration			
PMA (wk)	**Postnatal (d)**	**Dose (mg/kg)**	**Interval (h)**
≤29	0–7	5	48
	8–28	4	36
	≥29	4	24
30–34	0–7	4.5	36
	≥8	4	24
≥35	All	4	24

Abbreviation: PMA, postmenstrual age.

Infant, Children, and Adolescent Dosing

CONVENTIONAL DOSING:

- Infants and children younger than 5 years: 2.5 mg/kg/dose every 8 hours
- Children 5 years and older: 2 to 2.5 mg/kg/dose every 8 hours

HIGH-DOSE, EXTENDED INTERVAL DOSING (IN PATIENTS WITH NORMAL RENAL FUNCTION): 5 to 7.5 mg/kg/dose every 24 hours

DOSAGE FOR RENAL IMPAIRMENT: Yes

Monitoring in Neonates

WHEN TO DRAW LEVELS

- Peak: After second dose (see "Timing of Levels").
- Trough: After second dose (just before third dose).
- Levels are unnecessary if patient is on antibiotics for 48 to 72 hour rule-out sepsis protocol.
- Consider more frequent monitoring in hypothermia treatment.

TIMING OF LEVELS

- Peak: 30 minutes after end of 30-minute infusion
- Trough: 0 to 30 minutes before next dose

GOAL LEVELS

- Gentamicin peak: 6 to 12 mcg/mL (3 to 5 is an acceptable range for gram-positive synergy)
- Gentamicin trough: <1 mcg/mL

Gentamicin Dose and Monitoring Recommendations for HIE Cooling Patients

WHEN TO DRAW LEVELS

- First levels done as described above.
- Repeat peak and trough levels after rewarming.
  - — Peak: After forth dose (see "Timing of Levels")
  - — Trough: Before fourth dose
- Levels are unnecessary if patient is on antibiotics for 48 to 72 hour rule-out sepsis protocol.

TIMING OF LEVELS

- Peak: 30 minutes after end of 30-minute infusion
- Trough: 0 to 30 minutes before next dose

Monitoring in Infants, Children, and Adolescents

WHEN TO DRAW LEVELS

- Peak: After third dose (see "Timing of Levels").
- Trough: After third dose.
- Levels may be unnecessary if patient is on antibiotics for 48 to 72 hour rule-out sepsis protocol.

TIMING OF LEVELS

- Peak: 30 minutes after end of 30-minute infusion
- Trough: 0 to 30 minutes before next dose

GOAL LEVELS

- Gentamicin peak (conventional dosing): 6 to12 mcg/mL (3 to 5 is an acceptable range for gram-positive synergy)
- Gentamicin peak (high-dose, extended interval dosing): May be 2 to 3 times greater than conventional dosing peak levels
- Gentamicin trough: <2 mcg/mL (<1 mcg/mL is ideal, especially for high-dose, extended interval)

Tobramycin

Neonatal Dosing

Dosing Table for IV Systemic Administration			
PMA (wk)	**Postnatal (d)**	**Dose (mg/kg)**	**Interval (h)**
≤29	0–7	5	48
	8–28	4	36
	≥29	4	24
30–34	0–7	4.5	36
	≥8	4	24
≥35	All	4	24

Abbreviation: PMA, postmenstrual age.

Infant, Children, and Adolescent Dosing

CONVENTIONAL DOSING:

- Infants and children younger than 5 years: 2.5 mg/kg/dose every 8 hours
- Children 5 years and older: 2 to 2.5 mg/kg/dose every 8 hours

CYSTIC FIBROSIS DOSING:

- Conventional CF dosing: 3.3 mg/kg/dose every 8 hours
- High-dose, extended interval dosing: 7 mg/kg/dose every 12 hours or 10 mg/kg/dose every 24 hours

DOSAGE FOR RENAL IMPAIRMENT: Yes

Monitoring in Neonates

WHEN TO DRAW LEVELS

- Peak: After second dose (see "Timing of Levels").
- Trough: After second dose (just before third dose).
- Levels are unnecessary if patient is on antibiotics for 48 to 72 hour rule-out sepsis protocol.

TIMING OF LEVELS

- Peak: 30 minutes after end of 30-minute infusion
- Trough: 0 to 30 minutes before next dose

GOAL LEVELS

- Tobramycin peak: 6 to 12 mcg/mL (3 to 5 mcg/mL is an acceptable range for gram-positive synergy)
- Tobramycin trough: <1 mcg/mL

Monitoring in Infants, Children, and Adolescents

WHEN TO DRAW LEVELS

- Peak: After third dose (see "Timing of Levels").
- Trough: Prior third dose.
- Levels may be unnecessary if patient is on antibiotics for 48 to 72 hour rule-out sepsis protocol.

TIMING OF LEVELS

- Peak: 30 minutes after end of 30-minute infusion
- Trough: 0 to 30 minutes before next dose

GOAL LEVELS

- Tobramycin peak (non–cystic fibrosis dosing): 6 to12 mcg/mL (3 to 5 mcg/mL is an acceptable range for gram-positive synergy)
- Tobramycin peak (cystic fibrosis dosing): 8 to 14 mcg/mL
- Tobramycin trough: <2 mcg/mL (<1 mcg/mL is ideal)

Vancomycin

Neonatal Dosing

Meningitis: 15 mg/kg/dose
Bacteremia: 10 mg/kg/dose

Dosing Table for IV Administration		
PMA (wk)	**Postnatal (d)**	**Interval (h)**
≤29	0–14 >14	18 12
30–36	0–14 >14	12 8
37–44	0–7 >7	12 8

Abbreviation: PMA, postmenstrual age.

Infants, Children, and Adolescent Dosing

CONVENTIONAL DOSING: 15 to 20 mg/kg/dose every 6 to 8 hours (Consider every 6 hours for patients older than 2 months who do not have a history of cardial abnormalities.)

DOSAGE FOR RENAL IMPAIRMENT: Yes

Monitoring in Neonates

TROUGHS ONLY EXCEPT WITH

- Central nervous system infections
- Osteomyelitis
- Infective abscess
- Goal trough >10 mcg/mL

Monitoring in Infants, Children, and Adolescents

Only trough levels are recommended.

WHEN TO DRAW LEVELS

- Trough: Before third dose (for neonates) or fourth dose(for infants, children, and adolescents)
- Peak: After third dose (when necessary)

TIMING OF LEVELS

- Peak: 60 minutes after end of 60-minute infusion
- Trough: 0 to 30 minutes before next dose

GOAL LEVELS

- Trough for neonates: 5 to 15 mcg/mL
- Trough for non-neonates: 10 to 20 mcg/mL
  - — Consider higher goal of 10 to 15 mcg/mL (for neonates) or 15 to 20 mcg/mL (for infants, children, and adolescents) for serious infections or anatomic sites with difficult penetration (eg, meningitis, osteomylitis, bacteremia, endocarditis, hospital-acquired pneumonia caused by *Staphylococcus aureus*) upon recommendation from pediatric infectious diseases or clinical pharmacist.
- Peak: 25 to 40 mcg/mL

ANTISEIZURE

Fosphenytoin

Note: All dosing is expressed in phenytoin equivalents (PE). 1 mg of fosphenytoin = 1 mg of phenytoin.

Neonatal Dosing

LOADING DOSE: 15 to 20 mg PE/kg IM or IV infusion over at least 10 minutes.

MAINTENANCE DOSE: 4 to 8 mg PE/kg IM or IV slow push every 24 hours. Begin maintenance 24 hours after loading dose.

Term infants older than 1 week may require up to 8 mg PE/kg/dose every 8 to 12 hours.

Infants, Children, and Adolescent Dosing

LOADING DOSE

- Status epilepticus: 15 to 20 mg PE/kg IV
- Non-emergent: 10 to 20 mg PE/kg IV or IM

MAINTENANCE DOSE: 4 to 6 mg PE/kg IV every day in 2 to 3 divided doses

Monitoring

WHEN TO DRAW LEVELS

- Monitor the drug via phenytoin levels in serum.
- Consider obtaining a level 2 hours (if IV infusion) or 4 hours (if IM infusion) after administration of the loading dose.
- Achieving a steady state takes about 1 week, but you may want to take a level if patient continues to seize.
- Maintenance doses may be titrated if symptomatic, even if levels are pending.
- Consider obtaining serum albumin level.

