Article/Review

Early Detection and Early Intervention in Cerebral Palsy: A Narrative Review of Current Evidence and Its Application in Resource-Limited Settings

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Abstract:
Cerebral palsy is the most common cause of physical disability in childhood, yet for most of the twentieth century it was diagnosed only after the first birthday, long after the period of greatest neuroplasticity had passed. Over the past decade this has changed. Combinations of neonatal magnetic resonance imaging, the Prechtl General Movements Assessment and the Hammersmith Infant Neurological Examination now permit accurate detection before six months of corrected age, and an international clinical practice guideline has defined what should be offered to infants once they are identified. This narrative review synthesises the current evidence on detection tools and their reported accuracy, on early intervention and its documented limits, and on the specific obstacles that arise where magnetic resonance imaging, trained assessors and structured rehabilitation are scarce. Particular attention is given to the applicability of these approaches in Central Asia, where published local data remain sparse. The review argues that the principal barrier to earlier diagnosis in such settings is no longer technological but organisational, and outlines what a feasible detection pathway would require.

Keyword: cerebral palsy, early diagnosis, infant, magnetic resonance imaging, neurologic examination, early intervention, educational, child development, developing countries.

Introduction

Cerebral palsy describes a group of permanent disorders of movement and posture attributed to non-progressive disturbances occurring in the developing fetal or infant brain. It is the most common cause of physical disability in childhood, and its consequences extend well beyond motor impairment into cognition, communication, feeding, vision, sleep and pain. For clinicians, the defining problem of cerebral palsy has never been recognising it in an established case; a five-year-old with spastic diplegia is not a diagnostic puzzle. The problem has been recognising it early enough for recognition to matter.

For most of the twentieth century the average age at diagnosis in high-income countries lay between twelve and twenty-four months, and considerably later where services were scarce. This delay was not accidental. It followed from a diagnostic culture that waited for motor milestones to be missed and for tone abnormalities to become unambiguous, and from a widespread and understandable reluctance to attach a permanent label to an infant whose trajectory might yet prove benign. The cost of that caution, however, is now measurable. The first months of life are the period of most intense synaptic formation and activity-dependent refinement, and interventions delivered during that window act on a nervous system that is more responsive than it will ever be again. Waiting for certainty means spending the most valuable therapeutic months doing nothing.

The turning point was the publication in 2017 of a systematic review and clinical practice guideline demonstrating that cerebral palsy can be predicted accurately before five months of corrected age [1]. Working from pooled diagnostic-accuracy data, that guideline identified three instruments with sufficient predictive performance to be used clinically: neonatal magnetic resonance imaging, the

Quoting: N.Sh. Islomova . Early Detection and Early Intervention in Cerebral Palsy: A Narrative Review of Current Evidence and Its Application in Resource-Limited Settings. **2026**, 5, 3, 2. https://doi.org/10.56121/MSU-2026-3-00014

Received: 22.03.2026
Corrected: 18.04.2026
Accepted: 20.05.2026
Published: 29.06.2026

Prechtl Qualitative Assessment of General Movements, and the Hammersmith Infant Neurological Examination. Their combination, rather than any single test, is what makes early detection reliable. Four years later, a companion international clinical practice guideline set out what should actually be delivered to infants so identified, issuing recommendations across nine outcome domains [2]. Together these two documents restructured the field: the question is no longer whether early diagnosis is possible but whether a given health system is organised to deliver it.

That last question is where the international literature becomes uneven. The evidence base for early detection was assembled overwhelmingly in settings with universal neonatal follow-up, accessible magnetic resonance imaging and a supply of certified assessors. A scoping review of early detection in low- and middle-income countries identified only thirteen relevant studies worldwide [3], and reviews of cerebral palsy in resource-limited regions consistently attribute the higher observed burden not to a different disease but to later diagnosis and constrained access [4]. Central Asia is barely represented in this literature at all. Uzbek-language publications on cerebral palsy exist but are concentrated in the pedagogical and speech-therapy domains rather than in early neurological detection [5–7], and the regional clinical literature is largely Russian-language and oriented towards the management of established disease rather than its early identification [8].

