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CLINICAL REVIEW

Developmental assessment of children

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Developmental assessment is the process of mapping a child's performance compared with children of similar age. The comparison group is obtained from a representative sample of the population that the child comes from. Several factors contribute to performance varying greatly between different population groups.[1] In a multicultural society it can be challenging to find appropriate benchmarks for these standards.

This article reviews the literature on the assessment of child development. It aims to highlight what normal developmental parameters are, when and how to assess a child, and when to refer for specialist assessment.

What is child development?

Development is the process by which each child evolves from helpless infancy to independent adulthood.

Growth and development of the brain and central nervous system is often termed psychomotor development and is usually divided into four main domains:

- Gross and fine motor skills
- Speech and language
- Social and personal and activities of daily living
- Performance and cognition.

Fetal brain development starts by the fourth week of gestation and progresses rapidly throughout intrauterine life and early childhood. Brain development—the target of developmental surveillance and screening—reflects neurological maturation. It consists of a complex process of cell growth, migration, connection, pruning, and myelination, and it persists through at least the second decade. This fundamental phenomenon, which determines brain development, is a preprogrammed process that occurs in all children.

What is normal development?

The pattern of development is remarkably constant, within fairly broad limits, but the rate at which goals are achieved varies from child to child. Skills are acquired sequentially, with one goal acquired after another. Later goals often depend on achievement of earlier goals within the same field—for example, children must learn to sit independently before they can stand and then walk.

Descriptions of normal development, linked to the ability to perform a particular task at a particular age, relate to the performance of the average child. The acquisition of a key performance skill, such as walking, is referred to as a milestone. For each skill, the normal age range for attainment of the milestone varies widely. A median age is the age at which half a population of children acquire a skill. A limit age is the age at which a skill should have been achieved and is two standard deviations from the mean. It is important to know which milestones are most consistent. Smiling socially by the age of 8 weeks is a consistent milestone, whereas crawling is not. Crawling occurs at a widely varying time point, and some children with normal development never learn to crawl.

Genetic factors may determine the fundamental developmental potential, but environmental factors have crucial influences on the profile achieved. Positive experiences during early childhood may enhance brain development, particularly in the area of linguistic and social skills. Unfortunately, however, the brain is also vulnerable to various insults, particularly in the early embryonic stages, but also in later life (box 1). Studies on abandoned Romanian children provide good evidence of how an adverse environment affects brain growth. Children who were institutionalised have smaller brains than those who were adopted abroad or brought up in a family environment, including foster care in Romania.[4] Other studies showed significant gains in cognitive and language skills after abandoned children are taken into care.[5 6]

What is developmental delay?

Many clinicians use the term "global developmental delay" to mean a significant delay in two or more of the four main developmental domains listed above. Significant delay is defined as performance two or more standard deviations below the mean on age appropriate standardised norm-referenced testing (usually a secondary care procedure). In the United Kingdom and the United States, the term global developmental delay is usually

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Summary points

- Every consultation is an opportunity to ask flexible questions about a child's development as part of comprehensive medical care
- Parents who voice concerns about their child's development are usually right
- Loss of previously acquired skills (regression) is a red flag and should prompt rapid referral for detailed assessment and investigation
- Parents and carers are usually more aware of norms for gross motor milestones, such as walking independently, than for milestones and patterns of normal speech, language acquisition, and play skills; consider targeted questioning
- Consider use of developmental screening questionnaires and measurement tools to supplement clinical judgment

Sources and selection criteria

We searched PubMed, the *Cochrane Database of Systematic Reviews*, and reference lists of relevant publications using the subject headings and key words "development", "developmental assessment", "developmental delay", "disability", "mental retardation", "developmental screening tools", "screening", and "diagnosis". We also reviewed guidelines from the American Academy of Pediatrics[2] and the UK Healthy Child Programme.[3]

We have extensive clinical experience in developmental paediatrics in the United Kingdom and United States, which we drew on to comment on the extensive and potentially confusing technology currently used for developmental assessment.

