

Evolution of Cerebral Palsy Diagnosis in a High-Risk Neonatal Population: A Cohort Study over Two Decades

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Keywords

Cerebral Palsy; Early Diagnosis; Neonatal Follow-Up; Prematurity; Neurodevelopment

Abstract

Background

Early diagnosis of cerebral palsy (CP) enables timely intervention and improved outcomes. International guidelines recommend standardized tools such as magnetic resonance imaging (MRI), the Hammersmith Infant Neurological Examination (HINE), and the Prechtl General Movements Assessment (GMs). In Belgium, a structured and reimbursed neonatal follow-up program for preterm infants (prematurity convention) was introduced in 2012. This study evaluated how the diagnostic process of CP has evolved in this context.

Methods

We conducted a retrospective cohort study including children with CP admitted to the Neonatal Intensive Care Unit of University Hospitals Leuven. Two birth cohorts were compared: pre-implementation (2006-2010) and post-implementation (2016-2020). Clinical and neurodevelopmental data

were extracted from medical records. Primary outcomes were age at diagnosis and use of standardized tools. Secondary outcomes included timing of parental communication, referral to specialized care, and initiation of early interventions.

Results

Seventy-eight children were included (38 in 2006-2010; 40 in 2016-2020). Median age at diagnosis did not differ significantly between cohorts (12.0 vs. 10.5 months; $p=0.564$). Children with higher Gross Motor Function Classification System (GMFCS) levels were diagnosed earlier ($p=0.003$). The more recent cohort showed earlier communication of motor concerns, earlier referral, and earlier initiation of interventions such as constraint-induced movement therapy and home guidance.

Conclusions

Despite the introduction of structured follow-up, age at diagnosis did not decrease. However, diagnostic age was comparable to international programs with full guideline implementation. Improvements in communication, referral, and intervention timing were observed over time. Further integration of standardized tools may enhance early detection and outcomes.

Introduction

Cerebral palsy (CP) is the most frequently diagnosed physical disability in childhood (1). It occurs worldwide, with a higher prevalence reported in low- and middle-income countries (2). The Surveillance of Cerebral Palsy in Europe (SCPE) defines CP as a group of permanent disorders of movement and posture that cause activity limitation and are attributed to non-progressive disturbances occurring in the developing foetal or infant brain (3). CP is classified into three main motor types - spastic, dyskinetic, and ataxic - which can be further categorised as unilateral (affecting one side of the body) or bilateral (affecting both sides) (3). Although it is primarily a motor disorder, comorbidities are common and may include

chronic pain, intellectual disability, epilepsy, hip displacement, behavioural disorder and hearing or visual impairments (4).

Historically, perinatal asphyxia was considered the primary cause of CP. However, over the years multiple antenatal, perinatal, and postnatal risk factors have been identified, including intrauterine growth restriction, congenital anomalies, prematurity, neonatal seizures, hypoglycaemia, and infections (5). Advances in neonatal intensive care have significantly improved survival rates among preterm and critically ill newborns (6). While these infants remain at high risk for long-term neurodevelopmental impairments, including CP, overall prevalence of CP in high-income countries has remained stable or declined over recent

TABLE 1: Neonatal characteristics.