The aim of this review is therefore threefold: to summarise the current evidence on detecting cerebral palsy before six months of corrected age and the reported accuracy of each instrument; to set out what early intervention can and cannot presently claim; and to examine which components of this approach are realistically transferable to a setting such as Uzbekistan, where the constraint is rarely knowledge and almost always infrastructure, training and referral pathways.

Materials and Methods

This is a narrative review. The literature was identified through searches of PubMed, Google Scholar and the Cochrane Library conducted during 2026, using combinations of the terms "cerebral palsy", "early diagnosis", "general movements assessment", "Hammersmith Infant Neurological Examination", "early intervention", "prevalence" and "low- and middle-income countries", together with their Russian equivalents (" ", " ", "") and Uzbek equivalents ("bolalar serebral falaji", "erta tashxis", "reabilitatsiya"). Reference lists of retrieved guidelines and systematic reviews were screened for additional sources. Priority was given to clinical practice guidelines, systematic reviews, population-based registers and prospective diagnostic-accuracy studies published within the last five years, with older work included where it remains the definitive source for a given claim. Publications in English, Russian and Uzbek were eligible, and regional literature was sought deliberately in order to represent the Central Asian context. No formal risk-of-bias assessment or quantitative synthesis was performed, and the review is not registered; it is presented as a narrative synthesis rather than as a systematic review.

Definition, Classification and Epidemiology

Contemporary practice classifies cerebral palsy by predominant motor type (spastic, dyskinetic, ataxic or mixed), by topographical distribution, and above all by function. The Gross Motor Function Classification System, which stratifies ambulation and mobility into five levels, has largely displaced purely descriptive classification because it predicts service need and long-term outcome more usefully than motor phenotype alone.

The best current estimate of global birth prevalence comes from a systematic analysis pooling data from forty-one regions in twenty-seven countries, which reported approximately 1.6 cases per 1000 live births in high-income countries and materially higher figures where perinatal care is less developed [9]. Within high-income settings the trend is downward and the phenotype is becoming less severe. Australian register data show singleton birth prevalence falling from 1.8 to 1.2 per 1000 across two decades, with declines in every gestational-age stratum [10], and Danish national data record a fall to 1.73 per 1000 for birth years 2008-2013 from 1.99 per 1000 in the preceding period, again accompanied by milder presentations [11]. These improvements are attributed to better obstetric surveillance, antenatal corticosteroids, magnesium sulphate for neuroprotection, and the introduction of therapeutic hypothermia for hypoxic-ischaemic encephalopathy, which remains the

only proven treatment for that condition and demonstrates that a major cerebral palsy pathway is modifiable [12].

Such declines are not universal. Register data for Aboriginal and Torres Strait Islander children show a birth prevalence of 1.9 per 1000, higher than the surrounding population and only beginning to fall [13], illustrating that national averages conceal substantial inequity. Regional data from the post-Soviet space are comparatively scarce; a study of 1162 cases in Baku reported prevalence of 0.27-0.37% across births between 2006 and 2016, rising to 10.35% among newborns weighing under 1500 g [14]. That last figure is the more informative one, because it locates the burden precisely where an early-detection programme would be targeted: the high-risk neonatal follow-up population.

Detecting Cerebral Palsy Before Six Months

The instruments now recommended for early detection are summarised in Table 1, with their reported performance and their practical limitations.

The Prechtl Qualitative Assessment of General Movements evaluates the spontaneous movement repertoire of the infant from video recordings. Its critical window is the fidgety-movement period, roughly nine to twenty weeks post-term, during which the absence of normal fidgety movements is strongly associated with later cerebral palsy; pooled sensitivity in the 2017 guideline approached 98% [1]. The method requires no equipment beyond a camera, which makes it attractive for resource-limited settings, but it requires a trained and periodically recertified observer, and inter-observer reliability outside specialist centres is its principal vulnerability.

