CHAPTER 23

Growth and Development

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Chapter contents

Children are distinguished from people in other age groups by physical growth and developmental changes that are ongoing, normative, and expected. These changes usually proceed in an orderly progression that allows for individual variation. The family physician must be familiar with the range of normal physical and developmental changes that occur in the process of providing health supervision to children.

Growth is a dynamic process in which increasing cell size and number in various tissues result in a physical increase in the size of the body as a whole. Simultaneously, development occurs as tissues differentiate in form and mature in function, reflecting the person's genetic heritage and environmental interaction. Nutritional, family, emotional, sociocultural, and community influences as well as physical factors play a role in shaping the child's psychological and physiological development (Vaughan and Litt, 1992). The child responds emotionally to a particular stimulus in an apparently innate and characteristic style that reflects his or her temperament.

Knowledge of normal as well as abnormal patterns of growth and development enables the physician to assist the child in maximizing his or her fullest potential. Growth in height and weight is a sensitive reflection of a child's general health. Deviations from normal can reflect the presence of physical illness or a disturbance in the child's environment. Box 23-1 lists some significant causes of growth abnormalities.

Care of Children in Family Medicine

Family physicians have the opportunity to provide family-centered pediatric care in the context of the child's family and community. The office should be "child friendly" and child safe with at least one room equipped to evaluate the child's physical growth. Blood pressure cuffs should be available to measure a child's blood pressure, at least from age 36 months and older. Electrical outlets and cords should be secured and potentially hazardous chemicals and biohazard

DOI: 10.1016/B978-1-4377-1160-8.10023-5

Box 23-1 Significant Causes of Growth Abnormalities in Children

Short stature

Familial

Constitutional growth delay
Familial (genetic) short stature

Genetic

Down syndrome
Noonan's syndrome
Russell Silver syndrome
Skeletal dysplasia (dwarfism)
Turner's syndrome
Virilizing congenital adrenal hyperplasia (tall child, short adult)

Systemic disorders

AIDS
Asthma (poorly controlled)
Cancer, caused by poor nutrition, chemotherapy, or radiotherapy
Celiac disease
Chronic heart failure
Congenital heart disease
Cushing's syndrome
Cystic fibrosis
Diabetes mellitus (poorly controlled)
Endocrine disease
Gastrointestinal disease
Growth hormone deficiency, congenital or acquired
Heart disease
Hypopituitarism
Hypothyroidism
Immunologic diseases
Inflammatory bowel disease (Crohn's disease)
Malabsorption syndromes
Pulmonary disease
Renal disease, chronic renal failure, renal tubular acidosis
Severe combined immunodeficiency

Environmental

Malnutrition
Psychosocial deprivation
Toxin or drug exposure (e.g., lead)

Tall stature*

Familial

Constitutional acceleration of growth
Familial tall stature

Genetic

Beckwith-Wiedemann syndrome
Cerebral gigantism (Soto's syndrome)
Homocystinuria
Marfan's syndrome

Systemic disorders

Endocrine disease
Pituitary gigantism (acromegaly)
Thyrotoxicosis

*Data from Bell J. Tall stature. In Finberg L (ed). Saunders Manual of Pediatric Practice. Philadelphia, Saunders, 1998, pp 728-730.

bins stored either out of reach or under lock and key from curious young toddlers. Guidelines for the frequency of "well child" or "well teen" visits are available from the American Academy of Pediatrics (AAP) *Bright Futures: Guidelines for Health Supervision of Infants, Children, and Adolescents* (Hagan et al., 2008).

Initial history for a new infant or child includes the birth history, nutritional history (e.g., breastfed vs. bottle-fed), developmental milestones achieved, immunization record, and environmental history (e.g., do parents smoke?) Later, the physician or staff will also perform anticipatory guidance, including injury prevention and the need to immunize against vaccine-preventable diseases.

Observation of the parent-child interaction informs the physician about the relationship between parent(s) and the child, especially with infants and young children. The parent sitting in a chair reading a magazine while her young infant teeters on an exam table engenders more concern than the parent who is standing next to the child or has him in her lap. Observation of the child's appearance, alertness, muscle tone, state of hydration, and respiratory status also raise or lower the index of concern about a child. The cardiorespiratory examination is often done best if the child is sitting or lying on a parent's lap, whereas examination of the abdomen, genitalia, and hips is generally done on the exam table. The HEENT examination is often done last because it is the most likely to provoke discomfort.

Blood Pressure Monitoring

Hypertension has become increasingly common in children and adolescents. Since 1988, the prevalence of high blood pressure has increased, especially for certain populations, such as Mexican-Americans and blacks (Din-Dzietham et al., 2007). The rising rate of obesity, particularly truncal obesity, at least partly accounts for this. Because of potential end-organ damage and cardiovascular risk in adulthood, auscultatory monitoring of blood pressure (BP) is recommended during health care visits for all children 3 years and older and for younger children with certain high-risk features (Box 23-2). Automatic devices may be needed to measure BP in young infants. Elevated BP should be confirmed on repeat visits. The guidelines define *hypertension* as average systolic or diastolic BP of 95% or higher for gender, age, and height on three or more occasions. *Prehypertension* is defined as values of 90% or greater and less than 95%. For adolescents, BP greater than or equal to 120/80 mm Hg but less than 95% is defined as prehypertensive. Because of the inclusion of a diverse population, these guidelines and tables appear applicable to all ethnic groups (see **eTables 23-1** and **23-2** online at www.expertconsult.com).

The approach to confirmed hypertension in children should be individualized and should consider variables such as comorbidities and family history. In overweight or obese children, the possibility of metabolic syndrome should be investigated. Lifestyle changes, including diet and exercise, may be sufficient for overweight children with stage 1 hypertension (BP at 95% to 99% plus 5 mm Hg). Children with stage 2 hypertension (BP >99% plus 5 mm Hg) and those with end-organ damage likely require medical therapy (National High Blood Pressure Education Program Working Group, 2004).

Box 23-2 Indications for Blood Pressure (BP) Measurement in Children Under 3 Years Old

History of prematurity, very low birth weight, or other neonatal complication requiring intensive care
Congenital heart disease (repaired or nonrepaired)
Recurrent urinary tract infections, hematuria, or proteinuria
Known renal disease or urologic malformations
Family history of congenital renal disease
Solid-organ transplant
Malignancy or bone marrow transplant
Treatment with drugs known to raise BP
Other systemic illnesses associated with hypertension (e.g., neurofibromatosis, tuberous sclerosis)
Evidence of elevated intracranial pressure

Data from National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents: The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics 2004;114:555-576.

Measuring Physical Parameters of Growth

Key Points

- Measure height and weight at all well-child visits.
- Measure head circumference in children up to 24 months of age and blood pressure in children 3 years and older.
- Plot measurements on NCHS growth charts to demonstrate normal growth.
- Investigate significant deviations if the child's growth crosses multiple percentile lines on the growth chart.

Weight, length, and head circumference are the most useful routine measurements in infants. Total body length in children up to age 2 is obtained most accurately by placing them in the recumbent position and measuring from crown to heel. The child's head is placed perpendicular to the surface touching a fixed plate, the hips and knees are fully extended, and the soles of the feet are placed against a sliding board. Older children should have their shoeless standing height measured with a stadiometer with their heels and back touching the wall. Regardless of age, the head should be positioned so that the outer canthus of the eye is aligned with the external auditory canal and perpendicular to the measuring surface (Halac and Zimmerman, 2004). Children should ideally be weighed on the same scale at each visit. Infants should preferably be weighed nude; older children may wear light clothing but not shoes. Height and weight are then plotted on age- and gender-appropriate growth charts developed by the National Center for Health Statistics (NCHS) (see **eFig. 23-1,** *A-H,* and Web Resources).

Body mass index (BMI) is a reliable indicator of body fatness for most children and teenagers that is age and gender specific. A BMI less than the 5th percentile for age is *underweight,* from the 5th to 85th percentile is *healthy weight,* from the 85th up to 95th percentile is *overweight,* and the 95th percentile or greater is considered *obese* (CDC, 2009). BMI charts are also available from the same website.

Head circumference reflects the growth of the cranium and its contents. It should be determined and recorded at all routine physical examinations during the first 2 years of life. This also may be done as part of the initial examination at any age. A nonstretchable measuring tape (usually paper or flexible plastic) is used to obtain the greatest circumference encompassing the occipital, parietal, and frontal prominences. A small head circumference (microcephaly) may be familial; caused by craniosynostosis, congenital viral infections, fetal drug syndromes, or underlying structural abnormalities; or secondary to trauma, infection, or dysmorphic syndromes. A large head circumference (macrocephaly) most often is caused by hydrocephalus, but it may be familial, caused by intracranial bleeding or masses or thickening of the skull, or associated with fragile X syndrome and other conditions (Green, 1986).

Proper Use and Interpretation of Growth Charts

The growth charts shown in **eFigure 23-1** online were revised by NCHS (2000) from surveys of generally well-nourished children representing a cross section of ethnic and economic groups in the United States. These graphs provide a normal range of weight and length or height for a given chronologic age. Recumbent length is recorded on the chart for children from birth to 36 months, and standing height is recorded on the chart for children from 2 to 18 years. Premature infants should have their chronologic age adjusted according to their degree of prematurity up to age 2 years, because most catch-up growth is complete by this time. Although a height or weight above the 95th percentile or below the 5th percentile should alert the physician to a possible problem, these can represent the outer fringe of the normal range.

Linear growth in infants has been shown to occur in incremental bursts rather than continuously (Lampl et al., 1992). A growth curve constructed by a series of heights and weights taken over time allows the physician to compare current growth with the child's previous pattern. The *linear growth velocity,* or rate of gain in height, decreases from 25 cm per year during the first year of life to a prepubertal rate of 5 to 6 cm/yr by age 6 or 7 years (Miller and Zimmerman, 2004). The rate accelerates during puberty. A child whose growth curve parallels the normal curve regardless of the child's absolute percentile has a normal rate of growth for that particular child. In comparison, a child whose height or weight crosses multiple percentile lines or whose linear growth rate drops below 4 cm/yr requires further evaluation for nutritional, psychosocial, or organic problems that could impede or accelerate growth (Lipsky and Horner, 1988). Children with genetic short stature have normal length and weight at birth, but their growth percentiles decline within the first 2 to 3 years of life as they reach their genetic potential (Halac and Zimmerman, 2004).

Although careful measuring and plotting of growth parameters is the most accurate method by which to follow a child's physical growth, approximate growth guidelines are helpful to the physician in remembering and forming an overall impression of the child's progress (Table 23-1).

Familial Short Stature and Constitutional Growth Delay

Each child has a different rate of maturation, or what Boas termed "tempo of growth" (Tanner, 1986). Persons with *short stature* are more than 2 standard deviations (SD) below the

Table 23-1 Approximate Growth Guidelines for Children

Age	Length or Height (ht)	Weight (wt)
Newborn	50 cm (20 inches) average	3.4 kg (7.5 pounds) average
Newborn to 3 months	—	1 kg/month (1 oz/day) average wt gain
3-12 months	—	Wt (kg) = [Age (mo) + 9] ÷ 2 Wt (lb) = Age (mo) + 11*
12 months	75 cm (30 in) average	Triples birth weight
12-24 months	Increases by >10 cm/yr	0.25 kg/month
>5 years	>5 cm (2 in)/yr until adolescent growth spurt	2.3 kg (5 lb)/yr until adolescent growth spurt
2-12 years	Ht (cm) = [Age (yr) × 6] + 77 Ht (in) = [Age (yr) × 2.5] + 30* (e.g., 4-year-old = 40 inches)	Ages 1-6: Wt (kg) = [Age (yr) × 2] + 8 Wt (lb) = Age (yr) × 5 = 17* Ages 7-12: Wt (kg) = [Age (yr) × 7 − 5] ÷ 2 Wt (lb) = Age (yr) × 7 + 5*
Puberty	8-14 cm/yr	

*Modified from Needleman RD. The first year. In Behrman RE, Kliegman RM, Jenson HB (eds). Nelson Textbook of Pediatrics, 17th ed. Philadelphia, Saunders, 2004, p 31.