Box 1 Environmental causes of damage to brain development

Antenatal

- Early maternal infections, such as rubella, toxoplasma, cytomegalovirus
- Late maternal infections, such as varicella, malaria, HIV
- Toxins—for example, alcohol, pesticides, radiation, smoking
- Drugs—for example, cytotoxics, antiepileptics

Postnatal

- Infections—for example, meningitis, encephalitis, cytomegalovirus
- Metabolic disorders, such as hypoglycaemia, hyponatraemia or hypernatraemia, dehydration
- Toxins—for example, lead, mercury, arsenic, chlorinated organic compounds, solvents
- Trauma, especially head injury
- Severe understimulation, maltreatment, or domestic violence
- Malnutrition, especially deficiency of iron, folate, and vitamin D
- Maternal mental health disorders, most commonly depression

reserved for younger children (typically under 5 years of age). In the UK learning disability is usually applied to older children, when IQ testing is more valid and reliable (although formal testing of IQ is rarely performed in clinical practice and the child's assessment is based on functional abilities). In the US, the term developmental disability or mental retardation is used in the over 5 age group.

The term developmental impairment or disorder covers a heterogeneous group of conditions that start early in life and present with delay or an abnormal pattern of progression in one or more developmental domain. Children with autism spectrum disorder fall into this category. In this context, the use of the term developmental delay has been challenged because it conveys a message that the child may "catch up," which is often not true.[7] Nevertheless, it remains in common use because it is well understood by professionals and parents.

How common are developmental problems?

Global developmental delay affects 1-3% of children. About 1% (95% confidence interval 90-141 per 10 000) of children have an autism spectrum disorder,[8] 1-2% a mild learning disability, 0.3-0.5% a severe learning disability, and 5-10% have a specific learning disability in a single domain.[9 10]

Structured assessment of a child's development aims mainly to clarify the quantity and quality of the child's developmental status. However, the procedure also offers several advantages in terms of health promotion (box 2).

Children develop at different rates, and it is important to distinguish those who are within the "normal" range from those who are following a pathological course. We now have good evidence that early identification and early intervention improve the outcomes of children with developmental impairments.[11 12]

A persuasive body of work, which reviewed evidence from neurosciences, developmental psychology, social sciences, epidemiology (including animal and human studies), longitudinal studies, case series, and case reports,[13-15] describes the importance of the early years in promoting healthy brain development. This literature builds on the scientific understanding of brain development and finds that environments that do not promote healthy development have a cumulative and ongoing negative impact on a range of social, economic, and learning outcomes over the life course. This body of work emphasises that early interventions are an effective way to improve children's outcomes than later remediation.

Given the importance of the early years, early intervention is crucial. Early intervention seems to be even more important for children with developmental disabilities than for children more generally, because learning is cumulative, and barriers to healthy development early in life impede development at each subsequent stage.[16 17]

Obviously, identification of abnormality must be followed by further action. Children develop relentlessly, and if they are on a deviant path the course becomes more difficult to change as time goes by. Early child health promotion, which includes support for parenting and treatment, is an effective investment that may prevent the need for more intensive, costly, and often

Box 2 Benefits of developmental assessment

- Early diagnosis and intervention
- Early diagnosis of conditions with a genetic basis, such as Duchene muscular dystrophy and fragile X syndrome, facilitates genetic counselling for families
- Provides carers with reliable information before a developmental problem becomes obvious and gives them more time to adjust to the child's difficulty and make appropriate management plans for their family
- Carers are reassured and relieved of anxiety if assessment shows that the child is within the normal range
- Early assessments can be compared with later ones, allowing the practitioner to follow a child's individual developmental trajectory
- Provides an opportunity to encourage good parenting and developmental stimulation

less effective intervention later on. A series of systematic reviews of strategies for improving child development in 13 relatively deprived countries, published in the *Lancet*, found good evidence that interventions at pre-school age are highly cost effective.[18] A linked editorial stated that "Neglect of young children most in need is an outrage—and a huge strategic mistake."[19]

How do children present with developmental problems?