Neonatal characteristics	Children born 2006-2010 (%) N = 38 (100)	Children born 2016-2020 (%) N = 40 (100)	P-Value
Male	24 (63.2)	24 (60.0)	0.774
Gestational age in weeks (%)			0.034
Extremely preterm: <28 weeks	3 (7.9)	14 (35.0)	
Very preterm: 28-31 weeks	14 (36.8)	9 (22.5)	
Preterm: 32-36 weeks	11 (28.9)	8 (20.0)	
Term: 37-41 weeks	10 (26.3)	9 (22.5)	
Birth weight in grams, mean (SD)	2106 (942)	1661 (972)	0.784
Multiple pregnancy (%)	10 (26.3)	13 (32.5)	0.549
Antenatal steroids (%)			0.889
No	11 (40.7)	13 (35.1)	
Complete	13 (48.1)	19 (51.4)	
Incomplete	3 (11.1)	5 (13.5)	
Invasive respiratory support (%)			0.857
None	15 (39.5)	14 (35.0)	
<4h	2 (5.3)	1 (2.5)	
4h – 24h	5 (13.2)	7 (17.5)	
2 days – 180 days	16 (42.1)	18 (45.0)	
≥ 180 days	0 (0.0)	0 (0.0)	
Bronchopulmonary Dysplasia (%)	4 (10.5)	11 (27.5)	0.057
Retinopathy of Prematurity (%)			0.008
No	25 (78.1)	21 (53.8)	
Yes, not treated	0 (0.0)	1 (2.6)	
Yes, treated	0 (0.0)	11 (28.2)	
Not performed	7 (21.9)	6 (15.4)	
Necrotizing Enterocolitis (%)	4 (10.5)	5 (12.5)	0.785
Sepsis			0.602
Clinically suspected	6 (15.8)	10 (25.0)	
Culture proven	13 (34.2)	12 (30.0)	
White matter disease on ultrasound (%)			0.079
No white matter disease	17 (44.7)	11 (27.5)	
Transient periventricular flaring	3 (7.9)	2 (5.0)	
Persistent hyperechogenicity	9 (23.7)	21 (52.5)	
Localized cysts	3 (7.9)	4 (10)	
Cystic periventricular leukomalacia	6 (15.8)	2 (5.0)	
Intracerebral haemorrhage (%)			0.946
No intracerebral haemorrhage	18 (47.4)	16 (40.0)	
IVH grade 1	8 (21.1)	10 (25.0)	
IVH grade 2	4 (13.2)	6 (15.0)	
IVH grade 3	4 (10.5)	3 (7.5)	
Periventricular haemorrhagic infarction	2 (5.3)	4 (10.0)	
Other haemorrhages	1 (2.6)	1 (2.5)	
Neurological examination at discharge (%)			0.709
Normal	24 (64.9)	29 (72.5)	
Suspected	6 (16.2)	6 (15.0)	
Abnormal	7 (18.9)	5 (12.5)	
Time of oral autonomy in weeks, mean (SD)	37.32 (2.14) (n=19)	39.77 (2.76) (n=31)	0.198

decades (2). Given the neuroplasticity of the developing brain, early diagnosis is essential to ensure that interventions are timely and effective. As a result, significant research has been conducted in recent years to enhance diagnosis and treatment strategies (7, 8). In 2017, international guidelines for early and accurate diagnosis of CP were published. Before the corrected age of 5 months, magnetic resonance imaging (MRI), together with clinical signs found in the Prechtl Qualitative Assessment of General Movements (GMs), and the Hammersmith Infant Neurological Examination (HINE) are recommended (9, 10). After 5 months, MRI and HINE remain the most predictive tools (8). For diagnosing unilateral CP specifically, the Hand Assessment for Infants (HAI) is valuable due to its focus on asymmetries in hand function (11 – 13).

Recent studies have demonstrated that implementing international guidelines for early detection of CP can significantly lower the age of diagnosis. In the United States, Maitre et al. (2020) showed that applying a standardised pathway using the recommended tools across a follow-up network led to a decrease in diagnostic age, with 76% of children diagnosed before 12 months (14). Similarly, in Australia, Te Velde et al. (2021) reported that structured implementation of the standardised tools both reduced the age at CP diagnosis and improved guideline adherence to international guidelines (15). For infants at risk of unilateral CP, Ryll et al. (2021) found that the Hand Assessment for Infants (HAI) could accurately predict CP from as early as 3.5 months, with sensitivity up to 93% (16). These findings highlight the clinical value of structured, guideline-based assessment in improving early diagnosis.

Early intervention plays a pivotal role in optimizing motor, cognitive, and communication skills, while also preventing and managing associated comorbidities. Beyond improving outcomes for the child, timely intervention also supports the mental well-being of parents and caregivers. Delayed diagnosis has been linked to higher levels of parental stress, anxiety, and depression (8, 17). Therefore, intervention should also integrate parental education and psychological support alongside child-focused therapy.

University Hospitals Leuven (UHL) has a 36-bed level 4 NICU and is a CP reference centre, one of five nationally recognised centres in Belgium that collaborate in CP-related data collection. Since a substantial proportion of infants later diagnosed with CP have identifiable perinatal risk factors, this setting provides a unique opportunity to investigate the timing of diagnosis, referral, and outcomes in a high-risk cohort.

The objective of this study was to evaluate how the diagnostic process of children with cerebral palsy (CP) has evolved over time at UHL, by comparing two birth cohorts (2006-2010 and 2016-2020) with regard to the timing of CP diagnosis and the diagnostic

tools used. We hypothesized that, following the implementation of structured and reimbursed neonatal follow-up within the Belgian prematurity convention in 2012, children in the more recent cohort would be diagnosed at a younger age and would have earlier access to specialised care and interventions.