Box 23-3 Causes of Short Stature and Relationship to Bone Age and Growth Rate

Bone age less than chronologic age

Growth rate normal or slightly decreased

Constitutional growth delay

Growth rate decreased

Endocrine disorders
Cushing's syndrome
Growth hormone deficiency
Chronic systemic disease
Crohn's disease
Heart failure
Renal failure
Severe malnutrition
Severe psychosocial deprivation

Bone age equals chronologic age

Growth rate normal or slightly decreased

Familial short stature
Skeletal dysplasias
Rickets

Growth rate decreased

Chromosomal disorders
Down syndrome
Turner's syndrome

Bone age greater than chronologic age

Growth rate initially increased but short adult

Congenital adrenal hyperplasia
Exogenous androgenic steroids
Precocious puberty

mean in height and constitute approximately 2.5% of children (Miller and Zimmerman, 2004). If a child's growth falls outside the range of normal, it is useful to obtain a bone-age radiograph, usually of the left hand and wrist, and compare it to age-specific standards. Children must be at least 2 years of age to reliably identify epiphyseal ossification centers. Box 23-3 lists some causes of retarded or accelerated bone age. Calculation of mean predicted adult height is also useful in determining whether a child is fulfilling her or his genetic potential. The mean predicted adult height is calculated as follows (Rogol, 2004):

Boy's mean height =
[Father's height + (Mother's height + 13 cm)] ÷ 2
Girl's mean height =
[(Father's height - 13cm) + Mother's height] ÷ 2

Children and adolescents of short stature whose bone age is delayed relative to their chronologic age have more growth potential than do children with a skeletal age appropriate for their chronologic age. If an organic cause of short stature has been excluded, children with delayed bone age are likely to have *constitutional growth delay*. The majority of these children are boys who were of normal length and weight at birth. Their growth rate decelerates during the first 2 years of life and subsequently returns to normal. The children then follow a lower percentile on the growth curve until the onset of their pubertal growth spurt and development, which often occurs later than their peers. There is usually a family history of delayed growth and development (Bareille and Stanhope, 1998). The bone age of these children equals their height age, which is the age at which their height plots on the 50th percentile of the growth chart.

Children with familial short stature usually have parents or close relatives who are short. They often have normal birth weight and length, but their growth rate declines during the first 2 to 3 years of life. Their growth curve subsequently parallels the normal curve but falls below the fifth percentile (Bareille et al., 1998). Their bone age is approximately equal to their chronologic age but less than their height age. These children usually enter puberty at the appropriate age. The U.S. Food and Drug Administration (FDA) has approved the use of recombinant growth hormone for the treatment of idiopathic short stature. This can result in an increase of predicted height of more than 7 cm (Miller and Zimmerman, 2004). Because of potential side effects and the high cost, treatment should be undertaken in consultation with a specialist in pediatric growth disorders.

Pubertal Growth and Development

All children grow at a different tempo, with some maturing earlier than others and some later. This difference is most apparent during puberty. The NCHS growth charts now extend to age 20 years. Tanner and Davies (1985) took the

Table 23-2 Sexual Maturity Stages in Boys and Girls

Stage	Male genitalia	Pubic hair	Female breasts
1	Preadolescent: testes, scrotum, and penis are childlike in size.	None; may be vellus hair, as over abdomen.	Preadolescent: elevation of papilla only.
2	Slight enlargement of scrotum with reddening of skin; little or no enlargement of penis.	Sparse growth of long, slightly pigmented, downy hair, straight or slightly curled, primarily at base of penis or along labia.	Breast bud stage; breast and papilla form a small mound; areolar diameter enlarges.
3	Further enlargement of scrotum; penis enlarges, mainly in length.	Hair considerably darker, coarser, and more curled; spreads sparsely over junction of pubes.	Further enlargement of breast and areola with no separation of their contours.
4	Further enlargement and darkening of scrotum; penis enlarges, especially in breadth; glans develops.	Adult-type hair that does not extend onto thighs, covering a smaller area than in adult.	Areola and papilla project to form a secondary mound above the contour of the breast; stage 4 development of the areolar mound does not occur in 10% of girls and is slight in 20%; when present, it may persist well into adulthood.
5	Adult in size and shape.	Adult in quantity and type with extension onto thighs but not up linea alba.	Mature female; papilla projects and areola recesses to general contour of breast.
6	—	Spreads up linea alba (80% of men, 10% of women).	

Modified from Tanner JM. Normal growth and techniques of growth assessment. Clin Endocrinol Metab 1986;15:436.

earlier NCHS data and constructed height and weight velocity curves for American boys and girls that account for those groups who mature earlier and later. These charts also allow for notation of the various stages of puberty described by Tanner (1986) (Table 23-2).

The onset of puberty generally occurs at age 9 in American girls, with the peak height velocity occurring at age 11.5 years (range, 9.7 to 13.5 years for early to late maturers). American boys have onset of puberty at age 11 and peak height velocity at 13.5 years (range, 11.7 to 15.3 years) (Tanner and Davies, 1985). Because boys have two additional years of prepubertal growth and a peak height velocity greater than that of girls, their ultimate height is usually taller. Head, hands, and feet are first to reach their adult size, followed by leg length, trunk length (which accounts for much of the spurt), and body breadth. Pubertal boys develop greater shoulder breadth than do pubertal girls, who develop wider hips. Adolescents can be reassured that their bodies eventually will become more proportionate with their hands and feet. Boys ultimately gain greater muscle size and strength than do girls, while losing limb fat. This results from their increased secretion of testosterone, which also increases red cell mass and hemoglobin (Tanner, 1986).

The adolescent growth spurt in skeletal and body dimensions is associated closely with the development of the reproductive system. Although the onset and rate of maturation vary according to the individual, the sequence is usually the same within genders (Figs. 23-1 and 23-2). Girls who demonstrate signs of puberty before 7 to 8 years of age and boys who show signs before 9 years should be evaluated for *precocious puberty.* Conversely, girls who do not show signs of puberty by age 13 and boys by age 14 should be evaluated for *pubertal delay* (Plotnick, 1999).

The first sign of puberty in boys is an increase in growth of the testes and scrotum, with reddening and wrinkling of the scrotal skin. Pubic hair appears within 6 months, followed by phallic enlargement in 12 to 18 months and peak height velocity 2 to 2.5 years after testicular enlargement (Copeland, 1986). Axillary hair usually appears 2 years after the beginning of pubic hair growth (stage 4 pubic hair), but there is considerable variability. Some boys may have enlargement of the breasts midway through adolescence. Following the attainment of peak height velocity, boys develop mature spermatozoa, full facial hair, and voice change. However, breaking of the voice is a late and often gradual process.

In girls, the breast bud is the first sign of puberty, and the pubertal growth spurt typically occurs concurrently, peaking at stage 3 breast and pubic hair. The uterus and vagina develop simultaneously with the breast, but menarche usually does not occur until stage 4 breast and pubic hair. Although the peak height velocity has been passed, girls may grow an average of 6 cm more after menarche. Early cycles may be irregular and anovulatory, but early sterility should never be presupposed (Tanner, 1986).

Screening Healthy Children

Key Points

- All newborns should have a hearing screen within the first month of life.
- Examine eyes at all well care visits; screen vision beginning at age 3 years.
- Provide anticipatory guidance regarding discipline starting at 15 months of age.

Preventive care services for children often include screening for health conditions in which early detection and early treatment can prevent or ameliorate more serious disease in the future. Screening tests should detect most persons with

the condition *(sensitivity)* while excluding most persons who do not have the condition *(specificity)* in a cost-effective manner. In an inner-city Medicaid population, high continuity of care in infancy was associated with improved screening for anemia, lead, and tuberculosis (Flores et al., 2008).

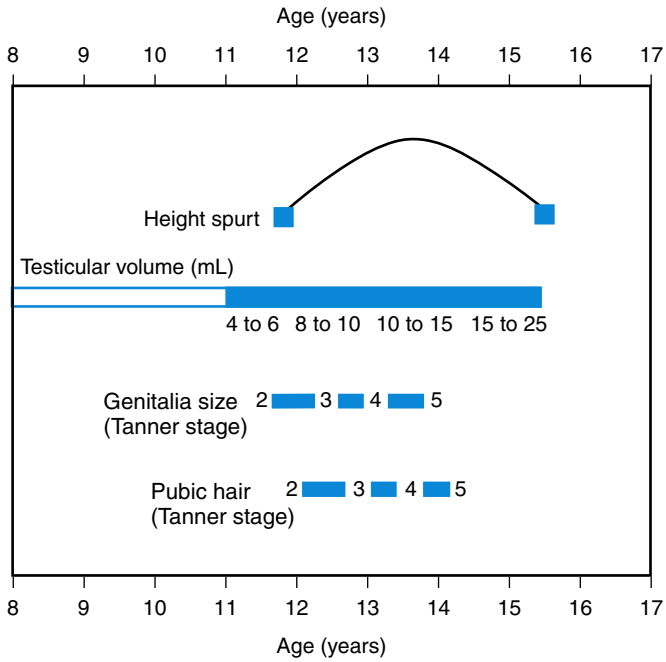

Figure 23-1 Sequence of pubertal events in average American boys. *(Modified from Brookman RR, Rauh JL, Morrison JA, et al: The Princeton Maturation Study; 1976, unpublished data for adolescents in Cincinnati, Ohio. In Copeland KC, Brookman RR, Rauh JL [eds]: Assessment of Pubertal Development. Columbus, Ohio, Ross Products Division, Abbott Laboratories, 1986, p 4.)*

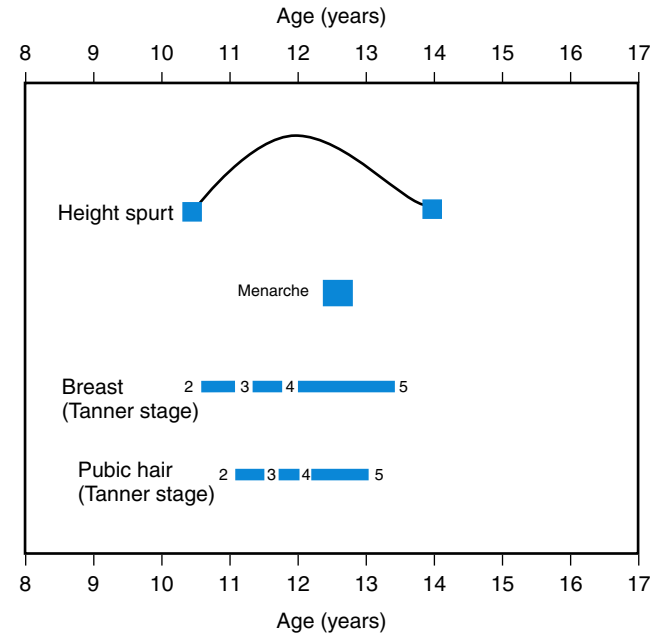

Figure 23-2 Sequence of pubertal events in average American girls. *(Modified from Brookman RR, Rauh JL, Morrison JA, et al: The Princeton Maturation Study, 1976 unpublished data for adolescents in Cincinnati, Ohio. In Copeland KC, Brookman RR, Rauh JL [eds]: Assessment of Pubertal Development. Columbus, Ohio, Ross Products Division, Abbott Laboratories, 1986, p 4.)*

Hearing and Vision Screening

Early detection and intervention for hearing and vision deficits are important for maximal long-term functioning. Without appropriate opportunities to learn language, children with significant hearing deficits fall behind peers in terms of communication, cognition, reading, and social-emotional development, with long-term effects on educational attainment and adult employment (AAP Joint Committee on Infant Hearing, 2007). It is now recommended that all infants be screened for hearing loss by 1 month of age, regardless of risk factors. Those who do not pass the screening should have a complete audiologic evaluation by 3 months of age, and those with confirmed hearing loss should receive appropriate treatment by 6 months to ensure optimal outcome. Regardless of the outcome of newborn screening, ongoing surveillance of hearing status is recommended. Developmental delays and other risk factors (Box 23-4), particularly in language, as well as the presence of parental concern about hearing, should prompt referral for a complete audiologic evaluation, even if the newborn screen was normal and there are no risk factors for hearing impairment (Hagan et al., 2008). Gradations of hearing loss are presented in Table 23-3.