Children with developmental problems may present in several ways:

- In countries with routine child health surveillance or developmental screening practices, concerns may be raised at scheduled contacts
- In children with identified risk factors (such as prematurity) who have undergone developmental surveillance, developmental problems may be detected early
- Parents may recognise a delay or be worried about a child's behaviour or social skills and seek professional advice (either through their health visitor, public health nurse, or general practitioner)
- Professionals in a nursery or day care setting may recognise deviant patterns of development and highlight their concerns to the family, thus prompting referral
- Concerns may be detected opportunistically at health contacts for other reasons, such as childhood illnesses, if questions are asked about development.

Development can be assessed at several levels, depending on the circumstances. Screening is a process to identify children at increased risk of having developmental difficulties that uses relatively brief and simple techniques, according to well recognised criteria.[20] Screening tests are inherently imperfect assessments because they have to balance the risk of missing a child with delays (sensitivity) versus erroneously identifying children without true delays (specificity).[21] Repeating the test after an appropriate time interval, or conducting a secondary screening with a more accurate and specific test, may improve test accuracy. The inherent trade-off of sensitivity and specificity makes screening controversial—it is promoted universally in some countries,[2] whereas others have a selective policy.[22]

The practice of child health surveillance and screening has changed in the UK since the introduction of the Healthy Child Programme (HCP) which supersedes Health for all Children IV. In the UK, the HCP offers every child and family a programme that includes developmental reviews to facilitate early detection of, and action to deal with, developmental delay.[3] The emphasis is on a review at 2.5 years. The HCP is based on a model of "progressive universalism"—in other words, standard services that are available to everyone (universal) and extra services available to those who need them or are at risk (progressively more services provided according to need). It is basically a child health promotion programme that includes opportunities for developmental surveillance and screening or case finding. It is a flexible and non-prescriptive programme that can be adapted locally according to population needs. Primary care practitioners should opportunistically ask flexible questions about a child's development at every visit where possible, as part of comprehensive medical care (box 3). Children identified as at risk (often by a health visitor) may be referred for further assessment in primary or secondary care. Currently, standardised developmental screening tools are not routinely used in primary care in the UK.

By contrast, in the US the American Academy of Pediatrics (AAP) and many American state Medicaid programmes recommend the use of standardised developmental screening tools during each routine healthcare visit. The AAP guideline for health supervision, *Bright Futures*,[23] suggests the use of structured developmental screens from the age of 18 months. The 2009 Affordable Care Act requires health insurance plans to cover preventive care,[24] as described in *Bright Futures*. Despite these federal protocols, strategy and implementation vary greatly between individual states.

How to assess a child's development

A good starting point is to believe parents and carers who are worried about their child.

Box 4 lists factors that can result in a deviant pattern of development. It is important that these are elicited through appropriate history and examination. Ask about prenatal, perinatal, and postnatal events, including maternal health during pregnancy. Ask about the child's acquisition of developmental milestones (table 1⇓). The personal child health record ("red book" in the UK) is often a valuable source of information because it contains details of pregnancy, mode of delivery, condition at birth, Apgar scores, birth weight, birth head circumference, and newborn hearing screen results. A sensitive but thorough environmental, social, and family history is essential, particularly asking about consanguinity and a family history of developmental problems or learning difficulties, which may point to metabolic problems or recessive conditions.

Many parents make video recordings of their child on a camera or mobile telephone and these may be invaluable for illustrating the past and present developmental profile. Table 2⇓ lists the main physical examination features pertinent to developmental assessment. Always consider difficulties of hearing and vision when there are concerns about development.