TIMING OF LEVELS

Trough: Before steady-state dose

GOAL LEVELS

- Total phenytoin level
  - First week of life: 6 to 15 mcg/mL
  - After 7 days of life: 10 to 20 mcg/mL
- Free (unbound) level
  - 1 to 2 mcg/mL

Levetiracetam (Keppra)

Neonatal Dosing

Note: Limited data available; dose not established.

IV: 10 mg/kg/day divided twice daily; increase dosage by 10 mg/kg over 3 days to 30 mg/kg/day; additional increases up to 45 to 60 mg/kg/day have been used with persistent seizure activity or clinical EEG findings. For treatment of status epilepticus, loading doses of 20 to 30 mg/kg/dose have been used by some centers.

ORAL: Initial, 10 mg/kg/day in 1 to 2 divided doses; increase daily by 10 mg/kg to 30 mg/kg/day (maximum reported dose: 60 mg/kg/day).

Infants, Children, and Adolescent Dosing

PARTIAL ONSET SEIZURES

- Infants between 1 and 6 months of age: 7 mg/kg/dose twice daily; can increase dosage every 2 weeks by 7 mg/kg/dose twice daily, as tolerated, to the recommended dose of 20 mg/kg/dose twice daily. Additional increases up to 45 to 60 mg/kg/day have been used with persistent seizure activity or clinical EEG findings. Commonly accepted maximum dose at most centers is 60 mg/kg/day.
- Infants older than 6 months and adolescents younger than 16 years: 10 mg/kg/dose IV/PO twice daily. May increase dose every 2 weeks by 10 mg/kg/dose, if tolerated, to a maximum of 60 mg/kg/day.
- Adolescents 16 years and older: 500 mg twice daily; may increase every 2 weeks by 500 mg/dose to the recommended dose of 1,500 mg twice daily. Efficacy of doses other than 3,000 mg/day has not been established. The same dose is indicated for myoclonic seizures in this patient population.

SEIZURE PROPHYLAXIS

- Loading dose: 20 mg/kg IV
- Maintenance dose: 10 mg/kg/dose twice daily for 7 days

STATUS EPILEPTICUS

Note: Limited data available; dose not established.

Loading dose of 50 mg/kg/dose (maximum dose: 2,500 mg) given IV; followed by IV or oral maintenance dosing determined by clinical response; reported IV maintenance dose is 30 to 55 mg/kg/day, divided twice daily

Monitoring

Trough concentrations are not routinely measured but may be useful in accessing magnitude of dosing adjustments, drug compliance, or both.

THERAPEUTIC CONCENTRATIONS: 10 to 40 mcg/mL

Phenobarbital

Neonatal Dosing

ANTICONVULSANT

- Loading dose: 20 mg/kg IV, given slowly over 10 to 15 minutes.
- Refractory seizures: Additional 5 mg/kg doses, up to a total of 40 mg/kg.
- Maintenance dosing**:** 3 to 4 mg/kg/day, beginning 12 to 24 hours after the load. Increase to 5 mg/kg/day if needed (usually by second week of therapy).
- Frequency/Route: Every 24 hours. IV slow push (most rapid control of seizures), IM, orally, or rectally.

NEONATAL ABSTINENCE SYNDROME

- Loading dose: 16 mg/kg orally on day 1.
- Maintenance: 1 to 4 mg/kg/dose orally every 12 hours.
- Based on abstinence scoring, weaning can be achieved by decreasing dose 20% every other day.

Infants, Children, and Adolescents

ANTICONVULSANT LOADING DOSE

15 to 20 mg/kg (maximum: 1,000 mg/dose)

MAINTENANCE DOSING

Age	Maintenance Dosing
Infant	5–6 mg/kg/day divided in 1–2 doses
Children 1 to 5 y	6–8 mg/kg/day divided in 1–2 doses
Children 5 to 12 y	4–6 mg/kg/day divided in 1–2 doses
Adolescents >12 y	1–3 mg/kg/day divided in 1–2 doses

Monitoring

WHEN TO DRAW LEVELS

- Achieving a steady state takes 1 to 2 weeks, but you may want to take a level if patient continues to seize.
- Maintenance doses may be titrated if symptomatic, even if levels are pending.

TIMING OF LEVELS

Trough: Before steady-state dose

GOAL LEVELS

Trough: 15 to 40 mcg/mL

Topiramate (Topomax)

Neonatal Dosing

Note: Limited data. Further studies needed.

NEONATAL SEIZURES, REFRACTORY: Oral, 10 mg/kg/day

NEUROPROTECTANT FOLLOWING ANOXIC INJURY (WITH COOLING): Oral, 5 mg/kg/day

Infants, Children, and Adolescents

ANTICONVULSANT MONOTHERAPY

Children 2 to younger than 10 years of age

Initial: 25 mg once daily (in evening); may increase, if tolerated to 25 mg twice daily in week 2; thereafter, may increase by 25 to 50 mg/day at weekly intervals over 5 to 7 weeks up to the lower end of the target daily maintenance dosing range in the following table:

≤11 kg: 150–250 mg/day in 2 divided doses
12–22 kg: 200–300 mg/day in 2 divided doses
23–31 kg: 200–350 mg/day in 2 divided doses
32–38 kg: 250–350 mg/day in 2 divided doses
>38 kg: 250–400 mg/day in 2 divided doses

Children 10 years and older and adolescents

Initial: 25 mg twice daily; increase at weekly intervals by 50 mg/day up to a dose of 100 mg twice daily (week 4 dose); thereafter, may further increase at weekly intervals by 100 mg/day up to the recommended maximum dose of 200 mg twice daily

ANTICONVULSANT ADJUNCTIVE THERAPY

Children and adolescents 2 to 16 years of age

Initial: 1 to 3 mg/kg/day (maximum: 25 mg) given nightly for 1 week; increase at 1- to 2-week intervals by 1 to 3 mg/kg/day given in 2 divided doses; titrate dose to response; usual maintenance: 5 to 9 mg/kg/day given in 2 divided doses. Slower titrations rates should be utilized in generalized tonic clonic seizures.

Adolescents 17 years and older
Initial: 25 to 50 mg/day given daily for 1 week; increase at weekly intervals by 25 to 50 mg/day divided into 2 doses. Doses are titrated response with a usual maintenance dose of 100 to 200 mg twice daily (maximum dose: 1,600 mg/day). Slower titrations rates should be utilized in generalized tonic clonic seizures.

Monitoring
Measure serum bicarbonate levels at baseline and periodically during treatment. Routine monitoring of levels may be unnecessary, but consider target concentrations of 5 to 20 ng/mL.

Valproic Acid and Derivatives

Infants, Children, Adolescent Dosing

Note: due to the risk of valproic acid associated hepatotoxicity in patients younger than 2 years of age, valproic acid is not the preferred agent in this population.

SEIZURE DISORDER

- Oral: 10 to 15 mg/kg/day divided 3 to 4 times daily (valproic acid) or twice daily (divalproex sodium). Doses can be increased at weekly intervals to a maximum dose of 60 mg/kg/day.
- IV: Total daily dose IV is equal to total daily dose oral; however, IV should be divided into a frequency of every 6 hours.

REFACTORY STATUS EPILEPTICUS

- Loading dose: 20 to 40 mg/kg (maximum: 1,000 mg)
- Continuous infusion (to begin after loading dose): 1 mg/kg/h

WHEN TO DRAW LEVELS

- Drug is monitored via trough valproic acid levels.
- Should also consider obtained liver enzymes, serum ammonia, and CBC/platelets.