Eyesight evaluation is a recommended part of routine health maintenance examinations in children beginning in the newborn period. In young children (<3 years) the

Box 23-4 Risk Factors for Delayed Onset of Hearing Loss in Young Children

Caregiver concern regarding hearing, speech, language, or developmental delay
Family history of permanent childhood hearing loss
Neonatal intensive care longer than 5 days
In utero infections (e.g., cytomegalovirus)
Craniofacial anomalies (e.g., ear pits, ear canal defects)
Syndromes known to be associated with hearing loss (e.g., neurofibromatosis)
Neurodegenerative disorders (e.g., Friedreich's ataxia)
Postnatal infections (e.g., meningitis)
Head trauma (e.g., basal skull/temporal bone fracture)
Chemotherapy

Modified from Hagan JF, Shaw JS, Duncan PM (eds). Bright Futures: Guidelines for Health Supervision of Infants, Children, and Adolescents, 3rd ed. Elk Grove Village, Ill, American Academy of Pediatrics, 2008, p 232.

Table 23-3 Hearing Loss Scale

Hearing impairment	Hearing threshold (dB)
None	10-25
Mild	26-40
Moderate	41-55
Moderate to severe	56-70
Severe	71-90
Profound	>91

evaluation, besides the actual eye examination, is somewhat subjective and based on parental history. Children with risk factors, such as prematurity, family history of retinoblastoma or glaucoma, or significant developmental delays or neurologic difficulties, should be referred to an experienced pediatric ophthalmologist. More formal testing of visual acuity should begin at age 3 years, using standardized systems such as the Allen Cards, which have easily recognized pictures (AAP Committee on Practice and Ambulatory Medicine, 2003). Normal visual acuity is in the 20/30 to 20/40 range for children 3 to 4 years old, but increases to 20/20 by early school age. Eye-specific screening should be attempted in an effort to detect amblyopia (more than one line difference on the chart) (SOR: B). The suspicion of amblyopia or strabismus requires further evaluation to prevent long-term visual loss (AAP Committee on Practice and Ambulatory Medicine, 1996). Routine screening should be done at least through early school age, at puberty and whenever there are other signs, such as squinting or complaints of inability to see the board at school (Hagan et al., 2008).

Screening for Iron Deficiency Anemia

The U.S. Preventive Service Task Force currently has found insufficient evidence to recommend for or against routine screening asymptomatic infants age 6 to 12 months for iron deficiency anemia (USPSTF, 2006). Venous hemoglobin is more accurate than capillary hemoglobin for detecting anemia; however, true iron deficiency is much more common than iron deficiency anemia. In addition, there is evidence that even children with severe anemia who are treated with iron supplementation continue to demonstrate behavioral and developmental deficits 10 years afterwards (Lozoff et al., 2000). Nevertheless, the AAP Committee on Nutrition presents two options for screening for iron deficiency anemia. If a community has a significant level of iron deficiency anemia or infants who are at risk by virtue of their diet, universal screening is recommended for all full-term infants between 9 and 12 months old, with a second screening 6 months later at 15 to 18 months old. Selective screening may be done on a similar schedule only for children deemed to be at risk for iron deficiency anemia, including low-birth-weight infants, infants not receiving iron-containing formula, or breastfed infants over 6 months old who lack adequate iron in their diet.

Screening for Lead Toxicity

Lead is neurotoxic and affects both intellectual and behavioral function, even below the 10 μg/dL level established by the U.S. Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) (Canfield et al., 2003). Federal Medicaid law has required lead screening of young children eligible for Medicaid at ages 12 months and 24 months, and for children ages 36 to 72 months not previously tested. However, 1999–2004 NHANES data demonstrate that the percentage of children with blood lead levels of 10 μg/dL or higher had decreased to 3.4% for black and 1.2% for white children age 1 to 5 years. The USPSTF finds insufficient evidence to recommend for or against screening asymptomatic children 1 to 5 years old who are at increased risk. The CDC recommends targeted screening of specific groups of children, except in areas where universal screening is still recommended because of a prevalence of elevated lead levels. Specific state information can be obtained at http://www.cdc.gov/nceh/lead. Children considered at risk who require screening include (1) those suspected by a parent or health care provider to be at risk for exposure; (2) those with a sibling or frequent playmate with an elevated blood lead level; (3) those with a parent or caregiver who works professionally or recreationally with lead; (4) a household member uses traditional folk or ethnic remedies or cosmetics; or (5) family designated at increased risk for lead exposure by the health department because of local risk factors for lead exposure, such as residing in a high-risk zip code (Wengrovitz and Brown, 2009).

Screening for Tuberculosis

In 2007, there were approximately 10 million cases of new and recurrent tuberculosis (TB) and 1.8 million deaths worldwide, with the highest rates occurring in low-income countries (Marais et al., 2009). The incidence of active TB is much lower in the United States, but an estimated 10 to 15 million persons have *latent tuberculosis infection* (LTBI). Six groups considered at high risk are children, foreign-born persons, HIV-infected persons, homeless persons, detainees and prisoners in correctional facilities, and close contacts of infectious persons (CDC, 2005). Targeted rather than universal testing of children for TB is now recommended. Risk factors for LTBI include (1) previous positive tuberculin skin test; (2) birth in foreign country with high prevalence of TB (e.g., China, India, Mexico, Philippine Islands, Vietnam, certain African countries); (3) nontourist travel to a high-prevalence country for more than 1 week; (4) contact with TB-infected person, and (5) presence in the household of another person with LTBI (CDC, 2005). The Mantoux TB skin test is recommended for children because its correlation with results of interferon-γ release assays is often discordant in children (Connell et al., 2008).

Discipline

Parents frequently ask their primary care physician about discipline. Discipline should be a priority topic for anticipatory guidance at 15 months and 18 months (Hagan et al., 2008). Effective discipline requires three essential components: (1) a positive, loving relationship between the parent(s) and child, (2) positive reinforcement strategies to increase desired behaviors, and (3) punishment or removal of reinforcement to reduce or eliminate undesired behaviors (AAP Committee on Psychosocial Aspects, 1998). Although often confused with punishment, discipline actually means to *teach*. All children benefit from guidance and structure, and most children require occasional discipline. The best discipline is consistent and considers the child's developmental level as well as the child's point of view. Effective strategies include environmental modifications (e.g., childproofing the house), distraction, redirection, giving appropriate choices, and time-out. Although many parents spank (Regalado et al., 2004), corporal punishment is controversial and has potential long-term negative effects (Smith, 2006). Other methods of discipline are more effective over time and

should be used. Some families may require more intensive assistance, and clinicians should be aware of local resources for teaching parents.

Nutrition

Key Points

- Breast milk is the recommended food for infants and the standard to which infant formulas are compared.
- Give vitamin D supplements to all breastfed infants and those taking less than 1 L of vitamin D–fortified milk or formula per day.
- Begin iron-fortified cereal for infants older than 4 to 6 months or low-birth-weight infants older than 2 weeks.
- Obtain a fasting lipid profile in children with a family history of dyslipidemia, premature atherosclerotic vascular disease, or personal risk factors such as overweight, hypertension, smoking, and diabetes mellitus.

Infancy through Adolescence

Proper physical growth and appropriate cognitive development depend on adequate nutrition. Infants and young children with severe iron deficiency anemia were found to have significantly lower verbal and full-scale IQ scores and lower achievement test scores in arithmetic and writing than non-iron-deficient infants, even 10 years after treatment (Lozoff et al., 2000). An increase in behavioral problems was also reported, although this could not be directly linked to the preceding iron deficiency. In the Third National Health and Nutrition Examination Survey (NHANES III, 1988–1994), 7.2% of 12- to 16-year-old girls had iron deficiency, but only 1.5% demonstrated anemia (Halterman et al., 2001). Adolescent iron-deficient girls scored significantly lower math scores compared with non-iron-deficient girls. Vitamin D deficiency and insufficiency in children and adolescents has been reported worldwide, including North America (Wagner and Greer, 2008). Mealtime also represents a time for social interaction within the family unit, whether this is the bonding of mother and child during breastfeeding or discussion of the day's events during dinnertime.

Although malnutrition is still a problem in the United States, *inappropriate nutrition*, especially calorie-nutrient imbalance leading to overweight and obesity, has become commonplace. Recent NHANES studies demonstrate that the prevalence of overweight (BMI ≥95%) in girls 2 to 19 years old increased from 13.8% in 1999–2000 to 16% in 2003–2004, and the prevalence of overweight in boys 2 to 19 years old increased from 14% to 18.2% (Ogden et al., 2006). Increased pediatric BMI is associated with high blood pressure, sleep apnea, asthma, polycystic ovarian syndrome, type 2 diabetes, gastroesophageal reflux, and orthopedic problems (Benson et al., 2009). A nationwide survey of more than 6000 children and adolescents found that at least 30% consumed "fast food" on a typical day. These children consumed more total fat, total carbohydrate, more added sugars and sugar-sweetened beverages, less milk, and fewer fruits and nonstarchy vegetables than children who did not eat fast food (Bowman, 2004). The odds of having a BMI of 85th percentile or higher was more than four times that for 10- to 15-year-old children viewing more than 5 hours of television per day compared with those watching for 0 to 2 hours (Gortmaker et al., 1996). A survey of low-income preschool children in New York State found that children with a TV set in their bedroom watched 4.8 hours more TV/video than those without a bedroom TV. In this group the prevalence of child overweight (BMI >85%) was associated with an odds ratio of 1.06 for each additional hour per day of TV/video viewed (Dennison et al., 2002). Frequent television viewing can lead to decreased activity, excessive snacking on high-calorie junk foods, and subsequent obesity (Dietz and Gortmaker, 1985). In contrast, dieting in pursuit of the media's representation of the ideal woman can lead to eating disorders, such as bulimia or anorexia. The CDC has proposed 24 strategies to prevent obesity in the United States, including increasing the availability of healthier food and beverage choices, restricting the availability of less healthy foods and beverages in public service areas, and increasing the amount of physical activity in schools (Khan et al., 2009).

Infants and Toddlers

Infants require approximately 120 kcal/kg/day to meet basal metabolic requirements and the energy demands of growth and activity during the first 6 months of life. Low-birth-weight (LBW) newborns may require 130 to 150 cal/kg/day for catch-up growth (Klish, 2009). Weight gain should be 25 to 30 g/day during the first 3 months of life, decrease to 15 to 20 g/day between 3 and 6 months of age, and decrease to 10 to 15 g/day between 6 and 12 months (AAP, 2009). Energy requirements are increased by greater physical activity, stress imposed by disease processes (e.g., cystic fibrosis), or symptoms (e.g., fever). Fever can increase the fluid requirements of infants younger than 6 months beyond the usual 130 to 190 mL/kg/day (Barness and Curran, 1996).

The composition of human milk varies by time, day, and maternal nutrition and from woman to woman. Infant formulas contain about 50% more protein than human milk and, like breast milk, provide 40% to 50% of energy as fat (Table 23-4). Beginning at 2 years of age, fat calories should decrease to approximately 30% of total energy consumption, with less than 10% of calories from saturated fat, and dietary cholesterol less than 300 mg/day (AAP, 2009).

The ideal food for full-term infants during the first 12 months of life is human milk. Oliver Wendell Holmes once noted, "A pair of substantial mammary glands has the advantage over the two hemispheres of the most learned professor's brain in the art of compounding a nutritious fluid for infants" (Cone, 1979, p. 138). Human milk is fresh, readily available at the proper temperature, and generally free of contaminating bacteria. Its acid-resistant whey proteins include secretory immunoglobulin A (sIgA), α-lactalbumin, and lactoferrin, a whey protein that transports iron and inhibits the growth of a range of organisms in the intestine. The protein in human milk consists predominantly of whey proteins that are of higher nutritional quality and digested and absorbed more easily than cow's milk proteins (AAP, 2009).