Materials and Methods

Data collection

We conducted a retrospective cohort study to identify children with a diagnosis of CP after discharge from the NICU in UHL by querying the database of the UHL CP reference centre.

Since 2012, a structured and reimbursed neonatal follow-up program for preterm infants (prematurity convention) has been implemented in Belgium. Within this program, follow-up assessments are scheduled at fixed time frames after discharge and often alternate with visits to the local paediatrician. Infants born before 31 weeks of gestation and/or with a birth weight below 1500 g are eligible for four multidisciplinary assessments, scheduled at approximately 4, 9, and 24 months corrected age and around 60 months chronological age. Infants born at 31 weeks of gestation with a birth weight of at least 1500 g are eligible for two reimbursed assessments, including one assessment during infancy or early childhood and one between 4.5 and 5.5 years. The assessments are reimbursed through the Belgian healthcare system, although parents pay a small co-payment. To evaluate the potential impact of this structured follow-up programme, two birth cohorts were defined: a pre-implementation cohort (2006-2010) and a post-implementation cohort (2016-2020). The study periods were selected pragmatically as two five-year cohorts, and all eligible children born during these periods were included. Given the retrospective and exploratory nature of the study and the use of the available patient population, no formal a priori sample size calculation was performed, and no minimally clinically relevant difference in age at CP diagnosis was predefined. Inclusion criteria were a documented history of NICU admission at UHL at birth between 2006-2010 or 2016-2020, and a confirmed diagnosis of CP documented in the medical file, based on the Surveillance of Cerebral Palsy in Europe (SCPE) definition (3).

Exclusion criteria were transfers from an external hospital for surgery or second opinions, neurodevelopmental disorders not consistent with CP (e.g. genetic syndromes), degenerative or progressive neurological disorders (e.g. leukodystrophies, hereditary spastic paraplegia), neoplasms, and non-perinatal acquired brain injuries (e.g. shaken baby syndrome, post-NICU meningitis).

Potentially eligible patients were identified through the hospital's administrative and clinical databases, in