Much information can be gained by observing the child entering and moving around the clinic while playing with a few age appropriate toys, such as blocks, toy cars, pull-along toys, paper, and crayons. Observation of the child at home or nursery can also prove invaluable, as can reports from other carers, such as nursery workers or school teachers. For those interested in

Box 3 Suggested opportunistic screening questions[35]

- Do you have any concerns about the way your child is behaving, learning, or developing?
- Do you have any concerns about the way he or she moves or uses his or her arms or legs?
- Do you have any concerns about how your child talks and understands what you say?
- Does your child enjoy playing with toys? Describe what he or she does while playing
- Has your child ever stopped doing something he or she could previously do?
- Does your child get along with others?
- Do you have any concerns about how your child is learning to do things for himself or herself?

Box 4 Developmental variation

Normal patterns

- Late talking or walking (including bottom shuffling) may be familial
- Language development may seem delayed at first in children of bilingual families, but counting total words in both languages typically compensates for perceived delay. Receptive language precedes language expression
- Black and Indian infants are more likely than white ones to have advanced motor skills[1]

Correctable causes of slow development

- Undernutrition (failure to thrive)
- Iron deficiency anaemia
- Social isolation of the family or maternal depression
- Hypothyroidism

further reading about developmental assessment and examination, we recommend a comprehensive review of methods and interpretation by Sharma.[25]

In primary care, when time is limited, clinicians with paediatric experience should base their assessment on clinical judgment and knowledge of the broadly normal range of child development. Table 1 contains normal milestones and gives some indicators of when to worry and box 5 contains some important red flags for significantly disordered development, which should prompt early referral to secondary care for diagnostic assessment.

In children presenting with mild developmental delay in the absence of any red flags, primary care practitioners may consider basic investigations such as full blood count, bone profile, thyroid function tests, and measurement of vitamin D and creatine kinase. Some causes of mild developmental delay such as iron deficiency anaemia can be easily treated. However, to avoid multiple venepuncture, investigations should be deferred in children with moderate or serious delay, or red flags, because they will require a battery of tests in secondary care.

What tools are available for developmental assessment in primary care?

Professionals who work with children learn to recognise deviant patterns of development, but screening questionnaires and developmental screening tools can improve accuracy.[26 27]

Examples of screening questionnaires include: the ages and stages questionnaire (ASQ),[28] the parents ' evaluation of developmental status (PEDS),[29 30] and the modified checklist for autism in toddlers (M-CHAT).[31] These surveys can be self administered and can be answered by parents in the waiting room or during the consultation itself. These tools can help focus the consultation and increase the confidence of primary care practitioners in their referral decisions.

Several short (10-20 minutes) standardised assessment tools can be used to complement clinical impressions in primary care. Examples include the Denver developmental screening test, which is completed by an observer and gives "pass or fail" results in the four major developmental fields,[32] and the schedule of growing skills II. This last test is based on the standardised Sheridan stycar sequences,[33] and it objectively assesses the child's developmental level in nine subfields of development.[34] Both give visual maps of a child's developmental skills with clear cut-off points to guide referral to secondary care (table 3⇓).

When should a child be referred for specialist assessment?

The presence of a red flag (table 1 and box 5) is a clear indication for referral to secondary care. Referral is also recommended if there are concerns about the extent of developmental delay or the lack of response to primary care interventions, such as health visitor advice or speech and language therapy.

What happens when a child is referred to a specialist?

Children with developmental concerns are most often seen by community paediatricians who work as part of a multidisciplinary team, often in child development centres. Members of the team may include a nursery nurse, preschool teacher, speech and language therapist, physiotherapist, occupational therapist, and psychologist. The child usually has an initial consultation to clarify the nature of the developmental difficulties.

Investigations (blood and urine tests, cranial imaging) may be arranged at this stage or later. The child may then undergo a multidisciplinary team assessment and intervention package of care over several weeks, after which a diagnosis will be reached, a report issued, and recommendations for ongoing support made.