TIMING OF LEVELS: Trough before steady-state dose

GOAL LEVELS: Therapeutic: 50 to 100 mcg/mL (therapeutic levels are not well established; higher goal levels may be indicated in certain patients, but should consider a neurology consult)

RESOURCES

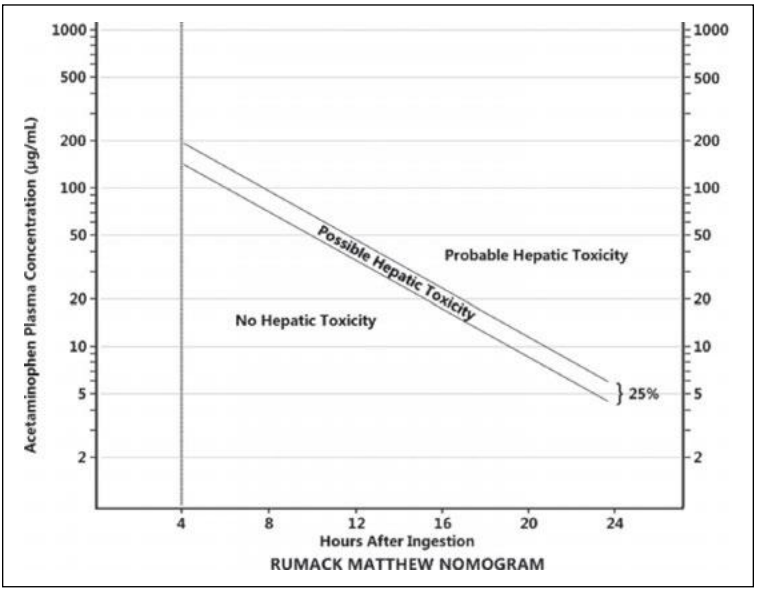
Lexicomp Online. Lexi-comp , Inc; 2013. http://online.lexi.com. Accessed December 23, 2013

Mark LF, Solomon A, Northington FJ, Lee CK. Gentamicin pharmacokinetics in neonates undergoing therapeutic hypothermia. *Ther Drug Monit*. 2013;35(2):217–222.

Neofax Online. Truven Health Analytics Inc; 2013. http://www.micromedex.com. Accessed December 23, 2013

11. Appendixes

ACETAMINOPHEN TOXICITY NOMOGRAM



Adapted from Rumack BH, Matthew H. Acetaminophen poisoning and toxicity. *Pediatrics.* 1975;55(6):871–876, and Rumack BH. Acetaminophen hepatotoxicity: the first 35 years. *J Toxicol Clin Toxicol.* 2002;40(1):3–20.

RABIES GUIDELINES

Rabies Postexposure Prophylaxis (PEP) Schedule—United States, 2010

Vaccination status	Intervention	Regimen[a]
Not previously vaccinated	Wound cleansing	All PEP should begin with immediate thorough cleansing of all wounds with soap and water. If available, a virucidal agent (e.g., povidine-iodine solution) should be used to irrigate the wounds.
	Human rabies immune globulin (HRIG)	Administer 20 IU/kg body weight. If anatomically feasible, the full dose should be infiltrated around and into the wound(s), and any remaining volume should be administered at an anatomical site (intramuscular [IM]) distant from vaccine administration. Also, HRIG should not be administered in the same syringe as vaccine. Because RIG might partially suppress active production of rabies virus antibody, no more than the recommended dose should be administered.
	Vaccine	Human diploid cell vaccine (HDCV) or purified chick embryo cell vaccine (PCECV) 1.0 mL, IM (deltoid area[b]), 1 each on days 0,[c] 3, 7 and 14.[d]
Previously vaccinated[e]	Wound cleansing	All PEP should begin with immediate thorough cleansing of all wounds with soap and water. If available, a virucidal agent such as povidine-iodine solution should be used to irrigate the wounds.
	HRIG	HRIG should not be administered.
	Vaccine	HDCV or PCECV 1.0 mL, IM (deltoid area[b]), 1 each on days 0[c] and 3.

[a] These regimens are applicable for persons in all age groups, including children.

[b] The deltoid area is the only acceptable site of vaccination for adults and older children. For younger children, the outer aspect of the thigh may be used. Vaccine should never be administered in the gluteal area.

[c] Day 0 is the day dose 1 of vaccine is administered.

[d] For persons with immunosuppression, rabies PEP should be administered using all 5 doses of vaccine on days 0, 3, 7, 14, and 28.

[e] Any person with a history of pre-exposure vaccination with HDCV, PCECV, or rabies vaccine adsorbed (RVA); prior PEP with HDCV, PCECV or RVA; or previous vaccination with any other type of rabies vaccine and a documented history of antibody response to the prior vaccination.

From Rupprecht CE, Briggs D, Brown CM, Franka R, Katz SL, Kerr HD, Lett SM, Levis R, Meltzer MI, Schaffner W, Cieslak PR; Centers for Disease Control and Prevention (CDC). Use of a reduced (4-dose) vaccine schedule for postexposure prophylaxis to prevent human rabies: recommendations of the advisory committee on immunization practices. *MMWR Recomm Rep.* 2010 Mar 19;59(RR-2):1-9. Erratum in: *MMWR Recomm Rep.* 2010 Apr 30;59(16):493.

Recommended Immunization Schedules for Persons Aged 0 Through 18 Years
UNITED STATES, 2014

This schedule includes recommendations in effect as of January 1, 2014. Any dose not administered at the recommended age should be administered at a subsequent visit, when indicated and feasible. The use of a combination vaccine generally is preferred over separate injections of its equivalent component vaccines. Vaccination providers should consult the relevant Advisory Committee on Immunization Practices (ACIP) statement for detailed recommendations, available online at http://www.cdc.gov/vaccines/hcp/acip-recs/index.html. Clinically significant adverse events that follow vaccination should be reported to the Vaccine Adverse Event Reporting System (VAERS) online (http://www.vaers.hhs.gov) or by telephone (800-822-7967).

The Recommended Immunization Schedules for Persons Aged 0 Through 18 Years are approved by the

Advisory Committee on Immunization Practices
(http://www.cdc.gov/vaccines/acip)

American Academy of Pediatrics
(http://www.aap.org)

American Academy of Family Physicians
(http://www.aafp.org)

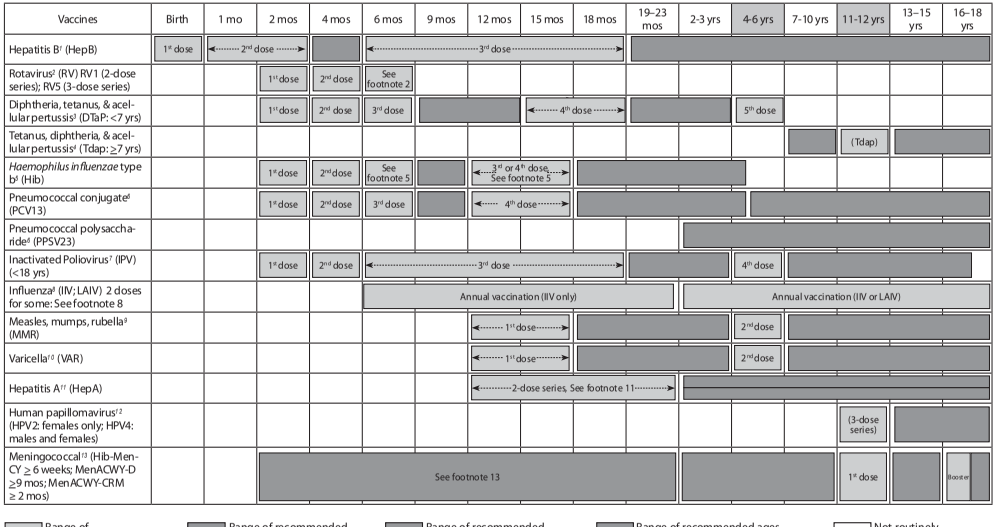
American College of Obstetricians and Gynecologists
(http://www.acog.org)

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Figure 1. Recommended immunization schedule for persons aged 0 through 18 years – United States, 2014.

(FOR THOSE WHO FALL BEHIND OR START LATE, SEE THE CATCH-UP SCHEDULE [FIGURE 2]).

These recommendations must be read with the footnotes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars in Figure 1. To determine minimum intervals between doses, see the catch-up schedule (Figure 2). School entry and adolescent vaccine age groups are in bold.



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This schedule is approved by the Advisory Committee on Immunization Practices (http//www.cdc.gov/vaccines/acip), the American Academy of Pediatrics (http://www.aap.org), the American Academy of Family Physicians (http://www.aafp.org), and the American College of Obstetricians and Gynecologists (http://www.acog.org).

NOTE: The above recommendations must be read along with the footnotes of this schedule.

FIGURE 2. Catch-up immunization schedule for persons aged 4 months through 18 years who start late or who are more than 1 month behind —United States, 2014.

The figure below provides catch-up schedules and minimum intervals between doses for children whose vaccinations have been delayed. A vaccine series does not need to be restarted, regardless of the time that has elapsed between doses. Use the section appropriate for the child's age. Always use this table in conjunction with Figure 1 and the footnotes that follow.