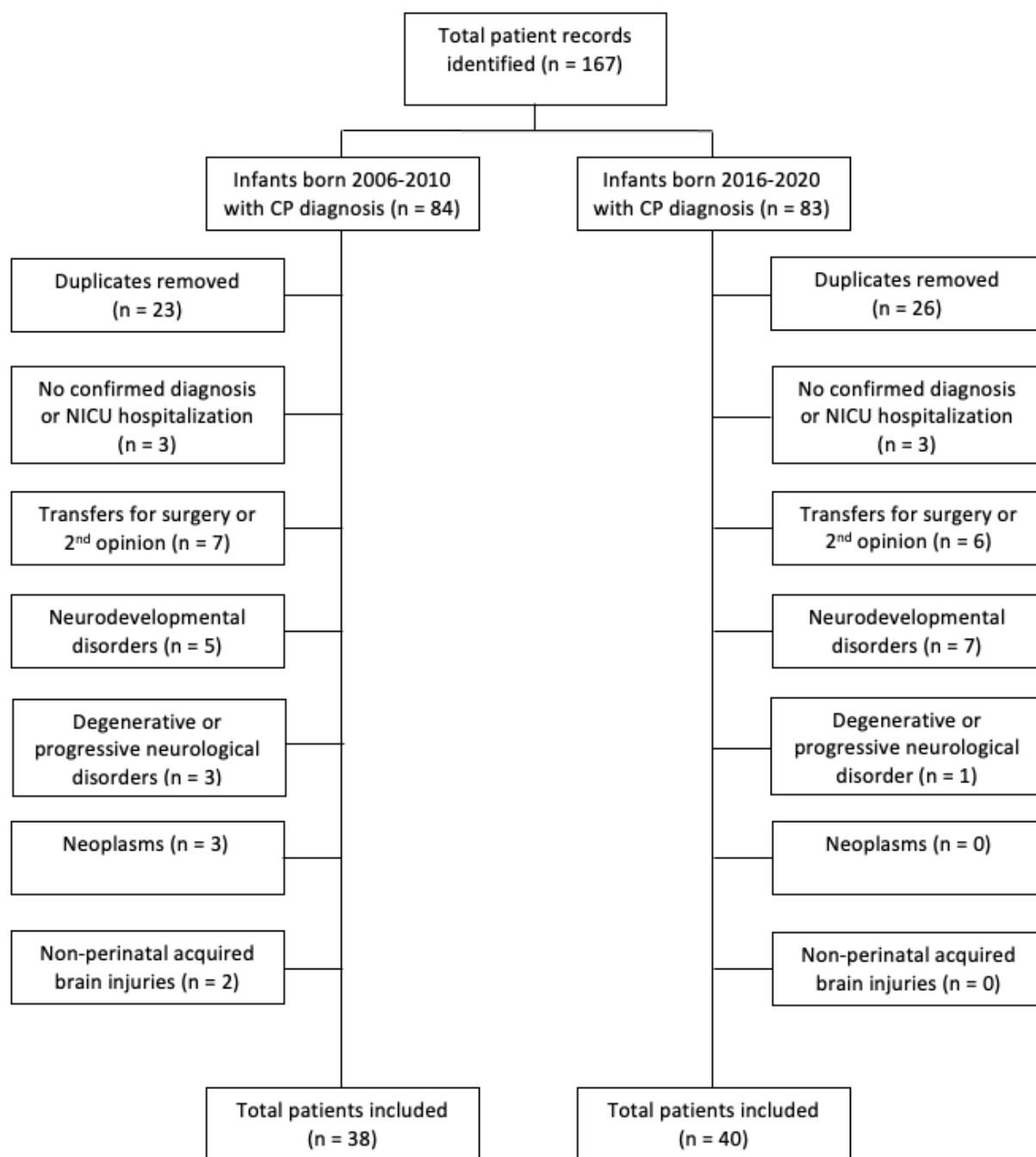


FIGURE 1: Flowchart of patient selection.

collaboration with the CP reference centre. To ensure comprehensive case identification, both diagnostic coding data and records of CP-related clinical consultations were used. All records were subsequently reviewed manually to confirm eligibility. Inclusion and exclusion criteria were applied based on detailed chart review to define the final study population.

One researcher (RD) performed manual chart review and extracted relevant clinical data using a standardised data collection form.

Data definitions and outcome parameters

All definitions were established a priori. Variables were

grouped into three categories: neonatal variables, follow-up and intervention variables, and diagnostic and clinical outcomes.

Neonatal variables were sex, gestational age in weeks, birth weight, multiple birth, exposure to antenatal corticosteroids, duration of invasive respiratory support in days. Bronchopulmonary dysplasia (BPD) was defined as supplemental oxygen use for more than 28 days and at 36 weeks postmenstrual age. Retinopathy of prematurity (ROP) was categorised as absent, present without treatment, present requiring treatment, or not assessed. Necrotizing enterocolitis was defined according to Bell's criteria (18). Sepsis was defined as

clinically suspected if antibiotic treatment was given for more than 72 hours, or as proven if blood culture was positive. White matter disease on cranial ultrasound was categorised based on De Vries et al. (19). Persistent hyperechogenicity was defined as periventricular echodensities that were iso- or hyperechogenic relative to the choroid plexus, persisting for more than 2 weeks, but without cystic involution. Intraventricular haemorrhage (IVH) was graded according to Papile et al., with the highest grade documented (20). Time to oral autonomy was recorded in weeks postmenstrual age. Neurological examination at discharge referred to the routine clinical assessment documented in the medical record. Examinations were performed by either a neonatologist or a paediatric resident and were not based on a standardised neurological assessment tool. The level of detail varied between medical records.

Follow-up and intervention variables included corrected age in months at the first follow-up visit after discharge and corrected age in months at the first documented communication to parents of concerns regarding motor development before CP diagnosis. Age at first follow-up after discharge was defined as the age at the earliest documented clinical follow-up after NICU discharge. This was based either on a scheduled appointment recorded in the discharge letter or on the first subsequent consultation identified in the electronic medical record system. Initiation of physiotherapy, home guidance, and constrained-induced movement therapy (CIMT) was noted, together with the corrected age in months at which each intervention was started.

Diagnostic and clinical outcomes included corrected age in months at CP diagnosis and at referral to the CP reference centre. Motor type, laterality classified as unilateral or bilateral, and the first documented Gross Motor Function Classification System (GMFCS) level were recorded. Brain MRI findings were categorised according to the SCPE as maldevelopments, predominant white matter injury, predominant grey matter injury, miscellaneous findings, or normal (21). Use of standardised neurological and motor assessment tools, including HINE, GMs, and HAI, was also documented.