Commercial cow's milk and soy-based formulas must contain higher levels of protein to compensate for their lower quality (see Table 23-4). However, they are quite acceptable for mothers who are unable to nurse their infants or for parents who wish to bottle-feed their children. Soy formulas are

Table 23-4 Comparison of Common Milks and Infant Formulas

Milk/ formula	kcal/30 mL	Protein (g/dL)	CHO (g/dL)	CHO type	Fat (g/dL)	Iron (mg/L)	comments
Human milk	20	1.0	6.9	Lactose (primary), glucose, oligosaccharides	4.4	<0.1	Small flocculent curd is easily digestible, and iron is absorbed.
Whole cow's milk	19	3.3	4.7	Lactose	3.7	Trace	Curd is less easy to digest. Can cause intestinal blood loss. Do not use before age 12 months.
Evaporated whole milk	43	6.9	10.0	Lactose	7.6	Trace	Curd is softer, smaller and may be less allergenic. Dilute and add dextrose to make 20 kcal/oz formula.
Prepared formula, cow's milk based	20	1.4-1.7	6.9-7.5	Lactose	3.4-3.8	4.7-12.2*	AAP recommends only iron-fortified formulas.
Prepared formula, soy based	20	1.7-1.8	6.8-7.4	Corn syrup, corn syrup solids, sucrose, corn maltodextrin	3.4-3.7	12-12.2	May use if lactase-deficient vegetarian, galactosemic, or allergic to cow's milk.†

Modified and compiled from Kleinman RE (ed). Pediatric Nutrition Handbook, 6th ed. Elk Grove Village, Ill, American Academy of Pediatrics (AAP), 2008, pp 1250-1265.
*Iron-fortified formula.
†However, cross-reactivity with cow's milk protein sometimes occurs.
CHO, Carbohydrate.

recommended for infants with hereditary lactase deficiency or galactosemia and may be tried in infants intolerant to cow's milk, but soy formula should not be used in preterm infants. Because some infants allergic to cow's milk protein will develop an allergy to soy protein, it is advisable to use an extensively hydrolyzed protein formula in cases of true milk allergy or malabsorption. These are lactose free and may contain medium-chain triglycerides to improve fat absorption (AAP, 2009).

Human breast milk or iron-fortified infant formula is recommended for the first 12 months of life. Cow's milk is not suitable for infants because the higher intake of protein, sodium, potassium, and chloride increases renal solute load. In addition, the lower concentrations of iron, zinc, essential fatty acids, vitamin E, and other micronutrients can result in deficiencies. Significant intestinal blood loss can occur in infants younger than 12 months of age receiving cow's milk. Very-low-fat milks lack adequate calories for growth despite promoting excessive volume ingestion. Breastfed full-term infants seldom develop iron deficiency anemia before 4 to 6 months of age because the iron present in breast milk is well absorbed. Iron-fortified infant cereal or meats are then good sources of the 1 mg/kg/day of elemental iron required by full-term infants. All preterm or LBW infants should receive at least 2 mg/kg/day of elemental iron from 2 weeks until 12 months of age (AAP, 2009). Parents should be warned that iron is toxic in excessive amounts, and appropriate precautions should be taken.

Children 6 months to 3 years old who do not drink fluoridated water or other beverages may be given 0.25 mg/day of supplemental fluoride. Human milk contains only small amounts of biologically active vitamin D, and rickets has been reported in breastfed infants, infants with darker skin pigmentation, and even older children with minimal exposure to sunlight. Consequently, all breastfed infants, partially breastfed, non-breastfed infants, and older children ingesting less than 1000 mL/day of vitamin D–fortified formula or milk should receive 400 IU/day of supplemental vitamin D daily beginning within the first few days of life until the infant or child is ingesting 1000 mL/day of vitamin D–fortified formula or milk (AAP, 2009). Higher doses of vitamin D may be required in children with chronic fat malabsorption. Vitamin B_{12} supplementation should be given to breastfed infants whose mothers are strict vegetarians.

Both WHO and AAP promote exclusive breastfeeding for the first 6 months of life. However safe, nutritious solid foods may be introduced between 4 and 6 months of age, when the infant is developmentally ready. The order of introduction of solid foods is generally not critical; however, single-ingredient foods should be tried for 1 week at a time to observe for possible allergic reactions before introducing another food or mixtures of foods. Single-grain infant cereals such as rice (which lacks gluten) are usually well tolerated and provide a source of fortified iron. Homemade infant foods should not have added salt or sugar. Honey is associated with infant botulism and should not be given to infants younger than 1 year. Teething biscuits or finely chopped foods may be given by 8 to 10 months of age. However, foods such as popcorn, nuts, or rounded candies should not be offered to infants or toddlers because of the risks of choking, aspiration, and even death. Potentially hazardous foods such as hot dogs and grapes must be cut into small pieces, and the caregiver should always be present during mealtime. Children should be weaned from the bottle to a "sippy cup" by 12 to 15

months of age and bedtime bottles discouraged because they are associated with dental caries (AAP, 2009).

A toddler's food intake may be quite variable from day to day or even meal to meal. Because young children cannot choose a well-balanced diet, parents must provide nutritious, safe, developmentally appropriate foods at regular meals and snacks. Children should be sitting in a designated area for mealtime, without distractions such as television (AAP, 2009). Small portions of food should be offered to preschool children, allowing the child to determine how much he or she will eat and offering more as necessary. Excessive portion sizes can contribute to obesity later in life. Guidelines about types and quantities of foods from the basic food groups are available from the U.S. Department of Agriculture (USDA) MyPyramid website (www.mypyramid.gov), which provides recommendations on the amount of grain products, vegetables, fruits, and milk products based on the person's age, gender, and activity level.

Parents should be counseled that toddlers and preschool children are often picky eaters but generally grow well despite this. Parents need to guide children in their selection of food by offering a variety of nutritious items such as fruits and vegetables, keeping in mind that it can require 8 to 10 exposures to a new food before a child accepts it (AAP, 2009). Mealtime should not turn into a battleground because forcing a child to clean the plate can lead to specific food dislikes or promote obesity in later life. Snacking or eating while watching television should be discouraged, and physical activity should be encouraged.

Healthy children eating a varied diet usually do not require a multivitamin supplement. Children who do not eat dairy products, meat, or eggs require supplemental vitamin B_{12} and are at risk for vitamin D deficiency, especially if they lack adequate sunlight exposure or have darkly pigmented skin. Children following strict vegetarian diets often have low intakes of iron and calcium that can require supplementation. They often have a low intake of zinc that may be obtained from zinc-fortified infant and adult cereals. The recommended fiber intake is 19 g/day for children 1 to 3 years old and 25 g/day for those 4 to 8 years old. Excessive fiber consumption may decrease the intake of energy-dense foods and inhibit the absorption of some minerals (AAP, 2009).

Children with malabsorption or hemolytic anemia can require additional folic acid. Parents who insist on using a vitamin supplement without any obvious deficiency on the part of the child should be counseled to use a preparation that does not exceed the dietary reference intakes (DRIs) established by the Institute of Medicine and the National Academy of Sciences. In particular, vitamins A and D can produce toxicity if given in excessive doses.

Adolescents

Adolescents are at greater risk than other age groups for nutritional deficiencies because they may skip meals, snack more, eat more fast foods, and follow fad diets for reasons ranging from weight loss to cultural differentiation. Teenage boys and girls often replace milk and juice with soft drinks, coffee, tea, and alcoholic beverages, thereby lowering their intake of calcium as well as vitamins A and C. Adolescents' iron intake may be lower than required for their rapid increases in lean body mass and hemoglobin mass in addition to menstrual blood loss in girls. Zinc is also required for growth and sexual maturation. Most teenagers do not ingest the recommended 1300 mg of calcium daily (AAP, 2009).

Energy requirements vary greatly in teenagers, depending on their gender, activity, and stage of adolescence. Sedentary adolescent girls require 1600 to 1800 cal/day and sedentary boys 1800 to 2200 kcal/day. As much as 200 kcal/day may be added for moderate physical activity and 200 to 400 kcal/day added for those who are very active (Daniels and Greer, 2008). Healthy pregnant women of normal BMI should tailor their prenatal diet to achieve a total weight gain of 11.5 to 16 kg (26-35 lb), or an additional 300 kcal/day during the second and third trimesters. Additional protein requirements are about 15 and 27 g/day during the second and third trimesters, respectively. Most will require some form of iron supplementation, about 30 mg/day during the second and third trimesters. Because zinc deficiency has potential teratogenic effects, pregnant adolescents should receive about 13 mg/day of zinc supplementation along with 1 mg/day of copper supplementation. All women of childbearing potential should take 400 to 600 μg of folic acid supplement per day in addition to 400 μg of dietary folate to decrease the risk of giving birth to children with neural tube defects. Pregnant women also require 1300 mg/day of calcium in their diet (AAP, 2009).

Universal screening for hypercholesterolemia in children is not currently recommended. A fasting lipid profile should be obtained in children who have a family history of dyslipidemia or premature (men ≤55 years, women ≤65 years) coronary heart disease or peripheral vascular or cerebrovascular disease. Children for whom the family history is not known or who have other risk factors such as overweight (BMI ≥85% and <95%), obesity (BMI ≥95%), hypertension (BP ≥95%), cigarette smoking, or diabetes mellitus should also be screened. This screening should be done between 3 and 10 years of age. The National Cholesterol Education Program (NCEP) guidelines indicate that a total cholesterol less than 170 mg/dL is acceptable, 170 to 199 mg/dL is borderline, and 200 mg/dL or greater is high. Similarly, a low-density lipoprotein (LDL) level less than 110 mg/dL is acceptable, 110 to 129 mg/dL is borderline, and higher than 130 mg/dL is elevated (Daniels and Greer, 2008). The American Heart Association has designated triglyceride (TG) levels greater than 150 mg/dL and high-density lipoprotein (HDL) level less than 35 mg/dL as abnormal. If initial lipid values are within acceptable levels, retesting should be done in 3 to 5 years.

It is recommended that all healthy children older than 2 years follow a diet in which a wide variety of foods provide adequate caloric intake to achieve proper growth and development as well as desirable weight. Total fat and saturated fat intake should be no more than 30% and 10%, respectively, of total calories; dietary cholesterol should be less than 300 mg/day. Children who are overweight or obese and have a high TG or low HDL level should be counseled regarding proper diet and increased physical activity. Children at especially high risk based on familial hyperlipidemias or premature cardiovascular disease may undertake a diet restricting saturated fat to 7% of total calories and cholesterol to 200 mg/day (Daniels and Greer, 2008). Children 10 years and older may be considered for pharmacologic therapy with LDL of 190 mg/dL or higher without additional risk factors, 160 mg/dL or greater with a family history of early heart disease or two or more other risk factors, or 130 mg/dL or higher if diabetes mellitus is present (AAP, 2009).

KEY TREATMENT

Ensure vitamin D intake of at least 400 IU/day, either by diet or supplementation (Wagner and Greer, 2008) (SOR: A).
Children 2 years and older should follow a diet with less than 30% of calories from total fat and 10% from saturated fat (Daniels and Greer, 2008) (SOR: B).
Communities should improve the availability of affordable healthier food and beverage choices and restrict the availability of less healthy choices in public service areas, by decreasing the cost of healthy foods and increasing the cost of less healthy foods (Khan et al., 2009) (SOR: B).

Behavior and Neurodevelopment

Key Points

- Development is a product of factors intrinsic and extrinsic to the child.
- Basic knowledge of child development enables clinicians to guide and educate families.
- Development proceeds in a basic sequence.
- Delays in one area of development may affect another.
- In preterm infants, correct for prematurity until age 2 years.

One of the rewards of providing primary care for a child is sharing with the family in the development of cognitive, motor, social, and language skills. Clinicians need to understand the theoretic framework on which the scientific understanding of child development is based in order to individualize the approach to the unique needs and concerns of each family. Physicians should develop strategies for clinically assessing child development and managing identified developmental abnormalities.

Theories of Development

Child development was widely studied in the 20th century. A general understanding of the common theories can enrich the clinician's relationship with young patients. Most researchers in child development believe that developmental outcomes are a product of intrinsic child factors, including genetic potential and temperament, and extrinsic environmental factors, such as intrauterine, infectious, traumatic, chemical, and sociocultural factors (Vaughan and Litt, 1992). The relative weights of each of these factors vary considerably among persons, thus frustrating the attempts of researchers to develop a formula for predicting developmental outcome for any individual person.