Persons aged 4 months through 6 years					
Vaccine	Minimum Age for Dose 1	Minimum Interval Between Doses			
		Dose 1 to dose 2	Dose 2 to dose 3	Dose 3 to dose 4	Dose 4 to dose 5
Hepatitis B[7]	Birth	4 weeks	8 weeks and at least 16 weeks after first dose; minimum age for the final dose is 24 weeks		
Rotavirus[2]	6 weeks	4 weeks	4 weeks		
Diphtheria, tetanus, & acellular pertussis[3]	6 weeks	4 weeks	4 weeks	6 months	6 months[3]
Haemophilus influenzae type b[5]	6 weeks	4 weeks if first dose administered at younger than age 12 months 8 weeks (as final dose) if first dose administered at age 12 through 14 months No further doses needed if first dose administered at age 15 months or older	4 weeks[5] if current age is younger than 12 months and first dose administered at < 7 months old 8 weeks and age 12 months through 59 months (as final dose)[5] if current age is younger than 12 months and first dose administered between 7 through 11 months (regardless of Hib vaccine [PRP-T or PRP-OMP] used for first dose); OR if current age is 12 through 59 months and first dose administered at younger than age 12 months; OR first 2 doses were PRP-OMP and administered at younger than 12 months. No further doses needed if previous dose administered at age 15 months or older	8 weeks (as final dose) This dose only necessary for children aged 12 through 59 months who received 3 (PRP-T) doses before age 12 months and started the primary series before age 7 months	
Pneumococcal[6]	6 weeks	4 weeks if first dose administered at younger than age 12 months 8 weeks (as final dose for healthy children) if first dose administered at age 12 months or older No further doses needed for healthy children if first dose administered at age 24 months or older	4 weeks if current age is younger than 12 months 8 weeks (as final dose for healthy children) if current age is 12 months or older No further doses needed for healthy children if previous dose administered at age 24 months or older	8 weeks (as final dose) This dose only necessary for children aged 12 through 59 months who received 3 doses before age 12 months or for children at high risk who received 3 doses at any age	
Inactivated poliovirus[7]	6 weeks	4 weeks[7]	4 weeks[7]	6 months[7] minimum age 4 years for final dose	
Meningococcal[13]	6 weeks	8 weeks[13]	See footnote 13	See footnote 13	
Measles, mumps, rubella[9]	12 months	4 weeks			
Varicella[10]	12 months	3 months			
Hepatitis A[11]	12 months	6 months			
Persons aged 7 through 18 years					
Tetanus, diphtheria; tetanus, diphtheria, & acellular pertussis[4]	7 years[4]	4 weeks	4 weeks if first dose of DTaP/DT administered at younger than age 12 months 6 months if first dose of DTaP/DT administered at age 12 months or older and then no further doses needed for catch-up	6 months if first dose of DTaP/DT administered at younger than age 12 months	
Human papillomavirus[12]	9 years	Routine dosing intervals are recommended[12]			
Hepatitis A[11]	12 months	6 months			
Hepatitis B[7]	Birth	4 weeks	8 weeks (and at least 16 weeks after first dose)		
Inactivated poliovirus[7]	6 weeks	4 weeks	4 weeks[7]	6 months[7]	
Meningococcal[13]	6 weeks	8 weeks[13]			
Measles, mumps, rubella[9]	12 months	4 weeks			
Varicella[10]	12 months	3 months if person is younger than age 13 years 4 weeks if person is aged 13 years or older			

NOTE: The above recommendations must be read along with the footnotes of this schedule.

Footnotes — Recommended immunization schedule for persons aged 0 through 18 years—United States, 2014

For further guidance on the use of the vaccines mentioned below, see: http://www.cdc.gov/vaccines/hcp/acip-recs/index.html.
For vaccine recommendations for persons 19 years of age and older, see the adult immunization schedule.

Additional information

- For contraindications and precautions to use of a vaccine and for additional information regarding that vaccine, vaccination providers should consult the relevant ACIP statement available online at http://www.cdc.gov/vaccines/hcp/acip-recs/index.html.
- For purposes of calculating intervals between doses, 4 weeks = 28 days. Intervals of 4 months or greater are determined by calendar months.
- Vaccine doses administered 4 days or less before the minimum interval are considered valid. Doses of any vaccine administered ≥5 days earlier than the minimum interval or minimum age should not be counted as valid doses and should be repeated as age-appropriate. The repeat dose should be spaced after the invalid dose by the recommended minimum interval. For further details, see *MMWR, General Recommendations on Immunization and Reports* / Vol. 60 / No. 2; Table 2. *Recommended and minimum ages and intervals between vaccine doses* available online at http://www.cdc.gov/mmwr/pdf/rr/rr6002.pdf.
- Information on travel vaccine requirements and recommendations is available at http://wwwnc.cdc.gov/travel/page/vaccinations.htm.
- For vaccination of persons with primary and secondary immunodeficiencies, see Table 13, "*Vaccination of persons with primary and secondary immunodeficiencies*," in General Recommendations on Immunization (ACIP), available at http://www.cdc.gov/mmwr/pdf/rr/rr6002.pdf.; and American Academy of Pediatrics. Immunization in Special Clinical Circumstances, in Pickering LK, Baker CJ, Kimberlin DW, Long SS eds. *Red Book: 2012 report of the Committee on Infectious Diseases. 29th ed.* Elk Grove Village, IL: American Academy of Pediatrics.

1. Hepatitis B (HepB) vaccine. (Minimum age: birth)

Routine vaccination:

At birth

- Administer monovalent HepB vaccine to all newborns before hospital discharge.
- For infants born to hepatitis B surface antigen (HBsAg)-positive mothers, administer HepB vaccine and 0.5 mL of hepatitis B immune globulin (HBIG) within 12 hours of birth. These infants should be tested for HBsAg and antibody to HBsAg (anti-HBs) 1 to 2 months after completion of the HepB series, at age 9 through 18 months (preferably at the next well-child visit).
- If mother's HBsAg status is unknown, within 12 hours of birth administer HepB vaccine regardless of birth weight. For infants weighing less than 2,000 grams, administer HBIG in addition to HepB vaccine within 12 hours of birth. Determine mother's HBsAg status as soon as possible and, if mother is HBsAg-positive, also administer HBIG for infants weighing 2,000 grams or more as soon as possible, but no later than age 7 days.

Doses following the birth dose

- The second dose should be administered at age 1 or 2 months. Monovalent HepB vaccine should be used for doses administered before age 6 weeks.
- Infants who did not receive a birth dose should receive 3 doses of a HepB-containing vaccine on a schedule of 0, 1 to 2 months, and 6 months starting as soon as feasible. See Figure 2.
- Administer the second dose 1 to 2 months after the first dose (minimum interval of 4 weeks), administer the third dose at least 8 weeks after the second dose AND at least 16 weeks after the **first** dose. The final (third or fourth) dose in the HepB vaccine series should be administered no earlier than age 24 weeks.
- Administration of a total of 4 doses of HepB vaccine is permitted when a combination vaccine containing HepB is administered after the birth dose.

Catch-up vaccination:

- Unvaccinated persons should complete a 3-dose series.
- A 2-dose series (doses separated by at least 4 months) of adult formulation Recombivax HB is licensed for use in children aged 11 through 15 years.
- For other catch-up guidance, see Figure 2.

2. Rotavirus (RV) vaccines. (Minimum age: 6 weeks for both RV1 [Rotarix] and RV5 [RotaTeq])

Routine vaccination:

Administer a series of RV vaccine to all infants as follows:

1. If Rotarix is used, administer a 2-dose series at 2 and 4 months of age.
2. If RotaTeq is used, administer a 3-dose series at ages 2, 4, and 6 months.
3. If any dose in the series was RotaTeq or vaccine product is unknown for any dose in the series, a total of 3 doses of RV vaccine should be administered.

Catch-up vaccination:

- The maximum age for the first dose in the series is 14 weeks, 6 days; vaccination should not be initiated for infants aged 15 weeks, 0 days or older.
- The maximum age for the final dose in the series is 8 months, 0 days.
- For other catch-up guidance, see Figure 2.

3. Diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccine. (Minimum age: 6 weeks. Exception: DTaP-IPV [Kinrix]: 4 years)

Routine vaccination:

- Administer a 5-dose series of DTaP vaccine at ages 2, 4, 6, 15 through 18 months, and 4 through 6 years. The fourth dose may be administered as early as age 12 months, provided at least 6 months have elapsed since the third dose.

Catch-up vaccination:

- The fifth dose of DTaP vaccine is not necessary if the fourth dose was administered at age 4 years or older.
- For other catch-up guidance, see Figure 2.

4. Tetanus and diphtheria toxoids and acellular pertussis (Tdap) vaccine. (Minimum age: 10 years for Boostrix, 11 years for Adacel)

Routine vaccination:

- Administer 1 dose of Tdap vaccine to all adolescents aged 11 through 12 years.
- Tdap may be administered regardless of the interval since the last tetanus and diphtheria toxoid-containing vaccine.
- Administer 1 dose of Tdap vaccine to pregnant adolescents during each pregnancy (preferred during 27 through 36 weeks gestation) regardless of time since prior Td or Tdap vaccination.

Catch-up vaccination:

- Persons aged 7 years and older who are not fully immunized with DTaP vaccine should receive Tdap vaccine as 1 (preferably the first) dose in the catch-up series; if additional doses are needed, use Td vaccine. For children 7 through 10 years who receive a dose of Tdap as part of the catch-up series, an adolescent Tdap vaccine dose at age 11 through 12 years should NOT be administered. Td should be administered instead 10 years after the Tdap dose.
- Persons aged 11 through 18 years who have not received Tdap vaccine should receive a dose followed by tetanus and diphtheria toxoids (Td) booster doses every 10 years thereafter.
- Inadvertent doses of DTaP vaccine:
  - If administered inadvertently to a child aged 7 through 10 years may count as part of the catch-up series. This dose may count as the adolescent Tdap dose, or the child can later receive a Tdap booster dose at age 11 through 12 years.
  - If administered inadvertently to an adolescent aged 11 through 18 years, the dose should be counted as the adolescent Tdap booster.
- For other catch-up guidance, see Figure 2.

5. *Haemophilus influenzae* type b (Hib) conjugate vaccine. (Minimum age: 6 weeks for PRP-T [ACTHIB, DTaP-IPV/Hib (Pentacel) and Hib-MenCY (MenHibrix)], PRP-OMP [PedvaxHIB or COMVAX], 12 months for PRP-T [Hiberix])

Routine vaccination:

- Administer a 2- or 3-dose Hib vaccine primary series and a booster dose (dose 3 or 4 depending on vaccine used in primary series) at age 12 through 15 months to complete a full Hib vaccine series.
- The primary series with ActHIB, MenHibrix, or Pentacel consists of 3 doses and should be administered at 2, 4, and 6 months of age. The primary series with PedvaxHib or COMVAX consists of 2 doses and should be administered at 2 and 4 months of age; a dose at age 6 months is not indicated.
- One booster dose (dose 3 or 4 depending on vaccine used in primary series) of any Hib vaccine should be administered at age 12 through 15 months. An exception is Hiberix vaccine. Hiberix should only be used for the booster (final) dose in children aged 12 months through 4 years who have received at least 1 prior dose of Hib-containing vaccine.

RECOMMENDED IMMUNIZATION SCHEDULE, continued

For further guidance on the use of the vaccines mentioned below, see: http://www.cdc.gov/vaccines/hcp/acip-recs/index.html.

5. ***Haemophilus influenzae* type b (Hib) conjugate vaccine (cont'd)**
   - For recommendations on the use of MenHibrix in patients at increased risk for meningococcal disease, please refer to the meningococcal vaccine footnotes and also to *MMWR* March 22, 2013 / 62(RR02); 1-22, available at http://www.cdc.gov/mmwr/pdf/rr/rr6202.pdf.

   Catch-up vaccination:
   - If dose 1 was administered at ages 12 through 14 months, administer a second (final) dose at least 8 weeks after dose 1, regardless of Hib vaccine used in the primary series.
   - If the first 2 doses were PRP-OMP (PedvaxHIB or COMVAX), and were administered at age 11 months or younger, the third (and final) dose should be administered at age 12 through 15 months and at least 8 weeks after the second dose.
   - If the first dose was administered at age 7 through 11 months, administer the second dose at least 4 weeks later and a third (and final) dose at age 12 through 15 months or 8 weeks after second dose, whichever is later, regardless of Hib vaccine used for first dose.
   - If first dose is administered at younger than 12 months of age and second dose is given between 12 through 14 months of age, a third (and final) dose should be given 8 weeks later.
   - For unvaccinated children aged 15 months or older, administer only 1 dose.
   - For other catch-up guidance, see Figure 2. For catch-up guidance related to MenHibrix, please see the meningococcal vaccine footnotes and also *MMWR* March 22, 2013 / 62(RR02); 1-22, available at http://www.cdc.gov/mmwr/pdf/rr/rr6202.pdf.

   Vaccination of persons with high-risk conditions:
   - Children aged 12 through 59 months who are at increased risk for Hib disease, including chemotherapy recipients and those with anatomic or functional asplenia (including sickle cell disease), human immunodeficiency virus (HIV) infection, immunoglobulin deficiency, or early component complement deficiency, who have received either no doses or only 1 dose of Hib vaccine before 12 months of age, should receive 2 additional doses of Hib vaccine 8 weeks apart; children who received 2 or more doses of Hib vaccine before 12 months of age should receive 1 additional dose.
   - For patients younger than 5 years of age undergoing chemotherapy or radiation treatment who received a Hib vaccine dose(s) within 14 days of starting therapy or during therapy, repeat the dose(s) at least 3 months following therapy completion.
   - Recipients of hematopoietic stem cell transplant (HSCT) should be revaccinated with a 3-dose regimen of Hib vaccine starting 6 to 12 months after successful transplant, regardless of vaccination history; doses should be administered at least 4 weeks apart.
   - A single dose of any Hib-containing vaccine should be administered to unimmunized* children and adolescents 15 months of age and older undergoing an elective splenectomy; if possible, vaccine should be administered at least 14 days before procedure.
   - Hib vaccine is not routinely recommended for patients 5 years or older. However, 1 dose of Hib vaccine should be administered to unimmunized* persons aged 5 years or older who have anatomic or functional asplenia (including sickle cell disease) and unvaccinated persons 5 through 18 years of age with human immunodeficiency virus (HIV) infection.

   ** Patients who have not received a primary series and booster dose or at least 1 dose of Hib vaccine after 14 months of age are considered unimmunized.*

6. **Pneumococcal vaccines. (Minimum age: 6 weeks for PCV13, 2 years for PPSV23)**

   Routine vaccination with PCV13:
   - Administer a 4-dose series of PCV13 vaccine at ages 2, 4, and 6 months and at age 12 through 15 months.
   - For children aged 14 through 59 months who have received an age-appropriate series of 7-valent PCV (PCV7), administer a single supplemental dose of 13-valent PCV (PCV13).

   Catch-up vaccination with PCV13:
   - Administer 1 dose of PCV13 to all healthy children aged 24 through 59 months who are not completely vaccinated for their age.
   - For other catch-up guidance, see Figure 2.