Statistical analysis

Data were analysed using IBM SPSS Statistics (version 29.0). Descriptive statistics were used to summarize patient characteristics and outcomes. Categorical variables are presented as counts and percentages, while continuous variables are described using means with standard deviations (SD) or medians with interquartile ranges (IQR), depending on distribution. Normality was assessed using the Shapiro-Wilk test. For group comparisons, independent samples t-tests were applied for normally distributed continuous variables and Mann-Whitney U tests when the assumption of normality was violated. Categorical variables were compared using chi-square tests. For some comparisons, statistical

testing could not be performed due to insufficient valid data in one of the groups. In these cases, results are reported descriptively without accompanying p-values. Visualizations were created in R using the ggplot2 package (22, 23).

Ethical approval

Ethical approval for this study was obtained from the Ethics Committee of University Hospital Leuven in accordance with institutional and national guidelines (S69315). Due to the use of existing medical records, the requirement for additional informed consent was waived by the ethics committee.

Results

Neonatal characteristics

We screened a total of 167 patient records. After excluding cases without a confirmed CP diagnosis, without NICU hospitalization, or meeting other exclusion criteria as described above, 78 patients were included in the final cohort for analysis, of whom 38 were born between 2006-2010 and 40 between 2016-2020 (see Figure 1). These cohorts correspond to the pre-implementation and post-implementation phases of the structured neonatal follow-up program, respectively. During these periods, a total of 3326 and 3417 infants were admitted to the NICU at UHL, respectively, providing the background population for this study.

Neonatal characteristics are summarized in table 1. The proportion of males was comparable between cohorts (63.2% in 2006-2010 vs. 60.0% in 2016-2020; $p=0.774$). Children in the recent cohort were significantly more often born extremely preterm (7.9% in 2006-2010 vs. 35.0% in 2016-2020; $p=0.034$). Birth weight did not differ between groups.

Retinopathy of prematurity was more frequently observed in the 2016-2020 cohort (21.1% in 2006-2010 vs. 53.8% in 2016-2020; $p=0.008$). Other neonatal complications, including BPD, sepsis, NEC and IVH did not differ significantly. Cystic periventricular leukomalacia was present in 15.8% in the 2006-2010 cohort versus 5% in the 2016-2020 cohort. At discharge, the routine clinical neurological examination was documented as normal in 64.9% of children in the 2006-2010 cohort and 72.5% in the 2016-2020 cohort ($p=0.709$).

Follow-up and interventions

The follow-up and intervention variables are summarized in table 2. In both cohorts, the corrected age at first follow-up was comparable (median 2 months corrected age in 2006-2010 vs. 1 month corrected age in 2016-2020; $p=0.165$), with the majority of children initially seen by the neonatology team (76.3% in 2006-2010 vs. 77.5% in 2016-2020). Among children with available documentation, the first recorded