A clinician who is familiar with the key elements of theoretic models can develop expertise in applying them appropriately to meet the needs of countless clinical scenarios. For example, a physician might use Erikson's theory of psychosocial stages to explain to a vexed parent of a 2-year-old that the child's constant temper tantrums represent a normal expression of the child's need to exert autonomy over the environment. In the next room, the physician might refer to Piaget's concept of concrete operational thought to explain why a 10-year-old might not be capable of considering remote consequences of present actions (e.g., "If I don't study for my science test, I might not meet my goal of becoming an astronaut").

Features of the most widely accepted developmental theories are found in many pediatric references (Dixon and Stein, 2000). A summary of the salient features of each theory and potential clinical applications is presented in Table 23-5.

Erikson's psychosocial stages theory is particularly relevant (Table 23-6). According to his theory, at each discrete life stage, persons are confronted with a crisis requiring integration of personal needs with sociocultural demands. Successful integration of needs and development indicates normal adaptation. A practitioner who is familiar with these stages can counsel families about the emotional needs of children at different ages and explain the appropriateness of challenging but normal childhood behavior.

The concept of temperament is also clinically relevant for primary care. *Temperament* is a set of consistent, inborn characteristics that influence how people interact with and learn from their environment (Thomas et al., 1968). The person's temperament characteristics are innate to his or her personality. Three basic temperament profiles based on nine separate infant characteristics are outlined in Table 23-7. These are broad generalizations, and not all infants fit easily into one of these three categories.

Each family's personal value system influences their reaction to a child of a particular temperament. For example, a highly competitive, athletically oriented family may view high-energy, high-intensity characteristics more positively than a family who values studiousness. Qualities such as introversion or extroversion are often based on characteristics of temperament and are not modified readily by the environment. In a family in whom "goodness of fit" between individual members' temperaments does not exist, knowledge of the inborn nature of temperament can help the family accept a child's unique characteristics. Anticipatory guidance can then focus on achieving a better relationship between family and child.

Guidelines for Clinical Assessment

Although individual children develop at their own rate, with great variability in the normal range, general rules for neurodevelopmental maturation can serve as guidelines to help practitioners formulate a developmental trajectory for each child (Sturner and Howard, 1997). The developmental trajectory can be envisioned as an individualized growth chart of anticipated developmental progress based on normal neurodevelopmental milestones and moderated by child, parent, and environmental factors such as temperament, parental mental health, and exposure to lead.

Development usually is categorized into the domains of language, fine motor, gross motor, personal-social, and cognitive. Delays can occur in one or any combination of these domains. For example, a child with mental retardation is likely to have delays in all domains, although gross motor skills may be fairly well preserved. Conversely, a child with cerebral palsy may have normal or near-normal cognitive development with significant delays in gross and fine motor function. Many of the neurodevelopmental rules of thumb address the relationships among these domains.

Children acquire developmental tasks in a predictable sequence. For example, children typically do not learn to walk until they have mastered crawling and then standing.

Table 23-5 Summary of Developmental Theories of Child Development

Theory (proponents)	Key features	Potential clinical applications
Normative approach: development as maturation (Gesell)	Behavior depends on neurologic and physical maturation. Universal progression of developmental sequence. Minimal rule of environment/temperament.	Basis for age norms for developmental milestones typically used in clinical setting.
Psychosexual and psychoanalytic theory: development as resolution of conflict (Freud, Erikson)	Emotional life exerts strong influence on development and behavior. Unconscious conflicts between biologic drive and social expectations continuously shape behavior and self-concept. Parents are primary interactors with child, influencing behavior into adulthood. Mastery of major developmental tasks at different stages is required for emotional growth.	Interpersonal relationships, especially with primary caregivers, influence present and future adjustment, functioning, and self-concept. Importance of "bonding."
Behaviorism and social learning: development as learning (Pavlov, Skinner, Bandura)	Behavior, but not its underlying influences and motives, can be studied and changed. Environmental stimuli are the major forces shaping development and behavior. Environmental stimuli act as positive and negative reinforcements to existing behavior.	Children imitate what they see, so environmental models are important to learning (e.g., influences of media). Basis for behavioral management approaches.
Constructivist views: development as cognitive change (Piaget)	Cognitive development depends on both nature and nurture. Child uses physical and mental abilities to observe and act on the environment. Observation and action advance cognitive development. Child's mental processing develops with age, influencing how child perceives and interacts with the world.	Children possess an innate drive to learn. Play is the medium by which children learn and develop. Parents can be guided in choosing appropriate playthings/settings to allow their children to learn.
Ecologic system: development as cultural and ecologic adaptation (Bronfenbrenner)	A set of interrelated systems (e.g., family, school, community, health services) influences development. These systems exert reciprocal influence on one another. Development is determined by interactions of child and family.	Child's needs must be considered in context of the family and the environment.

Table 23-6 Using Erikson's Psychosocial Stages to Guide Development

Psychosocial Stage	Guidance
Basic trust and mistrust (0-2 years; infancy)	Parent can provide consistent nurturing to aid development of attitude of trust.
Autonomy vs. shame and doubt (2-4 years)	Parent should allow safe exploration of environment and encourage decision making.
Initiative vs. guilt (5-7 years)	Limits on child should be for protection of child, family, and society, and not random or condemning.
Industry vs. inferiority (8-12 years)	Caregiver must work with the school to ensure that child is achieving to his or her abilities and feeling sense of competence vs. inferiority.
Identity vs. role confusion (13-17 years)	Selection of career goal; establishment of relationship with opposite sex; independence from family should be encouraged by caregiver; failures to adapt in previous stages make this stage more difficult.
Intimacy vs. isolation (18-22 years)	Need to make personal and occupational commitment.

Although most children are able to crawl by 9 months of age and walk by 14.5 months, even severely delayed children follow the sequence of crawl, stand, and walk (Milani-Comparetti and Gidoni, 1967). This predictable sequence is dictated by building on previously learned skills, as well as by maturation of the central nervous system (CNS) (Springate, 1981). Before a critical stage in the maturation of the CNS, certain skills cannot be learned regardless of the intellectual potential or will of the child or parent. For example, because CNS control of the external anal sphincter is incomplete before 18 to 24 months of age, it is impossible to toilet-train even the most precocious toddler before this age.

Responses to stimuli proceed from generalized, symmetric, whole-body reflexes to discrete, cortically controlled, voluntary actions. Newborn reflexes can be thought of in terms of their role in survival of the individual; an example is the rooting reflex, which helps the newborn seek out nutrition. Voluntary movements develop as the child learns to control the environment.

Development proceeds in head-to-toe (cephalocaudal) and proximal-to-distal directions. Therefore, the infant bears weight on the arms before bearing weight on the legs. As proximal-to-distal progression occurs, the infant becomes more precise in fine-tuning the smaller muscles involved in reaching, grasping, and manipulating an object with his or her hand. Vocalization skills follow this pattern as well. A newborn infant vocalizes with "grunts" originating in the

Table 23-7 Temperament Characteristics and Profiles

Feature	Description
Characteristics	
Activity	Frequency and speed of involvement
Rhythmicity	Regularity of physiologic functions (e.g., hunger, sleep, elimination)
Approach/withdrawal	Immediate reaction of child to new stimuli
Adaptability	Degree of ease or difficulty with which child adjusts to new stimuli
Intensity	Energy level of responses, without regard to positive or negative quality of the response
Mood	Predominance of pleasant and friendly versus unfriendly behavior during waking
Attention span/ persistence	Length of time the child will engage in a single activity with or without interruption
Distractibility	Degree of ease with which extraneous stimuli interfere with child's task performance
Sensory threshold	Amount of external stimulation required to evoke a response
Profiles	
Easy (40% of children)	Regularity of biologic functions; positive approach responses to new stimuli; high adaptability to change; mild to moderately intense mood that is predominantly positive
Difficult (10% of children)	Irregularity of biologic functions; negative withdrawal responses to new stimuli; no or slow adaptability to change; intense expressions of mood that are predominantly negative
Slow to warm up (15% of children)	Negative responses of mild intensity to new stimuli, with slow adaptability with repeated contact; mild intensity of reactions

Modified from Chess S, Thomas A. Dynamics of individual behavior development. In Levine MD, Carey WB, Crocker AC (eds). Developmental-Behavioral Pediatrics. Philadelphia, Saunders, 1992, p 86.

chest. As proximal-to-distal maturation develops, vocalizations originate more distally in the larynx (cooing), glottis (guttural syllables, "ga"), tongue ("da"), and lips ("ba").

Delays in one developmental domain can impair development in another domain. For example, an 18-month-old infant with motor impairments secondary to spina bifida lacks the freedom to explore the environment to learn how two pieces of furniture are oriented in space. Likewise, delays in one developmental domain can impair the practitioner's ability to evaluate skills in other domains. A 4-year-old toddler with cerebral palsy might understand the concept of sorting by shape but lack the motor control to manipulate the shapes to pass a standardized test.

An outline of salient features of development in each domain based on age is presented in Table 23-8. This guide to normal development should be considered by the physician along with past history, parental concerns, clinical observations, and developmental screening in the ongoing surveillance of child development. Until chronologic age 2 years, the development of a premature infant should be judged on corrected age, that is, the chronologic age minus the number of weeks premature.

Developmental Screening in Young Children

Key Points

- Always refer the child to audiology if language is delayed.
- Never ignore parents' concerns.
- Suspect delays and refer early.
- Developmental screening, using parent report measures, is more accurate than clinical judgment.
- Autism usually manifests as language delay.

Every encounter between a physician and child involves developmental and behavioral issues. Attention to such matters can benefit every child. By monitoring development, the primary care physician has the opportunity to customize anticipatory guidance based on the child's current abilities and temperament (Sturner and Howard, 1997).

Additionally, the family physician has a responsibility to identify children with delayed development. Federal law (Individuals with Disabilities Education Act [IDEA]) mandates physicians to refer children with suspected delays to early intervention (birth to 3 years) or early childhood services (3 to 5 years). The specifics of these services vary from state to state but are free and individualized according to the child's and family's needs (AAP Committee on Children with Disabilities, 1999). As the professional with the most frequent—and sometimes only—contact with young children, the family physician is in the ideal position to detect possible developmental problems. Additionally, parents may feel more comfortable sharing concerns and seeking advice from a trusted physician.

Early detection of delays is important, because brain development is most malleable in the early years of life (Shonkoff and Phillips, 2000). Early intervention has been shown to be cost-effective, resulting in better intellectual, social, and adaptive behavior, increased high school graduation and employment rates, and decreased criminality and teen pregnancy (Gomby et al., 1995; Reynolds et al., 2001). Unfortunately, less than half of children with developmental difficulties are identified before kindergarten (Pelletier and Abrams, 2002).

Research shows that clinical impression alone is quite poor at detecting developmental delays (Glascoe, 2000). This has led the AAP to recommend routine monitoring (surveillance) at all preventive care visits and use of standardized developmental screening tests at 9, 18, and 24 or 30 months of age, with the addition of autism-specific screening at 18 and 24/30 months (AAP Council on Children with Disabilities, 2006). Newer screening tools based on parent report can facilitate fulfilling this recommendation. Parent report has been found to be a reliable way to identify children in need of further developmental assessment, particularly if the concerns are elicited and interpreted in a standardized manner (Glascoe, 2003).