Examples of developmental instruments used in secondary care that are more accurate, sophisticated, and time consuming (2-3 hours) than those used in primary care include the Griffiths mental development scales, Bayley scales of infant development, and the Wechsler preschool and primary scale of intelligence.

Box 5 Red flags

These indicators suggest that development is seriously disordered and that the child should be promptly referred to a developmental or community paediatrician[10]

Positive indicators (the presence of any of the following)

- Loss of developmental skills at any age
- Parental or professional concerns about vision, fixing, or following an object or a confirmed visual impairment at any age (simultaneous referral to paediatric ophthalmology)
- Hearing loss at any age (simultaneous referral for expert audiological or ear, nose, and throat assessment)
- Persistently low muscle tone or floppiness
- No speech by 18 months, especially if the child does not try to communicate by other means such as gestures (simultaneous referral for urgent hearing test)
- Asymmetry of movements or other features suggestive of cerebral palsy, such as increased muscle tone
- Persistent toe walking
- Complex disabilities
- Head circumference above the 99.6th centile or below 0.4th centile. Also, if circumference has crossed two centiles (up or down) on the appropriate chart or is disproportionate to parental head circumference
- An assessing clinician who is uncertain about any aspect of assessment but thinks that development may be disordered

Negative indicators (activities that the child cannot do)

- Sit unsupported by 12 months
- Walk by 18 months (boys) or 2 years (girls) (check creatine kinase urgently)
- Walk other than on tiptoes
- Run by 2.5 years
- Hold object placed in hand by 5 months (corrected for gestation)
- Reach for objects by 6 months (corrected for gestation)
- Point at objects to share interest with others by 2 years

Specific instruments are also available for the diagnosis of developmental disorders such as autism spectrum disorder. Standardised structured parental interviews, such as the developmental, dimensional, and diagnostic interview and autism diagnostic interview-revised, complement objective assessments of the child, such as the autism diagnostic observation schedule.

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Educational resources for parents and carers

Contact a Family (www.cafamily.org.uk)—A directory of support organisations for a wide range of disabling conditions in childhood

Mencap (www.mencap.org.uk)—Information and advice for lay and professional carers of people with learning disabilities

Department of Education (www.education.gov.uk/publications/standard/earlysupport/page1)—Useful information for parents and carers regarding developmental delay and more specific diagnoses, such as Down's syndrome

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Tables

Table 1 | **Normal developmental milestones**

	Skills				
Age	**Gross motor**	**Fine motor and vision**	**Hearing, speech, and language**	**Social, emotional, and behavioural**	**Red flags**
6 weeks	Head level with body in ventral suspension	Fixes and follows	Becomes still in response to sound	Smiles	Unresponsive to sound or visual stimuli
3 months	Holds head at 90° in ventral suspension	Holds an object placed in the hand	Turns to sound	Hand regard, laughs, and squeals	Lack of social response or vocalisation
6 months	No head lag on pull to sit; sits with support; in prone position lifts up on forearms	Palmar grasp of objects; transfers objects hand to hand	Vocalisations	May finger feed self	Poor head control, floppiness, not reaching
9 months	Crawls; sits steadily when unsupported and pivots around	Pincer grasp; index finger approach; bangs two cubes together	2 syllable babble, non-specific—consonant-vowel, such as “mama”	Waves bye bye, plays pat-a-cake; indicates wants; stranger anxiety emerging	Can’t sit unsupported; no babble
12 months	Pulls to stand; cruises; may stand alone briefly; may walk alone	Puts block in cup; casts about	One or two words; imitates adults’ sounds	Imitates activities; object permanence (the understanding that objects still exist when they cannot be seen) established; stranger anxiety established; points to indicate wants	Not communicating by gestures, such as pointing; not weight bearing through legs
18 months	Walks well; runs	Builds tower of 2-4 cubes; hand preference emerges	6-12 words	Uses spoon; symbolic play—“talking” on telephone; domestic mimicry—“helps” in household chores like sweeping, wiping surfaces	Not walking; no symbolic play; no words
2 years	Kicks ball; climbs stairs two feet per step	Builds tower of 6-7 cubes; does circular scribbles	Joins 2-3 words; knows some body parts; identifies objects in pictures	Can remove some clothes	Not joining two words; cannot run
3 years	Stands briefly on one foot; climbs stairs one foot per step	Builds tower of 9 cubes; copies a circle	Talks in short sentences that a stranger can understand	Eats with fork and spoon; puts on clothing; may be toilet trained	Not communicating with words; cannot climb stairs