The Hammersmith Infant Neurological Examination is a scorable structured examination applicable from two to twenty-four months, with published cut-offs that stratify risk. It is inexpensive, requires only a mat and a few simple objects, and can be taught to general paediatricians. Reported sensitivity in the original guideline synthesis was approximately 90% [1]. Subsequent work has refined its use: an eleven-item abbreviated version detected cerebral palsy at three months with sensitivity 0.88 and specificity 0.92 in a validation cohort of 310 infants [15], and modelling of individual subscores rather than the global score improved discrimination from an area under the curve of 0.75 to 0.91 in a cohort of neonatal intensive care graduates [16]. For infants born very preterm, the neonatal counterpart of the examination performed at 32 weeks postmenstrual age predicted twelve-month motor impairment with 77% sensitivity and 74% specificity [17].

Neonatal magnetic resonance imaging contributes both diagnosis and aetiology, and its predictive value is greatest when combined with a movement-based assessment. In a cohort of high-risk term neonates, normal myelination of the posterior limb of the internal capsule combined with normal fidgety movements yielded a negative predictive value of 90% for any cerebral palsy and 98% for moderate to severe cerebral palsy [18]. That combination is clinically powerful in a way that is easy to overlook: it identifies, with high confidence, the infants who do *not* need intensive surveillance, and thereby concentrates scarce therapy resources on those who do.

Performance is not uniform across populations, and the literature is appropriately candid about this. In term infants treated with therapeutic hypothermia, atypical fidgety movements at three months and the Hammersmith examination at three, six and nine months predicted cerebral palsy with sensitivity above 80% and specificity above 90% [19]. By contrast, in infants with surgically treated congenital anomalies the predictive validity of three-month assessments was low, although a Hammersmith score below 60 retained a negative predictive value of 0.971 for delayed cognition [20]. The instruments are therefore not universally interchangeable, and their performance must be interpreted against the population in which they are applied.

Two developments may ease the training bottleneck. Automated analysis of general movements using deep learning achieved an area under the curve of 0.967 on external validation and improved the diagnostic accuracy of novice assessors by 11.0% [21], raising the possibility that video could be acquired locally and interpreted centrally or algorithmically. Separately, work in Bangladesh has shown that accurate diagnosis is achievable from three months of age in a tertiary neonatal cohort, with remotely administered developmental screening tools showing strong predictive validity between nine and twenty-four months [22]. Both findings matter more for Uzbekistan than any incremental refinement of the instruments themselves.

Table 1. Instruments for the early detection of cerebral palsy: features and limitations.

Instrument	Timing and reported performance	Limitations	Source
Prechtl General Movements Assessment	Video-based observation during the fidgety period, about 9-20 weeks post-term. Pooled sensitivity approaching 98% in the guideline synthesis.	Requires a trained, periodically recertified observer; inter-observer reliability falls outside specialist centres; the fidgety window is narrow and easily missed.	Novak et al. (2017) [1]
Brief Hammersmith Infant Neurological Examination	Eleven-item abbreviated examination applied at 3 months; sensitivity 0.88 and specificity 0.92 at a cut-off below 22, validated in 310 infants.	Validated in a single-centre cohort; abbreviation trades some diagnostic detail for speed; cut-offs are age-specific and not interchangeable across time points.	Romeo et al. (2024) [15]
Hammersmith Neonatal Neurological Examination	Performed at 32 weeks postmenstrual age in infants born very preterm; predicted 12-month motor impairment with 77% sensitivity and 74% specificity at a cut-off of 15.2 or below.	Moderate specificity generates false positives; validated for infants born before 31 weeks and not transferable to term populations.	Howard et al. (2023) [17]
Neonatal magnetic resonance imaging combined with general movements	Normal myelination of the posterior limb of the internal capsule plus normal fidgety movements gave 90% negative predictive value for any cerebral palsy and 98% for moderate to severe disease.	Requires neonatal magnetic resonance imaging, often with sedation or feed-and-wrap protocols; capital cost and scanner access are the limiting factors in most resource-limited services.	Glass et al. (2021) [18]
General movements and Hammersmith examination after therapeutic hypothermia	In term infants treated with hypothermia, atypical fidgety movements at 3 months and the Hammersmith examination at 3, 6 and 9 months predicted cerebral palsy with sensitivity above 80% and specificity above 90%.	Population-specific: derived in cooled term infants with hypoxic-ischaemic encephalopathy and should not be generalised to other high-risk groups without local validation.	Moss et al. (2025) [19]
Automated deep-learning general movements analysis	Quantitative fidgety-movement model reached an area under the curve of 0.967 on external validation and improved the accuracy of novice assessors by 11.0%.	Not yet in routine clinical use; performance depends on video acquisition quality and camera positioning; regulatory approval and local validation are outstanding.	Gao et al. (2023) [21]
Remote developmental screening in a low-resource cohort	In a Bangladeshi tertiary neonatal cohort, accurate diagnosis was possible from 3 months, with remotely administered screening tools showing strong predictive validity between 9 and 24 months.	Depends on caregiver access to a device and connectivity; screening instruments detect delay rather than establishing the diagnosis, so specialist confirmation is still required.	Karim et al. (2025) [22]
Structured differential diagnosis against mimics (regional reference)	Narrative framework for separating cerebral palsy from somatic, endocrine and hereditary-metabolic conditions that imitate it, with staged rehabilitation.	Narrative rather than diagnostic-accuracy evidence; no sensitivity or specificity reported, so it supports clinical reasoning rather than screening decisions.	Nemkova & Boldyrev (2024) [8]
Local descriptive and classificatory literature (regional context)	Uzbek-language account of the clinical forms of cerebral palsy encountered in children, aimed at a combined clinical and pedagogical readership.	Descriptive and educational in purpose; not indexed in international databases and not peer reviewed to the standard of the indexed literature; no early-detection data.	Mo'minova & Axmedova (2025) [5]