Table 23-8 Developmental Milestones in Young Children

Age	Gross motor	Fine motor/Reflex motor	Social/Adaptive/ Cognitive	Language
Neonate	Flexed attitude, turns head side to side when prone without lifting, head sags if unsupported, body sags on ventral suspension	*Reflex:* Moro symmetric, grasp reflex, stepping reflex, suck reflex, placing reflex	Fixates on face or light, moves in cadence with sound	Alerts to voice
1 mo	Extends legs more, holds chin up briefly when prone, head lag persists	*Reflex:* Persistence of neonatal reflexes, tonic neck posture	Watches person, visually tracks to midline, begins to smile, body moves in cadence with voice	Throaty noises, range of cries to signal hunger, pain, etc.
2 mo	Raises head from prone position, sustains head in plane with body or ventral suspension, head lag on pull to sit	*Reflex:* Stepping reflex fades	Smiles on social contact, attracts to voice	Coos
4 mo	Head up to vertical axis in prone position, bears weight on arms, extends legs, symmetric posture with hands in midline in supine position, no head lag on pull to sit, pushes with feet in standing position, holds head erect in sitting position	*Fine:* Grasps and attains object, brings to mouth *Reflex:* Grasps, Moro, tonic neck fade; downward parachute present	Laughs out loud, voices displeasure if contact is broken, excites at sight of food, regards a small pellet	Vowel sounds, visually searches for speaker
6 mo	Sits alone with rounded back, rolls over, pivots, creeps	*Fine:* Rakes at pellet, transfers, turns body to reach *Reflex:* Sideways parachute present	Prefers mother, responds to emotion, imitates banging, visually follows dropped objects	Polysyllabic babble, blows bubble ("raspberry"), laughs
9 mo	Sits with erect back, crawls, walks holding both hands, pulls to stand, can get to sitting position	*Fine:* Pokes with forefinger, uses assisted pincer grasp Reflex: Forward (7 mo) and backward parachute present, plantar grasp fades	Plays "peekaboo," "pat-a-cake"; waves bye-bye; finds an object after watching it hidden; may cry at sight of unfamiliar person	Responds to some verbal commands: "no"; imitates some sounds; uses "mama," "dada" nonspecifically
12 mo	Cruises holding on, stands alone, may take several steps, walks holding hand	*Fine:* Neat pincer grasp, releases on request; puts 2 cubes in cup, pellet in bottle	Plays ball, adjusts posture when dressing, drinks from a cup, imitates activity (talks on toy phone)	1-2 true words, symbolic gestures (e.g., shakes head "no"), points to indicate wants
15 mo	Walks alone, crawls up stairs, walks backward, rises after stooping	*Fine:* Dumps pellet from bottle or draws line with crayon when demonstrated, scribbles spontaneously, stacks 2 cubes	Feeds self with utensils, performs simple household tasks (pick up toys), hugs parent	Points to body parts, jargons, follows 1-step command without gestures
18 mo	Runs stiffly, sits on small chair, walks up stairs with hand holding rail	*Fine:* Tower of 4 cubes, dumps pellet on request, imitates line with crayon	Feeds self with utensils; kisses parent with pucker; explores drawers, wastebaskets; removes garment; seeks help when in trouble	10 words, says "no," names pictures, points to 1 body part
24 mo	Runs well; walks up and down stairs, one at a time; jumps in place, climbs on furniture; kicks ball	*Fine:* Tower of 7 cubes, "train" of 4 cubes; imitates vertical and circular crayon stroke; imitates folding paper	Listens to story with pictures, helps to undress, dresses with help, parallel play, uses spoon well	30-50 words; 2- or3-word sentences; uses pronouns, sometimes incorrectly; relates recent experience; speech 50% intelligible
36 mo	Alternates feet climbing stairs, stands on one foot briefly, broad jumps with both feet, pedals tricycle, throws ball overhand	*Fine:* Tower of 10 cubes, imitates "bridge" of 3 cubes, imitates cross, copies circle, attempts to draw person	Knows age and gender, counts 3 objects, repeats 3 serial numbers, understands turn-taking, washes and dries hands, helps with dressing	States full name; uses complete sentences; speech 75% intelligible to stranger; uses plurals, past tense, pronouns correctly

Continued

Table 23-8 Developmental Milestones in Young Children—cont'd

Age	Gross motor	Fine motor/Reflex motor	Social/Adaptive/ Cognitive	Language
48 mo	Hops on one foot, throws ball overhand, balances on each foot 2-3 seconds	*Fine:* Uses scissors to cut out pictures; copies cross, square; draws man with head and 2-4 body parts (pairs count as 1 part); tells a story	Counts 4 objects correctly, group play with role playing, toilets independently, dresses with little supervision	—
60 mo	Skips, balances on each foot 4-5 seconds	*Fine:* Copies triangle, 8- to10-part person	Counts 10 objects, prints first name, domestic role playing, asks meaning of words, dresses and undresses independently	Uses complete sentences, names 4 colors, repeats 10-syllable sentence, follows 3-stage command

Compiled from Vaughn VC, Litt IF. Growth and development. In Behrman RE, Kliegman RM, Nelson WE, Vaughn VC (eds): Nelson Textbook of Pediatrics, 14th ed. Philadelphia, Saunders, 1992, pp 41-42.

Parent report measures can be used in a variety of ways. They can be completed in the waiting room, sent out to be returned at the next appointment, or completed via an interview, either in person or by telephone with a staff member. It is helpful to have a staff member routinely inquire if the parents would like someone to go over the measure with them; this ensures that literacy or language issues are not barriers to screening. Even if staff administer the parent report, parent report measures are the most accurate and time-effective and cost-efficient method of developmental screening currently available. Accurate screening tools with acceptable sensitivity and specificity (70%-80%) are listed in Table 23-9. Physicians can bill for screening, although reimbursement varies widely (Glascoe, 2003). More information regarding developmental screening, including coding and billing aspects, can be found at the Developmental Behavioral Pediatrics website.

Table 23-9 Developmental Screening Tools

Tool	Age range	Time	Source
Ages and Stages Questionnaire	0-60 mo	~7 min	Paul H. Brooks, Publishers www.pbrookes.com
Child Development Inventories	3-72 mo	~10 min	Behavior Science Systems*
Parents' Evaluations of Developmental Status (PEDS)	Birth-8 yr	~2 min	Ellsworth & Vandermeer www.pedstest.com

*PO Box 580274, Minneapolis, MN 55458.

Evaluation of Developmental Delay

The estimated prevalence of developmental delay is 10%. Some children present with delays in multiple areas, or global developmental delay. *Global developmental delay* is defined as significant delay in two or more areas of development (gross or fine motor, speech and language, cognition, social and personal, and activities of daily living). The more severe the delay, the more likely a cause can be determined (Roberts et al., 2004). Once significant delay is recognized, parents are often eager to know the cause. The family physician can be instrumental in referring for appropriate intervention, as well as overseeing an initial workup.

Although many physicians refer to specialists (e.g., developmental pediatricians, neurologists) for further evaluation, these specialists may have long waiting lists. Some aspects of the workup can easily be ordered by the family physician. Guidelines from the American Academy of Neurology and Child Neurology Society for the workup of the child with global developmental delay are shown in Table 23-10 (Shevell et al., 2003). The guidelines listed in the table are evidence based and could be readily used by family physicians to start the workup while waiting for a specialist appointment. Results of the workup may facilitate more specific referrals. Even if not globally delayed, all children with language delay should have a formal audiology assessment to rule out hearing impairment.

Autism Screening

Autism is a developmental disability involving difficulties with communication and social interaction as well as unusual and restricted behavior. The prevalence of autism appears to be rapidly increasing, for reasons not yet clear (Fombonne, 2003; Yeargan-Allsopp et al., 2003). The latest prevalence estimates are 1.1 per 100 children (Kogan et al., 2009). This makes it essential that any primary care physician seeing children be able to recognize signs and symptoms suggesting autism and refer for further evaluation promptly. Early diagnosis allows earlier initiation of intensive behavioral intervention, which has been shown to be very helpful (Butter et al., 2003). Table 23-11 lists "red flags" that should prompt referral for further evaluation

Table 23-10 Evaluation of Global Developmental Delay

Indication	Workup
Everyone	
First-line workup	Comprehensive history and physical Hearing and vision screening Metabolic studies and T_4 (if newborn screen results not known) EEG if symptoms of seizures Screen for autism if language delayed
Positive family history	
Genetic, metabolic, or CNS disorder	Test for specific condition
Nonspecific developmental delays	Chromosomes and fragile X
Signs or Symptoms present	
Specific genetic disorder	Specialized genetic testing
Hypothyroidism	Thyroid studies
CNS abnormality	MRI
Other	
Possible lead exposure	Lead level
Regression of skills or parental consanguinity	MRI, chromosomes, fragile X, metabolic testing, EEG, genetics evaluation
No specific signs/ symptoms (stepwise in order)	MRI, chromosomes, fragile X, metabolic testing, Rett's syndrome testing

Data from Roberts G, Pafrey J, Bridgemohan C. A rational approach to the medical evaluation of a child with developmental delay. Contemp Pediatr 2004;21:76-100; and Shevell M, Asheval S, Donley D, et al: Practice parameter: evaluation of the child with global developmental delay. Neurology 2003;60:367-380.
CNS, Central nervous system, *EEG,* electroencephalogram; *MRI,* magnetic resonance imaging.

Table 23-11 Red Flags and Absolute Indications for Immediate Evaluation

Age	Sign
12 months	No babbling No pointing No gestures
16 months	No single words
24 months	No 2-word phrases
Any age	Loss of language or social skills

Modified from Filipek PA, Accardo PJ, Ashwal S, et al. Practice parameter: screening and diagnosis of autism. Neurology 2000;55:468-479.

(Filipek et al., 2000). A formal audiology evaluation is also indicated, as well as lead screening if the child has pica. It is important to keep in mind that most young children with autism are presented to their physician with the chief complaint of language delay. The physician should consider autism in the differential diagnosis for a child with language delay.

Assessing Development in the School-Age Child

Developmental surveillance in a school-age child should focus on identification of unsuspected learning problems, including attention-deficit/hyperactivity disorder (ADHD), mild mental retardation, and learning disabilities, as well as detection of emotional problems such as anxiety, depression, or school phobia. Emotional problems can be screened for using the Pediatric Symptom Checklist (PSC). The PSC is a one-page questionnaire that is relatively easy to administer and interpret during routine well-child care. Positive results should prompt the physician to probe further with questions regarding school, friends, family, moods, and activities. Referrals to other professionals can then be made if necessary. More information regarding the PSC is available on the Massachusetts General Hospital PSC website.

Asking the child and parent about school progress and reviewing report cards and standardized testing results are simple ways for the physician to monitor school progress. Checklists completed by the parent and teacher can provide further information about specific issues (e.g., attention) or behavior in general (Table 23-12).

Federal law (IDEA) mandates a free and appropriate education for all children, regardless of handicapping condition. Therefore, if a child is suspected to have a learning disability, the school is obligated to evaluate and provide necessary services, free of charge (AAP, 1999). The parent should be advised to request the evaluation, called the Multi-Factored Evaluation (MFE), in writing. Federal law requires the MFE be done within 60 days. The MFE consists of standardized assessments of various aspects of learning. Once the MFE is completed, school personnel meet with the parents to review testing results and determine if the child is eligible for special education services. These services may occur in the regular classroom or in a separate one, although the law requires that services be provided in the least restrictive environment. The goal is to keep children with their typical peers as much as possible.

Once a child is deemed eligible for services, an individualized education plan (IEP) is developed. Parent input is required as part of the process. If the parent disagrees with the suggested IEP, the parent has the right to due process. An explanation of due process must be given to all parents at the beginning of the MFE/IEP process. Once developed, the IEP is updated annually. Parents should receive progress reports throughout the school year. They may request interim changes to the IEP if needed. Reevaluations are conducted at least every 3 years (Henderson, 2001).

All this is often overwhelming for families. The physician can assist by providing simple explanations of the process as well as periodically reviewing the IEP and helping parents understand it. The physician should also encourage parents to become knowledgeable advocates for their child.

Some children have conditions that can benefit from extra assistance but that do not qualify as handicaps according to

Table 23-12 School-Age Checklists

Purpose	Ages	Description	Website/ Contact
Pediatric symptom checklist			
Brief screening for behavioral concerns	4-16 years	35 items completed by parents	psc.partners.org
Child behavior checklist			
In-depth screening for behavioral/ emotional problems	Separate forms for 1-5 years and 6-18 years	Parents, teachers, caregivers, youth (11-18 yr); 99-118 items depending on form used	www.aseba.org
Conners scales			
More specific for ADHD and learning difficulties	3-17 years	Parent, teacher, youth (12-17 yr); short and long forms, 27-87 items	www.pearson assessments.com
Clinical attention problem scale			
Brief, specific for attention and overactivity symptoms	6-12 years	24-item checklist Teacher version	www.dbpeds.org/handouts
Vanderbilt			
Symptoms of ADHD; common comorbidities	6-12 years	Teacher/parent; initial (43-55 items) and follow-up (26 items) forms	http://www.nichq.org/NIaCHQ/Topics/ChronicConditions/ADHD/Tools/

ADHD, Attention-deficit/hyperactivity disorder.

the IDEA. Conditions such as ADHD are covered by Section 504 of the Rehabilitation Act of 1973 (Henderson, 2001). The qualifications are broader under this law, allowing children with less serious issues to still receive special services. This assistance, though helpful, is often less extensive than if the child qualified for an IEP.