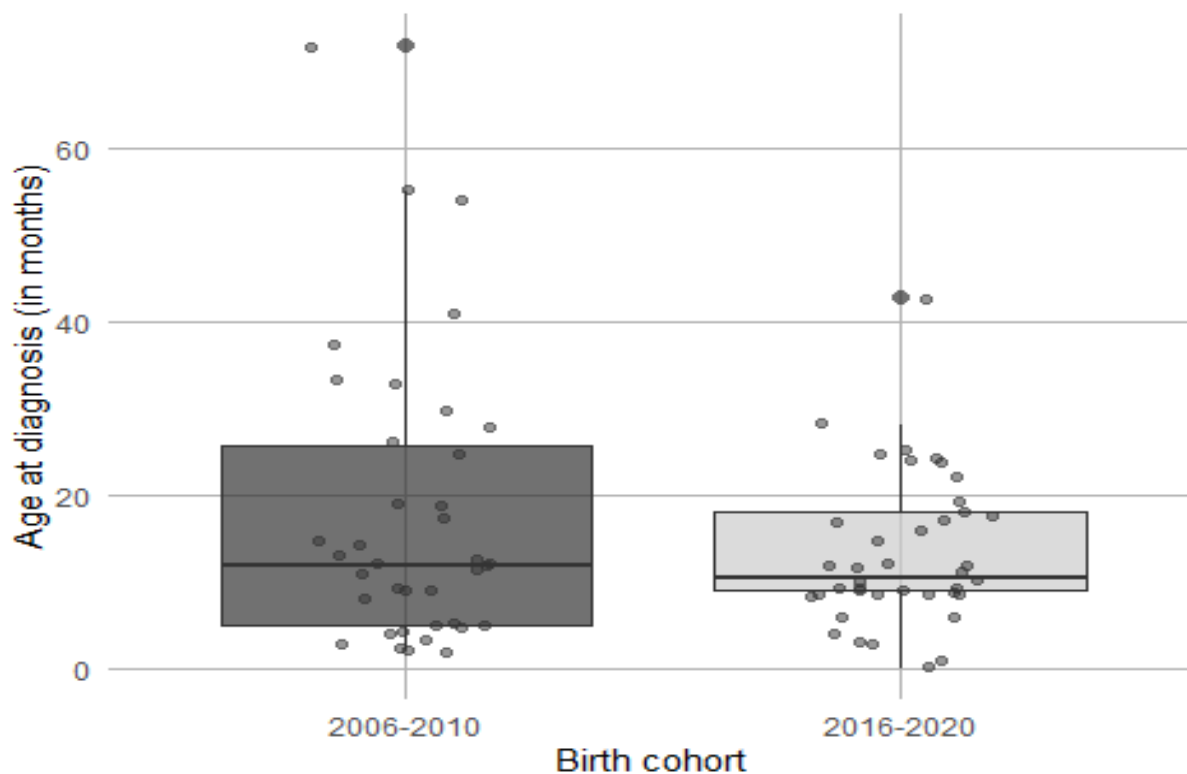


FIGURE 2: Age at cerebral palsy diagnosis by birth cohort. Boxplots showing the distribution of age (corrected age in months) at cerebral palsy (CP) diagnosis for the 2006–2010 and 2016–2020 birth cohorts. Each dot represents an individual child, the bold horizontal line indicates the median, the upper and lower lines represent the interquartile range (IQR).

communication of motor developmental concerns to parents occurred at a significantly younger corrected age in the 2016–2020 cohort (median 6 months corrected age in 2006–2010 vs. 0 months corrected age in 2016–2020; $p<0.001$). Documentation of parental communication was markedly more frequent in the post-implementation cohort (13% in 2006–2010 vs. 70% in 2016–2020).

The initiation of physiotherapy did not differ significantly (100% in 2006–2010 vs. 97.5% in 2016–2020; $p=0.327$). However, constrained induced movement therapy (CIMT) was both started more frequently (13.2% in 2006–2010 vs. 42.5% in 2016–2020; $p=0.004$) and at a significantly earlier age in the 2016–2020 cohort (mean 125.3 months corrected age in 2006–2010 vs. 14.7 months corrected age in 2016–2020; $p=0.016$). Similarly, home guidance was initiated at a younger age in the recent cohort (median 11 months corrected age in 2006–2010 vs. 2.5 months corrected age in 2016–2020; $p=0.024$).

Diagnostic and clinical outcomes

There was no significant difference in the time to diagnosis between the two cohorts (median 12 corrected age in 2006–2010 vs. 10.5 months corrected age in 2016–2020; $p=0.564$) (figure 2). The range was wider in the earlier cohort (2–72 months corrected age in 2006–2010 vs. 0–43 months corrected age

in 2016–2020), and a clear peak in diagnosis was observed at 9 months in the recent cohort. The median age of diagnosis decreased with increasing GMFCS scale and this was equal in the two cohorts ($p=0.016$) (figure 3). Referral to the CP reference centre occurred significantly earlier in the more recent cohort (median 33 months corrected age in 2006–2010 vs. 25 months corrected age in 2016–2020; $p<0.001$). In addition, the interval between diagnosis and referral was shorter (median 14.5 months corrected age in 2006–2010 vs. 6.0 months corrected age in 2016–2020; $p<0.001$) (figure 4).

On brain MRI, predominant white matter injury was the most common finding in both cohorts (84.2% in 2006–2010 vs. 84.6% in 2016–2020; $p=0.961$). No significant differences were observed between groups in the distribution of maldevelopment, white matter injury, or grey matter injury, although miscellaneous abnormalities were more frequently reported in the 2016–2020 cohort (21.1% in 2006–2010 vs 46.2% in 2016–2020; $p=0.020$).