Early Intervention and the Limits of the Evidence

Detection is only justified if something follows from it. The international clinical practice guideline for infants aged 0 to 2 years with or at high risk of cerebral palsy issued 28 recommendations across nine domains, covering motor function, cognition, communication, feeding, vision, sleep, tone management, musculoskeletal health and parental support [2]. Its central principles are that intervention should begin as soon as risk is identified rather than after diagnostic certainty, that it should be task-specific and environmentally enriched rather than passive, and that the parent is the delivery agent rather than an observer.

The honest position on efficacy is more measured than advocacy sometimes suggests. An overview of systematic reviews of early intervention found that more than half of trials compared an intervention with standard care rather than with an equally intensive alternative, and that only two demonstrated efficacy on that basis; constraint-induced movement therapy showed high effect sizes but no superiority over bimanual training delivered at equal intensity [23]. Subsequent trials have reinforced this reading. A randomised comparison of Baby-CIMT against Baby-BIM in 96 infants with congenital hemiplegia found no superiority of either, though both improved hand function and gains were greater when intervention began before six months of corrected age [24]. A randomised trial of fifty hours of hand-arm bimanual intensive therapy including lower extremities delivered over two weeks demonstrated feasibility in infants with unilateral cerebral palsy and improvements in bimanual use and goal attainment [25].

The pattern across these trials is consistent and clinically useful: intensity and timing appear to matter more than the specific branded protocol. That conclusion is liberating for a service with limited access to proprietary programmes, because it suggests that a well-structured, high-dose, parent-delivered, task-specific programme begun early may capture most of the available benefit. Telehealth may extend reach further; a systematic review concluded that telehealth-delivered early intervention is feasible and improves access and family-centred care, while noting that evidence for cognitive outcomes remains lacking [26].

Established disease also requires ongoing management, and the regional literature contributes here. Cognitive dysfunction in cerebral palsy affects perception, memory, attention, visuomotor coordination and speech, and requires integrated medical, psychological and pedagogical rehabilitation rather than motor therapy alone [27]. Chronic sialorrhoea, a common and socially disabling problem, was reduced in 93.8% of 226 children for a mean of 4.9 months following salivary-gland botulinum toxin injection in a Russian multicentre series of 608 procedures, with adverse events in 13.3% [28]. Adjunctive pharmacological approaches continue to be investigated in the regional literature, including agents targeting systemic inflammation in spastic forms [29], although such work generally involves small samples and requires confirmation against international standards of trial design.