   Vaccination of persons with high-risk conditions with PCV13 and PPSV23:
   - All recommended PCV13 doses should be administered prior to PPSV23 vaccination if possible.
   - For children 2 through 5 years of age with any of the following conditions: chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure); chronic lung disease (including asthma if treated with high-dose oral corticosteroid therapy); diabetes mellitus; cerebrospinal fluid leak; cochlear implant; sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; solid organ transplantation; or congenital immunodeficiency:
     1. Administer 1 dose of PCV13 if 3 doses of PCV (PCV7 and/or PCV13) were received previously.
     2. Administer 2 doses of PCV13 at least 8 weeks apart if fewer than 3 doses of PCV (PCV7 and/or PCV13) were received previously.
     3. Administer 1 supplemental dose of PCV13 if 4 doses of PCV7 or other age-appropriate complete PCV7 series was received previously.
     4. The minimum interval between doses of PCV (PCV7 or PCV13) is 8 weeks.
     5. For children with no history of PPSV23 vaccination, administer PPSV23 at least 8 weeks after the most recent dose of PCV13.
   - For children aged 6 through 18 years who have cerebrospinal fluid leak; cochlear implant; sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; congenital or acquired immunodeficiencies; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; generalized malignancy; solid organ transplantation; or multiple myeloma:
     1. If neither PCV13 nor PPSV23 has been received previously, administer 1 dose of PCV13 now and 1 dose of PPSV23 at least 8 weeks later.
     2. If PCV13 has been received previously but PPSV23 has not, administer 1 dose of PPSV23 at least 8 weeks after the most recent dose of PCV13.
     3. If PPSV23 has been received but PCV13 has not, administer 1 dose of PCV13 at least 8 weeks after the most recent dose of PPSV23.
   - For children aged 6 through 18 years with chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure), chronic lung disease (including asthma if treated with high-dose oral corticosteroid therapy), diabetes mellitus, alcoholism, or chronic liver disease, who have not received PPSV23, administer 1 dose of PPSV23. If PCV13 has been received previously, then PPSV23 should be administered at least 8 weeks after any prior PCV13 dose.
   - A single revaccination with PPSV23 should be administered 5 years after the first dose to children with sickle cell disease or other hemoglobinopathies; anatomic or functional asplenia; congenital or acquired immunodeficiencies; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; generalized malignancy; solid organ transplantation; or multiple myeloma.

7. **Inactivated poliovirus vaccine (IPV). (Minimum age: 6 weeks)**

   Routine vaccination:
   - Administer a 4-dose series of IPV at ages 2, 4, 6 through 18 months, and 4 through 6 years. The final dose in the series should be administered on or after the fourth birthday and at least 6 months after the previous dose.

   Catch-up vaccination:
   - In the first 6 months of life, minimum age and minimum intervals are only recommended if the person is at risk for imminent exposure to circulating poliovirus (i.e., travel to a polio-endemic region or during an outbreak).
   - If 4 or more doses are administered before age 4 years, an additional dose should be administered at age 4 through 6 years and at least 6 months after the previous dose.
   - A fourth dose is not necessary if the third dose was administered at age 4 years or older and at least 6 months after the previous dose.
   - If both OPV and IPV were administered as part of a series, a total of 4 doses should be administered, regardless of the child's current age. IPV is not routinely recommended for U.S. residents aged 18 years or older.
   - For other catch-up guidance, see Figure 2.

8. **Influenza vaccines. (Minimum age: 6 months for inactivated influenza vaccine [IIV], 2 years for live, attenuated influenza vaccine [LAIV])**

   Routine vaccination:
   - Administer influenza vaccine annually to all children beginning at age 6 months. For most healthy, nonpregnant persons aged 2 through 49 years, either LAIV or IIV may be used. However, LAIV should NOT be administered to some persons, including 1) those with asthma, 2) children 2 through 4 years who had wheezing in the past 12 months, or 3) those who have any other underlying medical conditions that predispose them to influenza complications. For all other contraindications to use of LAIV, see *MMWR* 2013; 62 (No. RR-7):1-43, available at http://www.cdc.gov/mmwr/pdf/rr/rr6207.pdf.

   For children aged 6 months through 8 years:
   - For the 2013–14 season, administer 2 doses (separated by at least 4 weeks) to children who are receiving influenza vaccine for the first time. Some children in this age group who have been vaccinated previously will also need 2 doses. For additional guidance, follow dosing guidelines in the 2013-14 ACIP influenza vaccine recommendations, *MMWR* 2013; 62 (No. RR-7):1-43, available at http://www.cdc.gov/mmwr/pdf/rr/rr6207.pdf.
   - For the 2014–15 season, follow dosing guidelines in the 2014 ACIP influenza vaccine recommendations.

   For persons aged 9 years and older:
   - Administer 1 dose.

For further guidance on the use of the vaccines mentioned below, see: http://www.cdc.gov/vaccines/hcp/acip-recs/index.html.

9. Measles, mumps, and rubella (MMR) vaccine. (Minimum age: 12 months for routine vaccination)

Routine vaccination:

- Administer a 2-dose series of MMR vaccine at ages12 through 15 months and 4 through 6 years. The second dose may be administered before age 4 years, provided at least 4 weeks have elapsed since the first dose.
- Administer 1 dose of MMR vaccine to infants aged 6 through 11 months before departure from the United States for international travel. These children should be revaccinated with 2 doses of MMR vaccine, the first at age 12 through 15 months (12 months if the child remains in an area where disease risk is high), and the second dose at least 4 weeks later.
- Administer 2 doses of MMR vaccine to children aged 12 months and older before departure from the United States for international travel. The first dose should be administered on or after age 12 months and the second dose at least 4 weeks later.

Catch-up vaccination:

- Ensure that all school-aged children and adolescents have had 2 doses of MMR vaccine; the minimum interval between the 2 doses is 4 weeks.

10. Varicella (VAR) vaccine. (Minimum age: 12 months)

Routine vaccination:

- Administer a 2-dose series of VAR vaccine at ages 12 through 15 months and 4 through 6 years. The second dose may be administered before age 4 years, provided at least 3 months have elapsed since the first dose. If the second dose was administered at least 4 weeks after the first dose, it can be accepted as valid.

Catch-up vaccination:

- Ensure that all persons aged 7 through 18 years without evidence of immunity (see *MMWR* 2007; 56 [No. RR-4], available at http://www.cdc.gov/mmwr/pdf/rr/rr5604.pdf) have 2 doses of varicella vaccine. For children aged 7 through 12 years, the recommended minimum interval between doses is 3 months (if the second dose was administered at least 4 weeks after the first dose, it can be accepted as valid); for persons aged 13 years and older, the minimum interval between doses is 4 weeks.

11. Hepatitis A (HepA) vaccine. (Minimum age: 12 months)

Routine vaccination:

- Initiate the 2-dose HepA vaccine series at 12 through 23 months; separate the 2 doses by 6 to 18 months.
- Children who have received 1 dose of HepA vaccine before age 24 months should receive a second dose 6 to 18 months after the first dose.
- For any person aged 2 years and older who has not already received the HepA vaccine series, 2 doses of HepA vaccine separated by 6 to 18 months may be administered if immunity against hepatitis A virus infection is desired.

Catch-up vaccination:

- The minimum interval between the two doses is 6 months.

Special populations:

- Administer 2 doses of HepA vaccine at least 6 months apart to previously unvaccinated persons who live in areas where vaccination programs target older children, or who are at increased risk for infection. This includes persons traveling to or working in countries that have high or intermediate endemicity of infection; men having sex with men; users of injection and non-injection illicit drugs; persons who work with HAV-infected primates or with HAV in a research laboratory; persons with clotting-factor disorders; persons with chronic liver disease; and persons who anticipate close, personal contact (e.g., household or regular babysitting) with an international adoptee during the first 60 days after arrival in the United States from a country with high or intermediate endemicity. The first dose should be administered as soon as the adoption is planned, ideally 2 or more weeks before the arrival of the adoptee.

12. Human papillomavirus (HPV) vaccines. (Minimum age: 9 years for HPV2 [Cervarix] and HPV4 [Gardisil])

Routine vaccination:

- Administer a 3-dose series of HPV vaccine on a schedule of 0, 1-2, and 6 months to all adolescents aged 11 through 12 years. Either HPV4 or HPV2 may be used for females, and only HPV4 may be used for males.
- The vaccine series may be started at age 9 years.
- Administer the second dose 1 to 2 months after the first dose (minimum interval of 4 weeks), administer the third dose 24 weeks after the first dose and 16 weeks after the second dose (minimum interval of 12 weeks).

Catch-up vaccination:

- Administer the vaccine series to females (either HPV2 or HPV4) and males (HPV4) at age 13 through 18 years if not previously vaccinated.
- Use recommended routine dosing intervals (see above) for vaccine series catch-up.

13. Meningococcal conjugate vaccines. (Minimum age: 6 weeks for Hib-MenCY [MenHibrix], 9 months for MenACWY-D [Menactra], 2 months for MenACWY-CRM [Menveo])

Routine vaccination:

- Administer a single dose of Menactra or Menveo vaccine at age 11 through 12 years, with a booster dose at age 16 years.
- Adolescents aged 11 through 18 years with human immunodeficiency virus (HIV) infection should receive a 2-dose primary series of Menactra or Menveo with at least 8 weeks between doses.
- For children aged 2 months through 18 years with high-risk conditions, see below.