Regardless of the issues, communication with school personnel is often helpful. Teacher rating scales (general or specific for certain concerns) may be useful, as well as direct communication, either verbally or in writing. Such dialogue also illustrates for families the advantages of cooperative teamwork with school personnel. It is always important for physicians to follow the Health Insurance Portability and Accountability Act (HIPAA) guidelines, obtain written permission from parents, and show discretion ("need to know") when sharing information with schools.

Immunizations

Key Points

- Avoid missed opportunities to vaccinate by reviewing the child's immunization record at every visit.
- Schedule adolescents for an immunization visit at age 11 to 12 years to catch up on missed vaccines and administer new ones.
- Provide current vaccine information statements to parents or guardians for each vaccine given during the visit.

Indications and Contraindications

Routine immunizations are essential for the control and prevention of previously common childhood infectious diseases. During 2008, more than 76% of U.S. children age 19 to 35 months received 4 or more doses of diphtheria, tetanus toxoids, and pertussis vaccines (DTP/DT/DTaP); 3 or more doses of poliovirus vaccine; 1 or more doses of any measles-containing vaccine; at least 3 doses of *Haemophilus influenzae* type b (Hib) vaccine; at least 3 doses of hepatitis B vaccine; and at least 1 dose of varicella vaccine (CDC, 2009). However, there is still considerable disparity in immunization rates among states and communities. Young children might not be immunized at the recommended age because of missed opportunities to vaccinate, deficient health care delivery in the public sector, lack of insurance, inadequate access to medical care, lack of public awareness about the necessity for immunizations, or concern about potential or alleged adverse effects of immunizations. Both AAFP and AAP endorse the Childhood and Adolescent Immunization Schedules (see **eTables 23-3** to **23-5** online) (SOR: A).

Parents or guardians should be questioned about possible contraindications, precautions, and any previous adverse events in response to vaccine administration (see **eTable 23-6**). They should be informed about the potential benefits and risks of the vaccine and the risks of the natural disease should the immunization not be given. Health care providers administering any vaccine covered by the National Vaccine Compensation Injury Act or purchased by federal contract must provide the most current *vaccine information statements* (VISs) detailing the potential benefits and risks of each vaccine to the parents or guardians each time that vaccine is given (AAP Red Book, 2009, 5-6). Copies of VISs may be obtained from the CDC (www.cdc.gov/vaccines/pubs/VIS/default.htm), the Immunization Action Coalition (www.immunize.org), or state health departments.

Vaccines have become "victims of their own success" (Cooper et al., 2008). Because they no longer are confronted with the presence of vaccine-preventable diseases, some individuals, parents, and groups have become more concerned about the alleged adverse effects of immunization. A Danish study is one of many that has confirmed the effectiveness of vaccines such Hib and pertussis and did not find an association of MMR or thimerosal-containing vaccines with autism spectrum disorders (Hviid, 2006). Physicians serve as the primary source of information about immunizations, and the family physician should explain the potential benefits and risks of immunizations to parents and older patients such as adolescents (Gellin et al., 2000). If parents still do not wish

to have their child vaccinated, further information and documentation may be obtained at http://www.aap.org/immunization/pediatricians/pdf/RefusaltoVaccinate.pdf.

Before administering vaccines, the physician should ask about the child's current state of health, as well as that of other family members. An immunosuppressed member of the household might contraindicate the administration of certain live-virus vaccines, such as nasal live, attenuated influenza vaccine (LAIV). Minor febrile illnesses are not contraindications to vaccine administration. General contraindications are a previous anaphylactic reaction to the specific vaccine or a severe hypersensitivity reaction to vaccine constituents such as gelatin or antibiotics such as neomycin, streptomycin, or polymyxin B. Latex allergy may also be a contraindication if the vaccines are supplied in vials or syringes containing natural rubber (AAP Red Book, 2009, 848-853).

Vaccine Administration

Most immunizations must be given by deep intramuscular (IM) or subcutaneous (SC) injection. IM injections should be given in the anterolateral thigh for infants or the deltoid muscle of the arm for older children. The sciatic nerve may be injured by deep intragluteal injections. Although acetaminophen (paracetamol) administered for 24 hours has been demonstrated to decrease mild to moderate reactions, such as temperature of 38° C (100.4° F) or greater, it may reduce antibody responses to some vaccine antigens (Prymula et al., 2009). Topical local anesthetics, sweet-tasting solutions, and breastfeeding may decrease injection pain for childhood immunizations (HELPinKIDS, 2009).

Immune responses may be impaired if two live-virus vaccines are given within 28 days of each other. Live-virus vaccines must be given simultaneously or at least 4 weeks apart (AAP Red Book, 2009, 22). If immune globulin (IG) is given, live-virus vaccine administration should be delayed for up to 3 to 6 months to allow optimal antibody production (AAP Red Book, 2009, 448). An even longer period may be required if high doses of intravenous (IV) gamma globulin have been given.

Schedule of Immunizations

The recommended schedule for childhood and adolescent immunizations are given online in **eTables 23-3** to **23-5**. A lapse in the immunization schedule does not require starting over the entire series. Doses of any vaccine should not be divided or reduced, because this can result in an inadequate response. Premature infants should receive the same vaccine dose, usually at the same chronologic age as full-term infants. Most vaccines can be administered simultaneously using separate syringes at separate sites (AAP Red Book, 2009, 33).

Poliovirus Vaccine

The last indigenous case of wild-type poliomyelitis in the United States occurred in 1979, and the last identified imported case occurred in 1993. From 1980 to 1996, there were approximately eight cases per year of vaccine-associated paralytic poliomyelitis (VAPP) caused by oral poliovirus vaccine (OPV) in the United States. In 2000, inactivated poliovirus vaccine (IPV) was recommended for all routine childhood polio vaccinations in the United States, and only one case of VAPP was imported from Central America in 2005 (AAP Red Book, 2009, 541).

Measles, Mumps, and Rubella Vaccine

The measles-mumps-rubella (MMR) vaccine should be given to children 12 to 15 months of age. The second MMR or measles-mumps-rubella-varicella (MMRV) vaccine is recommended before school entry at 4 to 6 years of age, but it can be given earlier in the event of an outbreak or as a requirement for travel, provided the second dose is given at least 28 days after the first. Physicians should review their records to ensure that all children receive the second MMR or MMRV by 11 to 12 years of age. Children may be immunized with MMR even if there is a pregnant or immunosuppressed family member, because the vaccine viruses are not transmitted (AAP Red Book, 2009, 47).

Haemophilus Influenzae Type b Conjugate Vaccine

The use of *H. influenzae* type b (Hib) conjugate vaccines has lowered the U.S. incidence of invasive Hib disease in children younger than 5 years of age by 99%. Vaccines currently available in the United States, such as HbOC (HibTITER), PRP-OMP (PedvaxHIB), and PRP-T (ActHIB, OmniHIB), are given beginning at age 2 months. ActHIB reconstituted with Tripedia as Trihibit is licensed only for the fourth dose of Hib and DTaP, while PRP-T (Hiberix) is licensed for use as a booster in children 15 months through 4 years of age (CDC,2009). PRP-OMP-HepB (Comvax) is administered at 2, 4, and 12 to 15 months of age and DTaP-IPV/PRP-T (Pentacel) at 2, 4, 6, and 15 to18 months of age (AAP Red Book, 2009, 318-321).

The schedule of administration varies according to the type of vaccine, as shown in **eTables 23-3** and **23-4.** Children age 15 to 59 months of age usually need only 1 dose of any Hib conjugate vaccine. Children with conditions predisposing to invasive Hib disease, such as sickle cell anemia, asplenia, human immunodeficiency virus (HIV) infection, chemotherapy for malignancies, and immunologic impairment, are given 2 doses of vaccine 2 months apart. Children age 60 months or older are generally not vaccinated unless they also have a chronic illness associated with an increased risk of Hib disease and require 2 doses of Hib conjugate vaccine 1 to 2 months apart (AAP Red Book, 2009, 321).

Acellular Pertussis Vaccine

Acellular pertussis vaccines combined with diphtheria and tetanus toxoids (DTaP) are used in the United States for the primary and booster doses in children. These vaccines (DAPTACEL, Infanrix, Tripedia) are immunogenic and produce fewer adverse local and systemic reactions, such as fever and irritability, than do whole-cell pertussis vaccines. Whenever possible, the same DTaP vaccine should be used throughout the entire vaccination series, because there are no data on safety or efficacy when different formulations of these vaccines are interchanged. However, if the previously used vaccine is not known or is unavailable, any of the DTaP vaccines licensed for use in children may be given to complete the immunization

series. Combination vaccines such as DTaP-IPV-HepB (Pediarix) and DTaP-IPV-Hib (Pentacel) are licensed for use as the first 3 doses and first 4 doses, respectively, of their components, whereas DTaP-IPV (Kinrix) is licensed only as the booster fifth dose of DTaP and fourth dose of IPV at ages 4 to 6 years (AAP Red Book, 2009, 508, 510).

Two vaccines containing reduced concentrations of diphtheria toxoid and pertussis antigens combined with tetanus toxoid (Tdap) are now licensed for use in adolescents and adults (Boostrix and ADACEL). The vaccines are recommended for adolescents 11 to 18 years of age in place of the Td booster to decrease the reservoir of *Bordetella pertussis* in this population. Increasing reports of pertussis in many U.S. states has led to a recent recommendation to give one dose of these vaccines to children 7 to 10 years of age who are incompletely immunized against pertussis.

Rotavirus Vaccine

Rotavirus is responsible for up to 500,000 deaths from diarrhea worldwide and 20 to 60 U.S. deaths in each year. Before the introduction of rotavirus vaccines (RV1 or Rotarix, RV5 or RotaTeq), rotavirus caused 3 million infections per year in the United States, resulting in more than 400,000 physician visits and 55,000 to 70,000 hospitalizations per year (CDC Pink Book, 2009, 245-256). RV1 is given as 2 oral doses at 2 and 4 months of age, and RV5 is given as 3 oral doses at 2, 4, and 6 months of age. The minimum interval between doses of either vaccine is 4 weeks. Neither vaccine should be started for infants age 15 weeks, 0 days or older, and all doses must given by 8 months, 0 days of age. The vaccine-specific package insert should be seen for full prescribing indications and contraindications.

Varicella Vaccine

Two SC doses of monovalent varicella (VZV) vaccine or MMRV are indicated in children age 12 months through 12 years. The doses should be separated by at least 3 months, with the second dose routinely recommended at age 4 to 6 years before kindergarten or first grade. Persons 13 years or older who do not have evidence of immunity to varicella should receive 2 doses of VZV vaccine at least 28 days apart because MMRV is not licensed in this age group. A second dose of varicella vaccine should be given to people who previously received only 1 dose. The vaccine is generally contraindicated in pregnant women, immunodeficient persons, or those receiving high doses of systemic corticosteroids (≥20 mg/day of prednisone or equivalent) for 14 days or more. However, VZV vaccine may be considered for HIV-infected patients with a CD4+ T-lymphocyte count of 15% or greater. Vaccine-strain VZV has been rarely transmitted, and vaccinated patients who develop a rash should avoid contact with immunocompromised persons (AAP Red Book, 2009, 724-726). Zoster vaccine is not interchangeable with varicella vaccine and is not used in children.

Hepatitis A Vaccine

Hepatitis A virus (HAV) is usually transmitted person to person through the fecal-oral route and by ingestion of contaminated food or water, but it has rarely been transmitted by transfusion of blood or blood products. Two HAV inactivated vaccines, HAVRIX and VAQTA, are licensed in the United States for use in children age 1 year and older. TWINRIX is a combined hepatitis A and hepatitis B vaccine licensed for use in persons at least 18 years old. Physicians should consult the package insert for proper dosing because there are different formulations of these vaccines.