The Resource-Limited Setting and the Central Asian Context

The obstacles to implementing early detection outside well-resourced systems are well described. Only thirteen studies of early detection tools had been conducted in low- and middle-income countries at the time of the most recent scoping review, distributed across general movements assessment, neonatal magnetic resonance imaging, neonatal and infant neurological examination and cranial ultrasound [3]. Reviews of aetiology and diagnosis in resource-limited regions attribute the excess burden to delayed presentation and access barriers, and propose low-cost responses: simplified clinical tools, mobile health approaches and community-based rehabilitation [4].

What such settings look like in practice is captured in the descriptive literature. Among children with cerebral palsy in Sahrawi refugee camps in southern Algeria, 65.5% had a history of perinatal distress, 52% had epilepsy, fewer than half could walk, and magnetic resonance imaging and electroencephalography were scarcely available [30]. Nutritional consequences are substantial: in a cross-sectional study of 428 Ugandan children with disabilities, of whom 38.6% had cerebral palsy, 45.2% were underweight and 38.3% stunted, and feeding difficulty doubled the odds of undernutrition [31]. The family burden is economic and social as much as clinical, as qualitative work with caregivers in Cameroon and Zambia documents, including stigma and supernatural attributions of causation [32,33]. Interventions that address poverty alongside therapy have consequently been trialled, as in a

cluster-randomised study of integrated microfinance and community-based rehabilitation in rural Bangladesh, where 97% of affected families lived below the poverty line [34].

For Uzbekistan specifically, the published evidence base is thin, and this is itself a finding. Uzbek-language publications on cerebral palsy address classification and clinical description [5], the characteristics and remediation of associated speech disorders [6], and combined medical-pedagogical and social approaches [7], but the literature is oriented towards the school-age child already carrying the diagnosis rather than towards the neonate at risk. The national clinical literature published in Uzbekistan increasingly addresses paediatric neurological conditions in local populations, including studies of the neurological manifestations of systemic paediatric disease [35] and of specific childhood neurological phenotypes in the Uzbek population [36], which indicates a developing regional research capacity that early-detection work could build upon. Russian-language sources remain the principal regional reference for the differential diagnosis of cerebral palsy against somatic, endocrine and hereditary-metabolic mimics, and for structured rehabilitation of established disease [8]. Outcome data for the specific population that an early-detection programme would serve are available in that literature: in a Russian cohort of 127 very and extremely preterm infants, cerebral palsy occurred in 36.4% of one rehabilitation group against 13.6% of controls, with diffusion tensor imaging showing high prognostic value [37].

Comorbidity and the Lifelong Perspective

Framing cerebral palsy as a motor diagnosis understates it. Epilepsy, cognitive impairment, communication difficulty, feeding and nutritional problems, visual impairment, sleep disturbance and chronic pain are common, and several of them affect outcome more than the motor impairment itself [27,30,31]. The international early intervention guideline reflects this by structuring its recommendations around nine domains rather than around gross motor function alone [2].

The perspective must also extend beyond childhood. Adults with cerebral palsy are substantially under-represented in the literature relative to children, and data on their comorbidity, functioning and quality of life are correspondingly scarce [38]. For a service planning an early-detection pathway, this is a reminder that the pathway's endpoint is not a diagnosis at six months but a functioning adult decades later, and that transition arrangements deserve consideration from the outset rather than as an afterthought.

Discussion

The first is that the scientific question of whether cerebral palsy can be detected in early infancy has been settled. Neonatal magnetic resonance imaging, the general movements assessment and the Hammersmith examination, used in combination and interpreted against the population to which they are applied, identify affected infants before six months of corrected age with accuracy sufficient for clinical action [1,18,19]. Debate now concerns refinement and implementation, not principle.

The second is that early intervention rests on a more qualified evidence base than is sometimes acknowledged, and that this qualification is useful rather than discouraging. Trials comparing active protocols against each other have generally found equivalence, while comparisons against standard care favour the active arm [23–25]. The reasonable interpretation is that dose, timing and task specificity carry most of the effect. A service that cannot obtain a proprietary programme is therefore not thereby excluded from delivering effective early intervention, provided it can deliver structured, intensive, parent-mediated, goal-directed therapy early.