Catch-up vaccination:

- Administer Menactra or Menveo vaccine at age 13 through 18 years if not previously vaccinated.
- If the first dose is administered at age 13 through 15 years, a booster dose should be administered at age 16 through 18 years with a minimum interval of at least 8 weeks between doses.
- If the first dose is administered at age 16 years or older, a booster dose is not needed.
- For other catch-up guidance, see Figure 2.

Vaccination of persons with high-risk conditions and other persons at increased risk of disease:

- Children with anatomic or functional asplenia (including sickle cell disease):
  1. For children younger than 19 months of age, administer a 4-dose infant series of MenHibrix or Menveo at 2, 4, 6, and 12 through 15 months of age.
  2. For children aged 19 through 23 months who have not completed a series of MenHibrix or Menveo, administer 2 primary doses of Menveo at least 3 months apart.
  3. For children aged 24 months and older who have not received a complete series of MenHibrix or Menveo or Menactra, administer 2 primary doses of either Menactra or Menveo at least 2 months apart. If Menactra is administered to a child with asplenia (including sickle cell disease), do not administer Menactra until 2 years of age and at least 4 weeks after the completion of all PCV13 doses.
- Children with persistent complement component deficiency:
  1. For children younger than 19 months of age, administer a 4-dose infant series of either MenHibrix or Menveo at 2, 4, 6, and 12 through 15 months of age.
  2. For children 7 through 23 months who have not initiated vaccination, two options exist depending on age and vaccine brand:
     a. For children who initiate vaccination with Menveo at 7 months through 23 months of age, a 2-dose series should be administered with the second dose after 12 months of age and at least 3 months after the first dose.
     b. For children who initiate vaccination with Menactra at 9 months through 23 months of age, a 2-dose series of Menactra should be administered at least 3 months apart.
     c. For children aged 24 months and older who have not received a complete series of MenHibrix, Menveo, or Menactra, administer 2 primary doses of either Menactra or Menveo at least 2 months apart.
- For children who travel to or reside in countries in which meningococcal disease is hyperendemic or epidemic, including countries in the African meningitis belt or the Hajj, administer an age-appropriate formulation and series of Menactra or Menveo for protection against serogroups A and W meningococcal disease. Prior receipt of MenHibrix is not sufficient for children traveling to the meningitis belt or the Hajj because it does not contain serogroups A or W.
- For children at risk during a community outbreak attributable to a vaccine serogroup, administer or complete an age- and formulation-appropriate series of MenHibrix, Menactra, or Menveo.
- For booster doses among persons with high-risk conditions, refer to *MMWR* 2013 62(RR02); 1-22, available at http://www.cdc.gov/mmwr/preview/mmwrhtml/rr6202a1.htm.

Catch-up recommendations for persons with high-risk conditions:

1. If MenHibrix is administered to achieve protection against meningococcal disease, a complete age-appropriate series of MenHibrix should be administered.
2. If the first dose of MenHibrix is given at or after 12 months of age, a total of 2 doses should be given at least 8 weeks apart to ensure protection against serogroups C and Y meningococcal disease.
3. For children who initiate vaccination with Menveo at 7 months through 9 months of age, a 2-dose series should be administered with the second dose after 12 months of age and at least 3 months after the first dose.
4. For other catch-up recommendations for these persons, refer to *MMWR* 2013 62(RR02); 1-22, available at http://www.cdc.gov/mmwr/preview/mmwrhtml/rr6202a1.htm.

For complete information on use of meningococcal vaccines, including guidance related to vaccination of persons at increased risk of infection, see *MMWR* March 22, 2013 / 62(RR02);1-22, available at http://www.cdc.gov/mmwr/pdf/rr/rr6202.pdf.

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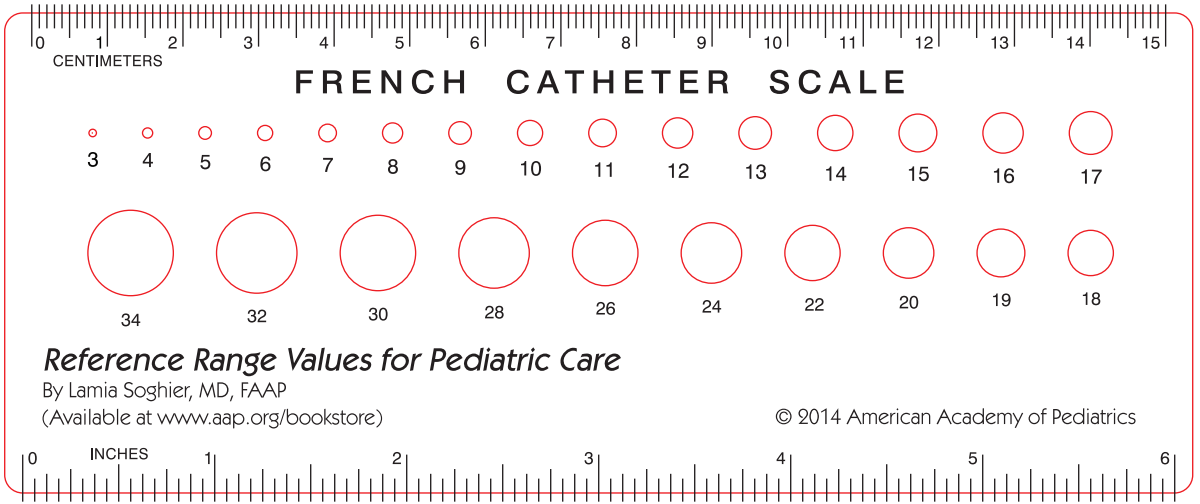
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By Lamia Soghier, MD, FAAP
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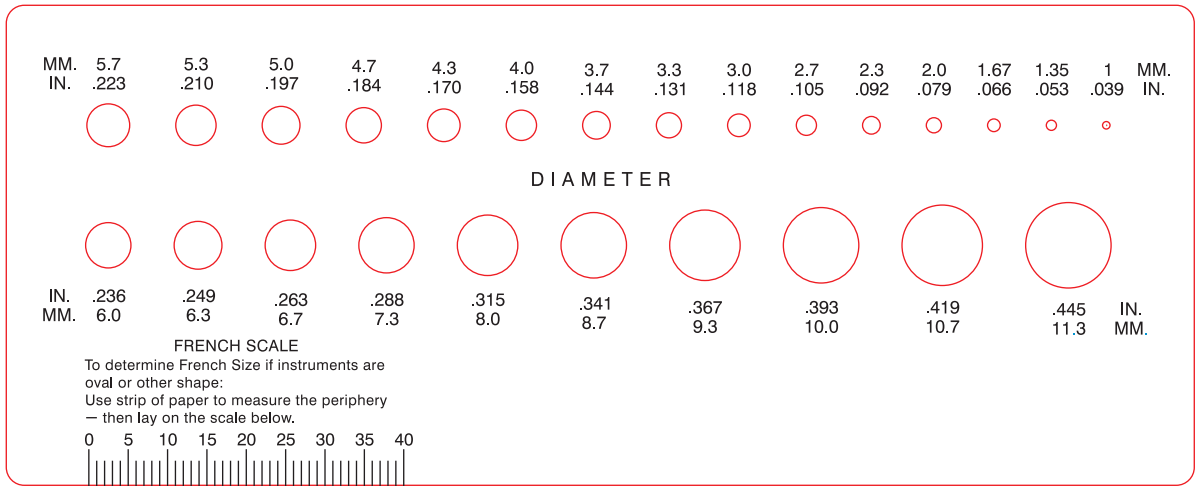
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FRENCH SCALE
To determine French Size if instruments are oval or other shape:
Use strip of paper to measure the periphery — then lay on the scale below.
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American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Recommendations for Preventive Pediatric Health Care

Bright Futures/American Academy of Pediatrics

Bright Futures
Prevention and health promotion for infants, children, adolescents, and their families ™

Each child and family is unique; therefore, these **Recommendations for Preventive Pediatric Health Care** are designed for the care of children who are receiving competent parenting, have no manifestations of any important health problems, and are growing and developing in satisfactory fashion. **Additional visits may become necessary** if circumstances suggest variations from normal.

Developmental, psychosocial, and chronic disease issues for children and adolescents may require frequent counseling and treatment visits separate from preventive care visits.