The HINE was not used in the earlier cohort but was applied in 10 children in the 2016–2020 cohort. The GMs was not performed in either cohort. The HAI was performed once in the recent cohort.

TABLE 2: Follow-up and intervention variables. If data were missing, the number of included cases was indicated in parentheses.

Follow-up and intervention variables	Children born 2006-2010 (%) N = 38 (100)	Children born 2016-2020 (%) N = 40 (100)	P-Value
First follow-up, corrected age in months (IQR)	2 (2) (n=36)	1 (2) (n=39)	0.165
Mention to parents, corrected age in months, median (IQR)	6 (29) (n=5)	0 (0) (n=28)	<0.001
Physiotherapy			
Started	38 (100.0)	39 (97.5)	0.327
Corrected age in months, median (IQR)	3 (7)	4 (9)	0.811
Constrained-Induced Movement Therapy			
Started	5 (13.2)	17 (42.5)	0.004
Corrected age in months, mean (SD)	125.25 (65.53)	14.67 (15.31)	0.016
Home guidance			
Started	24 (63.2)	22 (55.0)	0.515
Corrected age in months, median (IQR)	11 (19)	2.5 (16)	0.024

TABLE 3: Diagnostic and clinical outcomes. If data were missing, the number of included cases was indicated in parentheses.

Diagnostic and clinical outcomes	Children born 2006-2010 (%) N = 38 (100)	Children born 2016-2020 (%) N = 40 (100)	P-Value
Time of diagnosis, corrected age in months, median (IQR)	12 (22)	10.5 (9)	0.564
Referral to CP reference centre, corrected age in months, median (IQR)	33 (18) (n=38)	25 (17) (n=39)	<0.001
Motor type (%)			0.045
Spastic	36 (94.7)	32 (88.9)	
Dyskinetic	2 (5.3)	0 (0.0)	
Ataxic	0 (0.0)	0 (0.0)	
Mixed	0 (0.0)	4 (11.1)	
Unilateral – bilateral (%)			0.890
Unilateral	15 (39.5)	16 (41.0)	
Bilateral	23 (60.5)	23 (59.0)	
First GMFCS documented (%)			0.299
GMFCS I	19 (50)	20 (51.3)	
GMFCS II	8 (21.1)	9 (23.1)	
GMFCS III	7 (18.4)	4 (10.3)	
GMFCS IV	2 (5.3)	6 (15.4)	
GMFCS V	2 (5.3)	0 (0.0)	
MRI			
Maldevelopment (%)	6 (15.8)	5 (12.8)	0.710
Predominant white matter injury (%)	32 (84.2)	33 (84.6)	0.961
Predominant grey matter injury (%)	8 (21.1)	5 (12.8)	0.335
Miscellaneous (%)	8 (21.1)	18 (46.2)	0.020
Normal (%)	1 (2.6)	0 (0.0)	0.367