The third is that the binding constraint in settings such as Uzbekistan is organisational rather than technological. Two of the three recommended detection tools require no capital equipment: the Hammersmith examination needs a mat and a trained examiner, and the general movements assessment needs a video camera and a certified observer. What is missing is the connective tissue — a defined high-risk register drawn from neonatal units, a scheduled follow-up appointment at three months of corrected age, a cadre of trained assessors, an agreed referral threshold, and a therapy service able to accept referrals. Each of these is an administrative decision rather than a purchase. Emerging developments make the position more favourable still: algorithmic general movements analysis could relieve the assessor bottleneck [21], remote developmental screening has demonstrated

predictive validity in a comparable South Asian setting [22], and telehealth extends therapy reach where distance is the obstacle [26].

Several limitations of this review should be stated. It is a narrative rather than systematic synthesis: no protocol was registered, no formal risk-of-bias assessment was applied, and study selection reflects the author's judgement, so selection bias cannot be excluded. The diagnostic-accuracy figures quoted derive largely from specialist centres and high-risk cohorts, and applying them to unselected populations with lower disease prevalence would lower positive predictive value, an important caveat for any screening programme built on them. The Uzbek-language sources identified are drawn from local journals and conference proceedings that do not undergo the same peer review as the indexed international literature, and they are cited here as evidence of the regional discourse rather than as clinical evidence. Finally, the near-absence of Central Asian early-detection data means that the applicability arguments advanced here are extrapolations from other resource-limited settings and require local validation.

That last point defines the most useful next step. A prospective cohort recruiting high-risk neonates from Uzbek neonatal units, applying the Hammersmith examination and general movements assessment at three months of corrected age, and following motor outcome to two years would establish local predictive validity, quantify the achievable reduction in age at diagnosis, and provide the evidence a national programme would need. Such a study requires training and follow-up discipline rather than major capital investment, which places it within the reach of an academic centre.

Conclusions

Cerebral palsy can now be identified before six months of corrected age with accuracy sufficient to justify acting on it, and an international guideline defines what acting on it should mean. The evidence for early intervention supports early, intensive, task-specific and parent-delivered therapy rather than any single proprietary method, which makes the approach more transferable to resource-limited services than it first appears. For paediatric neurology in Uzbekistan and the wider Central Asian region, the practical implication is that the main components of early detection are already affordable: a structured neurological examination and a video-based movement assessment require training and organisation far more than equipment. What is presently absent is not knowledge or technology but a defined pathway linking neonatal units to follow-up assessment, and an evidence base generated locally. Establishing both would allow the region to convert an internationally settled scientific question into a change in the age at which its children are diagnosed, and therefore in the age at which their treatment begins.

Authors' contribution

Conceptualization, N.I.; methodology, N.I.; literature search and screening, N.I.; formal analysis and synthesis, N.I.; writing-original draft preparation, N.I.; writing-review and editing, N.I.; visualization, N.I. The author has read and agreed to the published version of the manuscript.

Funding source

This research received no external funding.

Ethics approval

Not applicable. This article is a review of previously published literature and did not involve studies with human participants or animals performed by the author.

Consent for publication.

Not applicable, as this study did not involve human participants.

Data Availability Statement

No new data were created or analysed in this study. All sources discussed are published and are listed in the References section, each with its digital object identifier where one has been assigned.

Acknowledgments

The author thanks the Department of Child Neurology, Central Asian Medical University, for academic support during the preparation of this review.

Conflict of interest

The author declares no conflict of interest.

Abbreviations

CP	cerebral palsy
GMA	General Movements Assessment
HINE	Hammersmith Infant Neurological Examination
HNNE	Hammersmith Neonatal Neurological Examination
MRI	magnetic resonance imaging
GMFCS	Gross Motor Function Classification System
PLIC	posterior limb of the internal capsule
CIMT	constraint-induced movement therapy
HABIT-ILE	hand-arm bimanual intensive therapy including lower extremities
AUC	area under the receiver operating characteristic curve
NPV	negative predictive value
LMIC	low- and middle-income country.

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