Table 2 | **Key features of the developmental examination**

Key features on examination	Possible diagnosis
Head circumference measured and plotted on centile chart and interpreted in context of height and weight centiles; consider measurement of parental occipitofrontal head circumference	Microcephaly or macrocephaly
Dysmorphic features: does the child look like other family members? Are there any unusual features?	Genetic, metabolic, or syndromic conditions, such as fragile X syndrome
Skin abnormalities: café au lait patches, axillary freckling, neurofibromas, or hypopigmented patches (ash leaf macules)	Suggestive of neurocutaneous syndromes, such as neurofibromatosis or tuberous sclerosis
Observation of child's movements to look for signs of unsteadiness, weakness, or spasticity; check tone, power, and reflexes where possible	Underlying neurological disorder
Child's ability to sit up and to stand up from lying down supine and to clear the floor on jumping from a standing position	Muscle weakness suggestive of a muscular dystrophy
Observation of eye movements and examination of eyes looking for cataracts, nystagmus, or wobbly eye movements	Disorder of vision; underlying neurological condition
General examination of respiratory and cardiovascular systems	Underlying systemic disease
Abdominal examination for hepatomegaly	Metabolic disorder

Table 3 | **Developmental screening questionnaires**

Instrument	Method	Age range	Outcome	Availability	Validation, sensitivity, specificity data
Parents' evaluation of developmental status (PEDS)	A parent reported questionnaire used to identify general developmental delay in primary care; takes 5 minutes to complete, 2 minutes to score	0-8 years	High, moderate, or low risk for developmental or behavioural problems	Purchase from publisher (www.pedstest.com)	Validated in a large diverse standardisation sample; sensitivity of 74-79% and specificity of 70-80% in ages 0-8 years for detection of developmental delays and behavioural problems[36]
Ages and stages questionnaire (ASQ)	A parent reported questionnaire of 30 developmental items used to identify general developmental delay in primary care; takes 10-15 minutes to complete	4-60 months	Cut-off point guides need for further assessment	Purchase from publisher (www.brookespublishing.com)	Validated in a large diverse standardisation sample; specificity ranges from 81% (16 months) to 92% (36 months), and 86% overall; sensitivity averages 72%; published validation studies[37]
Modified checklist for autism in toddlers (M-CHAT)	A parent report of 23 items used to screen for autism in primary care population; takes 2 minutes to complete	16-30 months	Cut-off point for further assessment	Freely available online (www.firstsigns.org/downloads/m-chat.PDF)	Published validation study[31]
Schedule of growing skills	Professional scores items in 9 developmental fields; takes 10-15 minutes to complete	0-59 months	Graphic profile of developmental age compared with chronological age; guidelines to aid professional judgment of next action	Purchase from publisher (www.gl-assessment.co.uk)	Original data validation study showed specificity of 94-100% and sensitivity of 44-82% in different fields[38]; validation of revised schedule showed high reliability (Cronbach α 0.91)[33]
Denver developmental screening test	Professional scores items in 4 developmental fields	2-71 months	Graphic display of developmental age with "pass/fail" score compared with "normal" centiles	Purchase from publisher (www.denverii.com)	Originally validated in Colorado, US; later statistical study showed specificity of 43% and sensitivity of 83%[32]