Childhood vaccination against HAV is recommended for all U.S. children 12 to 23 months of age and should be considered for unimmunized children ages 2 to 18 years old. Indications for immunization with hepatitis A vaccine include travel to or residence in countries or areas endemic for hepatitis A, residence in Native American or Alaskan Native communities with high rates of HAV infection, persons who receive clotting-factor concentrates, persons with chronic liver disease, injection drug users (IDUs), men who have sex with men (MSM), and people at risk of occupational (e.g., handlers of primates), household, and sexual exposure (AAP Red Book, 2009, 329-337).

Hepatitis B Vaccine

Hepatitis B virus (HBV) is endemic in Southeast Asia, the Pacific Islands, China, Africa, parts of the Middle East, and the Amazon Basin. More than 350 million people worldwide have chronic HBV infection. Although transmission in U.S. children is less likely because of high coverage with HBV vaccine, the risk of perinatal transmission of HBV from an infected mother to her infant varies from 10% to as high as 90%, depending on whether the mother is negative or positive for hepatitis B e antigen (HBeAg) (CDC Pink Book, 2009, 99-122).

Immunization with the pediatric formulations of hepatitis B vaccine is recommended for all infants soon after birth or before hospital discharge. HBV vaccine should be given to newborns of mothers positive for hepatitis B surface antigen (HBsAg) or infants of mothers whose HBsAg status is unknown. An infant born to an HBsAg-positive mother should receive an initial dose of 5 μg Recombivax HB or 10 μg Engerix-B and 0.5 mL of hepatitis B immune globulin (HBIG) IM at separate sites within 12 hours of birth. Repeat vaccine doses should be given at ages 1 month and 6 months. For infants of HbsAg-negative mothers, the combination DTaP-HBV-IPV (Pediarix) or PRP-OMP-HBV vaccine (Comvax) may also be used, beginning at 6 to 8 weeks of age. Practitioners should consult the package insert for the appropriate dose according to the formulation and intended use. Any adolescents who have not yet received HBV vaccine should also be immunized with 2 doses at least 4 weeks apart, with a third dose 4 to 6 months after the second dose (CDC Pink Book, 2009, 99-122).

Hepatitis B vaccine should be given to susceptible high-risk children or adults who are institutionalized; those who have end-stage renal disease, chronic liver disease, or HIV infection; those who receive clotting-factor concentrates; those who have an HIV-infected household or sexual contact; MSM; IDUs; and adoptees from or long-term travelers to countries endemic for hepatitis B (AAP Red Book, 2009, 337-356).

Conjugate Pneumococcal Vaccine

The 13-valent conjugate pneumococcal vaccine (PCV13) covers 64% of the serotypes that cause invasive pneumococcal disease in children younger than 5 years old. The vaccine

stimulates effective antibodies to all 13 serotypes in over 90% of recipients after three doses and is given to infants at 2, 4, 6, and 12 to 15 months of age. Children 7 to 11 months old require 2 doses 2 months apart, followed by a third dose at 12 to 15 months of age (2 or more months later). Children 12 to 23 months old require 2 doses 2 months apart. Only 1 dose is required for all healthy children 24 to 59 months of age. Children age 24 to 71 months at high risk for invasive pneumococcal disease should receive 2 doses of vaccine at least 8 weeks apart if they have not been previously immunized (CDC, 2010).

Influenza Vaccine

Routine annual immunization with trivalent inactivated influenza (TIV) vaccine is now recommended for all persons 6 months of age and older, including these with high-risk conditions such as HIV, chronic pulmonary (including asthma), cardiac, renal, or metabolic diseases; those receiving immunosuppressive or long-term aspirin therapy; those who have hemoglobinopathies, and those with any condition (e.g., cognitive dysfunction, seizure disorder, neuromuscular disorder) that could compromise respiratory function. TIV vaccine is also recommended for pregnant women and persons who are household contacts of high-risk patients, including health care workers. Several TIV products are now available, and providers should read the prescribing information regarding the appropriate age and dosing of these vaccines. Live, attenuated influenza vaccine (LAIV) is approved for use in healthy persons age 2 through 49 years and not pregnant. LAIV should not be used in persons with asthma or those in close contact with severely immunosuppressed hospitalized patients receiving care in a protected environment. Neither vaccine should be given to persons with a history of severe allergy to egg or any other vaccine component (CDC Pink Book, 2009, 141-154).

Conjugate Meningococcal Vaccine

Tetravalent meningococcal polysaccharide-protein conjugate vaccine (MCV4, Menactra, Sanofi Pasteur; and Menveo, Novartis) has been licensed in the United States for use in persons 2 to 10 years old and 11 to 55 years old. Routine immunization of all children age 11 to 18 years and especially 11 to 12 years at a health-care visit is recommended. The vaccines contain serogroups A, C, Y, and W-135, as does the current meningococcal polysaccharide vaccine (MPSV4). Serogroups C, Y, and W-135 cause 75% of all cases of meningococcal disease in persons older than 11 years in the United States (Bilukha and Rosenstein, 2005). Neither vaccine is protective against serogroup B, which accounts for most of the remaining cases. Persons 2 to 55 years with terminal complement or properdin deficiencies, anatomic or functional asplenia, and HIV should receive two doses 2 months apart (CDC, 2011). Travelers to countries with hyperendemic or epidemic *Neisseria meningitidis* (e.g., sub-Saharan Africa, Mecca during the Hajj) should also be immunized with MCV4 (CDC Pink Book, 2009, 177-188). College freshmen students living in dormitories have a higher risk of meningococcal infection than students living off campus and should be immunized with MCV4. MCV4 is given to all U.S. military recruits (AAP Red Book, 2009, 461-463). Revaccination is recommended for persons at prolonged increased risk who were vaccinated at age 7 years or older and were vaccinated 5 years previously, or for those at ages 2 to 6 years old and vaccinated 3 years previously (CDC, 2009). A booster dose of MCV4 is also recommended for adolescents at age 16 years who received their previous dose at age 11 or 12 years and at age 16 through 18 years for those who received their first dose at age 13 through 15 years (CDC, 2011).

Human Papillomavirus Vaccine

Although most human papillomavirus (HPV) infections spontaneously resolve, high-risk HPV types are found in 99% of cervical cancers with types 16 and 18, accounting for about 70% of cervical cancers worldwide. HPV is also believed to account for 90% of anal cancers; 40% of vulvar, vaginal, or penile cancers; and 12% of oral and pharyngeal cancers. Types 6 and 11 HPV account for 90% of genital warts and laryngeal papillomatosis. The bivalent HPV (types 16, 18) vaccine (Cervarix) and the quadrivalent HPV (types 6, 11, 16, 18) vaccine (Gardasil) are licensed for use in U.S. females age 10 to 25 and 9 to 26 years, respectively. Both are recommended for routine vaccination at age 11 or 12 years and are ideally given before onset of sexual intercourse. The bivalent HPV vaccine is given in a 3-dose series at time 0, 1, and 6 months and the quadrivalent HPV vaccine in a 3-dose series at time 0, 2, and 6 months, with the third dose following the first dose by at least 24 weeks (CDC Pink Book, 2009, 123-133). These vaccines are prophylactic only for the HPV types they contain and do not treat preexisting infection with these HPV types. They may be given at the same visit at different sites with the MCV4 and Tdap vaccines. The FDA (2009) has also approved the quadrivalent HPV vaccine for use in males 9 to 26 years old to prevent genital warts.

Special Clinical Situations

Children who are immunocompromised or infected with HIV usually should not be given live-virus vaccines. However, measles can cause severe disease and death in symptomatic HIV-infected patients. MMR (but not MMRV) is recommended at age 12 months for HIV-infected children with CD4+ T-lymphocyte counts of 15% or greater. The second dose can be given 28 days later to improve the immune response. Children with age-specific low CD4+ counts should not be given measles virus–containing vaccine (AAP Red Book, 2009, 447-455) All HIV-infected children or children of unknown status born to HIV-infected women should receive immune globulin at 0.5 mL/kg to a maximum dose of 15 mL, regardless of vaccination status, if exposed to wild-type measles. HIV-infected children are also at increased risk from complications of chickenpox and zoster, and those children with CD4+ counts of at least 15% should receive two doses of varicella vaccine 3 months apart. The MMRV vaccine is not used in this situation (AAP Red Book, 2009, 726).

Conjugate pneumococcal vaccine (PCV13) is recommended for all children younger than 60 months and children 24 to 71 months who have high-risk conditions such as sickle cell disease, functional or anatomic asplenia, HIV infection, other immune deficiencies or immunosuppressive therapies, chronic cardiac or pulmonary disease, chronic renal

insufficiency, diabetes mellitus, cerebrospinal fluid leaks, or cochlear implants. High-risk children who have received 4 doses of PCV13 should also receive 1 dose of the 23-valent polysaccharide pneumococcal vaccine (PPSV23, Pneumovax-23) at 24 months. Children 24 to 71 months old who have received less than 3 doses of PCV13 should receive 2 doses of PCV13 followed by 1 dose of PPSV23 at 8 weeks later. Immunosuppressed children and those with sickle cell disease or functional asplenia should receive a second dose of PPSV23 vaccine 5 years after the first dose (AAP Red Book, 2009, 524-535).

National Childhood Vaccine Injury Act

The National Childhood Vaccine Injury Act of 1986 was passed to provide compensation for children inadvertently injured by any of the routinely recommended childhood vaccines and to provide liability protection for manufacturers and for health care providers who administer the vaccines. The intent of the law is to ensure a stable supply of vaccine and allow routine immunizations to continue. The physician or other health care provider must maintain permanent documentation of the date, vaccine type, manufacturer, lot number, and name, address, and title of the person administering the vaccine. A list of reportable but not necessarily compensable events is available from the Health Resources and Services Administration. Significant adverse events should be reported to the Vaccine Adverse Event Reporting System (VAERS) at 1-800-822-7967 or www.vaers.hhs.gov.

Acknowledgment

This chapter incorporates some material that was written by Lorraine M. Fay, MD, for this chapter in the 6th edition of *Textbook of Family Practice.*

KEY TREATMENT

Administer all recommended or required immunizations, except when true contraindications or precautions are present or the immunizations are refused by the parent or patient (AAP Red Book, 2009; Hviid, 2006) (SOR: A).

Key Resource

Centers for Disease Control and Prevention. Atkinson W, Wolfe S, Hamborsky J, McIntyre L (eds). Epidemiology and Prevention of Vaccine-Preventable Diseases. Pink Book. 11th ed. Washington, DC, Public Health Foundation, 2009, pp 123-133, 141-154, 177-188. Inexpensive reference from CDC that is updated yearly, covering nuts and bolts of vaccine-preventable diseases and immunizations.

References

The complete reference list is available online at www.expertconsult.com.

Web Resources

www.aan.com
American Academy of Neurology; practice parameters for screening and diagnosis of autism and evaluation of developmental delay.

www.aap.org
American Academy of Pediatrics; good general information regarding health care for children and access to guidelines for developmental screening and other topics.

www.cdc.gov/growthcharts/clinical_charts.htm
National Center for Health Statistics; growth charts for female and male development.

www.cdc.gov/ncbddd/child/screen_provider.htm
Centers for Disease Control and Prevention; developmental screening for health care providers; excellent information about child development and screening with helpful links and patient material.

www.cdc.gov/vaccines/pubs/VIS/default.htm
Centers for Disease Control and Prevention, National Immunization Program; vaccine information statements.

www.dbpeds.org
Developmental Behavioral Pediatrics; wealth of information about developmental screening and other topics related to child development and behavior.

www.hrsa.gov/vaccinecompensation/table.htm
Health Resources and Services Administration, National Vaccine Injury Compensation Program, National Childhood Vaccine Injury Act; vaccine injury table lists potentially compensable vaccine adverse events.

www.immunize.org/vis
Immunization Action Coalition; vaccine information statements.

http://psc.partners.org
Massachusetts General Hospital, Pediatric Symptom Checklist; free access and instructions for use and scoring.

www.mypyramid.gov
US Department of Agriculture MyPyramid; allows development of a personalized meal plan based on age, gender, and activity level.

www.hhs.gov/ocr/hipaa/US Department of Health and Human Services, Office for Civil Rights, Health Insurance Portability and Accountability Act (HIPAA).

www.vaers.hhs.gov Vaccine Adverse Event Reporting System (VAERS); individuals, health care providers, and manufacturers may report vaccine-associated adverse events; this does not prove causation.