These guidelines represent a consensus by the American Academy of Pediatrics (AAP) and Bright Futures. The AAP continues to emphasize the great importance of **continuity of care** in comprehensive health supervision and the need to avoid **fragmentation of care.**

The recommendations in this statement do not indicate an exclusive course of treatment or standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

	INFANCY								EARLY CHILDHOOD							MIDDLE CHILDHOOD						ADOLESCENCE										
AGE[1]	PRENATAL[2]	NEWBORN[3]	3–5 d[4]	By 1 mo	2 mo	4 mo	6 mo	9 mo	12 m	15 mo	18 mo	24 mo	30 mo	3 y	4 y	5 y	6 y	7 y	8 y	9 y	10 y	11 y	12 y	13 y	14 y	15 y	16 y	17 y	18 y	19 y	20 y	21 y
HISTORY																																
Initial/Interval	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
MEASUREMENTS																																
Length/Height and Weight		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Head Circumference		●	●	●	●	●	●	●	●	●	●	●																				
Weight for Length		●	●	●	●	●	●	●	●	●	●																					
Body Mass Index												●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Blood Pressure[5]		★	★	★	★	★	★	★	★	★	★	★	★	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
SENSORY SCREENING																																
Vision		★	★	★	★	★	★	★	★	★	★	★	★	●[6]	●	●	●	★	●	★	●	★	●	★	★	●	★	★	●	★	★	★
Hearing		●[7]	★	★	★	★	★	★	★	★	★	★	★	★	●	●	●	★	●	★	●	★	★	★	★	★	★	★	★	★	★	★
DEVELOPMENTAL/BEHAVIORAL ASSESSMENT																																
Developmental Screening[8]								●			●		●																			
Autism Screening[9]											●	●																				
Developmental Surveillance[8]		●	●	●	●	●	●		●	●		●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Psychosocial/Behavioral Assessment		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Alcohol and Drug Use Assessment																						★	★	★	★	★	★	★	★	★	★	★
PHYSICAL EXAMINATION[10]		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
PROCEDURES[11]																																
Newborn Metabolic/Hemoglobin Screening[12]		◄	●	►																												
Immunization[13]		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Hematocrit or Hemoglobin[14]						★			●		★	★		★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
Lead Screening[15]							★	★	●or★[16]		★	●or★[16]		★	★	★	★															
Tuberculin Test[17]				★			★		★		★	★		★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
Dyslipidemia Screening[18]												★			★		★		★		★	★	★	★	★	★	★	★	◄	●	►
STI Screening[19]																						★	★	★	★	★	★	★	★	★	★	★
Cervical Dysplasia Screening[20]																						★	★	★	★	★	★	★	★	★	★	★
ORAL HEALTH[21]							★	★	●or★[21]		●or★[21]	●or★[21]	●or★[21]	●[22]			●[22]															
ANTICIPATORY GUIDANCE[23]	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

1. If a child comes under care for the first time at any point on the schedule, or if any items are not accomplished at the suggested age, the schedule should be brought up to date at the earliest possible time.
2. A prenatal visit is recommended for parents who are at high risk, for first-time parents, and for those who request a conference. The prenatal visit should include anticipatory guidance, pertinent medical history, and a discussion of benefits of breastfeeding and planned method of feeding per AAP statement "The Prenatal Visit" (2001) [URL: http://aappolicy.aappublications.org/cgi/content/full/pediatrics;107/6/1456].
3. Every infant should have a newborn evaluation after birth, breastfeeding encouraged, and instruction and support offered.
4. Every infant should have an evaluation within 3 to 5 days of birth and within 48 to 72 hours after discharge from the hospital, to include evaluation for feeding and jaundice. Breastfeeding infants should receive formal breastfeeding evaluation, encouragement, and instruction as recommended in AAP statement "Breastfeeding and the Use of Human Milk" (2005) [URL: http://aappolicy.aappublications.org/cgi/content/full/pediatrics;115/2/496]. For newborns discharged in less than 48 hours after delivery, the infant must be examined within 48 hours of discharge per AAP statement "Hospital Stay for Healthy Term Newborns" (2004) [URL: http://aappolicy.aappublications.org/cgi/content/full/pediatrics;113/5/1434].
5. Blood pressure measurement in infants and children with specific risk conditions should be performed at visits before age 3 years.
6. If the patient is uncooperative, rescreen within 6 months per AAP statement "Eye Examination in Infants, Children, and Young Adults by Pediatricians" (2007) [URL: http://aappolicy.aappublications.org/cgi/content/full/pediatrics;111/4/902].
7. All newborns should be screened per AAP statement "Year 2000 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs " (2000) [URL: http://aappolicy.aappublications.org/cgi/content/full/pediatrics;106/4/798]. Joint Committee on Infant Hearing. Year 2007 position statement: principles and guidelines for early hearing detection and intervention programs. *Pediatrics*. 2007;120:898–921.
8. AAP Council on Children With Disabilities, AAP Section on Developmental Behavioral Pediatrics, AAP Bright Futures Steering Committee, AAP Medical Home Initiatives for Children With Special Needs Project Advisory Committee. Identifying infants and young children with developmental disorders in the medical home: an algorithm for developmental surveillance and screening. *Pediatrics*. 2006;118:405–420 [URL: http://aappolicy.aappublications.org/cgi/content/full/pediatrics;118/1/405].
9. Gupta VB, Hyman SL, Johnson CP, et al. Identifying children with autism early? *Pediatrics*. 2007;119:152–153 [URL: http://pediatrics.aappublications.org/cgi/content/full/119/1/152].
10. At each visit, age-appropriate physical examination is essential, with infant totally unclothed, older child undressed and suitably draped.
11. These may be modified, depending on entry point into schedule and individual need.
12. Newborn metabolic and hemoglobinopathy screening should be done according to state law. Results should be reviewed at visits and appropriate retesting or referral done as needed.
13. Schedules per the Committee on Infectious Diseases, published annually in the January issue of *Pediatrics*. Every visit should be an opportunity to update and complete a child's immunizations.
14. See AAP *Pediatric Nutrition Handbook*, 5th Edition (2003) for a discussion of universal and selective screening options. See also Recommendations to prevent and control iron deficiency in the United States. *MMWR*. 1998;47(RR-3):1–36.
15. For children at risk of lead exposure, consult the AAP statement "Lead Exposure in Children: Prevention, Detection, and Management" (2005) [URL: http://aappolicy.aappublications.org/cgi/content/full/pediatrics;116/4/1036]. Additionally, screening should be done in accordance with state law where applicable.
16. Perform risk assessments or screens as appropriate, based on universal screening requirements for patients with Medicaid or high prevalence areas.
17. Tuberculosis testing per recommendations of the Committee on Infectious Diseases, published in the current edition of *Red Book: Report of the Committee on Infectious Diseases*. Testing should be done on recognition of high-risk factors.
18. "Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) Final Report" (2002) [URL: http://circ.ahajournals.org/cgi/content/full/106/25/3143] and "The Expert Committee Recommendations on the Assessment, Prevention, and Treatment of Child and Adolescent Overweight and Obesity." Supplement to *Pediatrics*. In press.
19. All sexually active patients should be screened for sexually transmitted infections (STIs).
20. All sexually active girls should have screening for cervical dysplasia as part of a pelvic examination beginning within 3 years of onset of sexual activity or age 21 (whichever comes first).
21. Referral to dental home, if available. Otherwise, administer oral health risk assessment. If the primary water source is deficient in fluoride, consider oral fluoride supplementation.
22. At the visits for 3 years and 6 years of age, it should be determined whether the patient has a dental home. If the patient does not have a dental home, a referral should be made to one. If the primary water source is deficient in fluoride, consider oral fluoride supplementation.
23. Refer to the specific guidance by age as listed in Bright Futures Guidelines. (Hagan JF, Shaw JS, Duncan PM, eds. *Bright Futures: Guidelines for Health Supervision of Infants, Children, and Adolescents*. 3rd ed. Elk Grove Village, IL: American Academy of Pediatrics; 2008.)

KEY

● = to be performed ★ = risk assessment to be performed, with appropriate action to follow, if positive ◄—●—► = range during which a service may be provided, with the symbol indicating the preferred age

Reference Range Values
for Pediatric Care

[STORMRG]

Lamia Soghier, MD, FAAP
Editor

Contributing editors
Katherine Pham, PharmD, BCPS
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