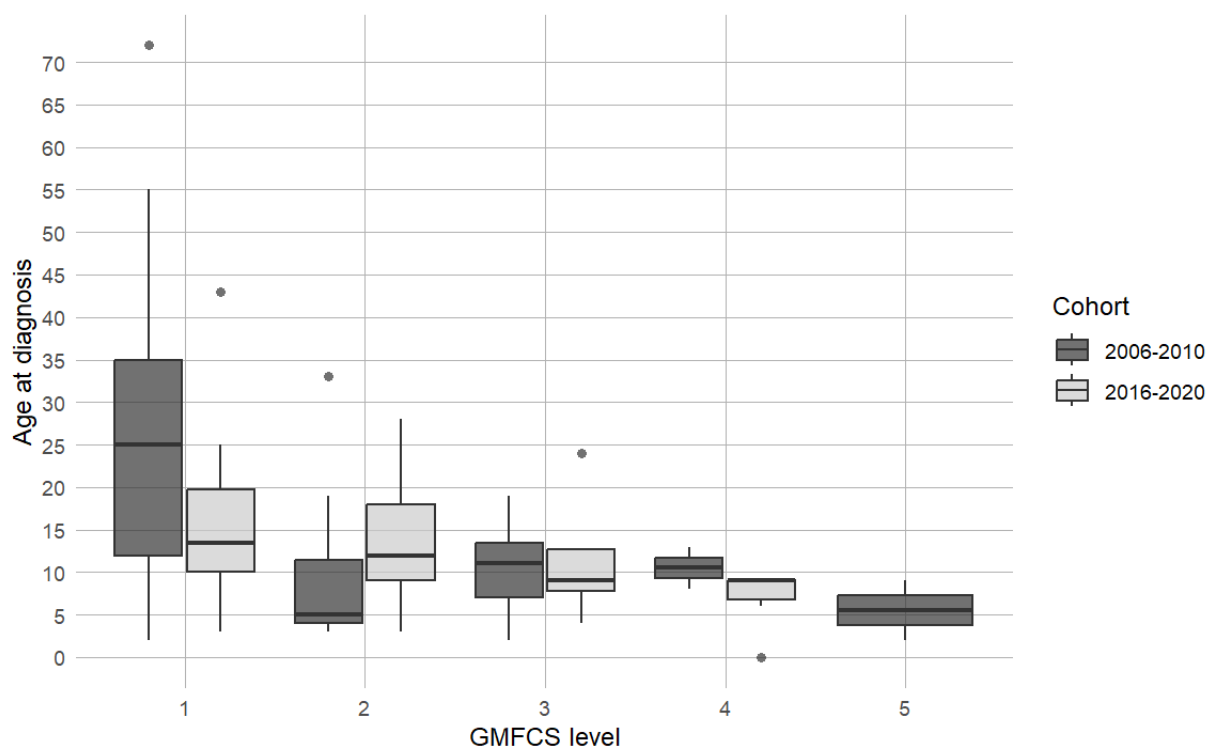


FIGURE 3: Age at cerebral palsy diagnosis by GMFCS level and birth cohort. Boxplots showing the age (corrected age in months) at cerebral palsy (CP) diagnosis by Gross Motor Function Classification System (GMFCS) level for the 2006-2010 (dark) and 2016-2020 (light) birth cohorts. The bold horizontal line indicates the median, the upper and lower lines represent the interquartile range (IQR). For GMFCS level 5, no cases were present in the 2016-2020 cohort.

Discussion

In this study, we investigated changes in the timing and approach to CP diagnosis in two high-risk neonatal birth cohorts a decade apart. We hypothesized that the implementation of structured and reimbursed neonatal follow-up within the Belgian prematurity convention in 2012 would result in earlier diagnosis of CP, as well as earlier referral and initiation of intervention.

The results show that the median age at diagnosis did not differ significantly between the two birth cohorts, with a median of 10.5 months corrected age in the most recent cohort. Contrary to our hypothesis, the introduction of structured follow-up was not associated with a statistically significant reduction in age at diagnosis. Nevertheless, the observed diagnostic age is close to that reported in international studies following full implementation of early detection guidelines. Maitre et al. reported a reduction in median diagnostic age from 19.5 months (95% CI 16.2-22.8) to 9.5 months (95% CI 4.5-14.6) following introduction of a standardised early detection pathway (14). Ryder et al. observed a decrease from 18.5 to 7.5 months after implementing a quality improvement initiative (24). Notably, the diagnostic age observed in our recent cohort approached these international findings despite the limited routine use of standardised assessments such as the GMs, HINE, and HAI at UHL during the study period. More systematic integration of these tools may therefore offer further opportunities to advance early detection. International initiatives across different clinical settings

emphasize that their successful implementation requires coordinated multidisciplinary pathways (25).

Several factors may explain why no significant reduction in diagnostic age was observed. First, elements of structured follow-up and heightened clinical awareness may already have been present at our centre prior to the formal implementation of the prematurity convention in 2012, thereby attenuating measurable differences between cohorts. Second, the study population consisted exclusively of high-risk infants admitted to a tertiary NICU, who are likely to have benefited from closer surveillance and earlier recognition of motor abnormalities even before standardisation. Together, these factors suggest that the incremental effect of formal reimbursement and structuring of follow-up may be more difficult to detect in such a setting.

The higher proportion of extremely preterm children in the 2016-2020 cohort may partly explain the higher frequency of ROP, as lower gestational age is an important risk factor for ROP. However, because the study included only children with CP rather than all infants admitted to the NICU, these findings should not be interpreted as temporal trends in the overall NICU population. As extremely preterm infants are eligible for structured neonatal follow-up and closer surveillance, the difference in gestational age distribution may have influenced the timing of CP recognition. The independent contribution of gestational age and ROP to diagnostic age could not be determined in this relatively small cohort. As expected, children with more

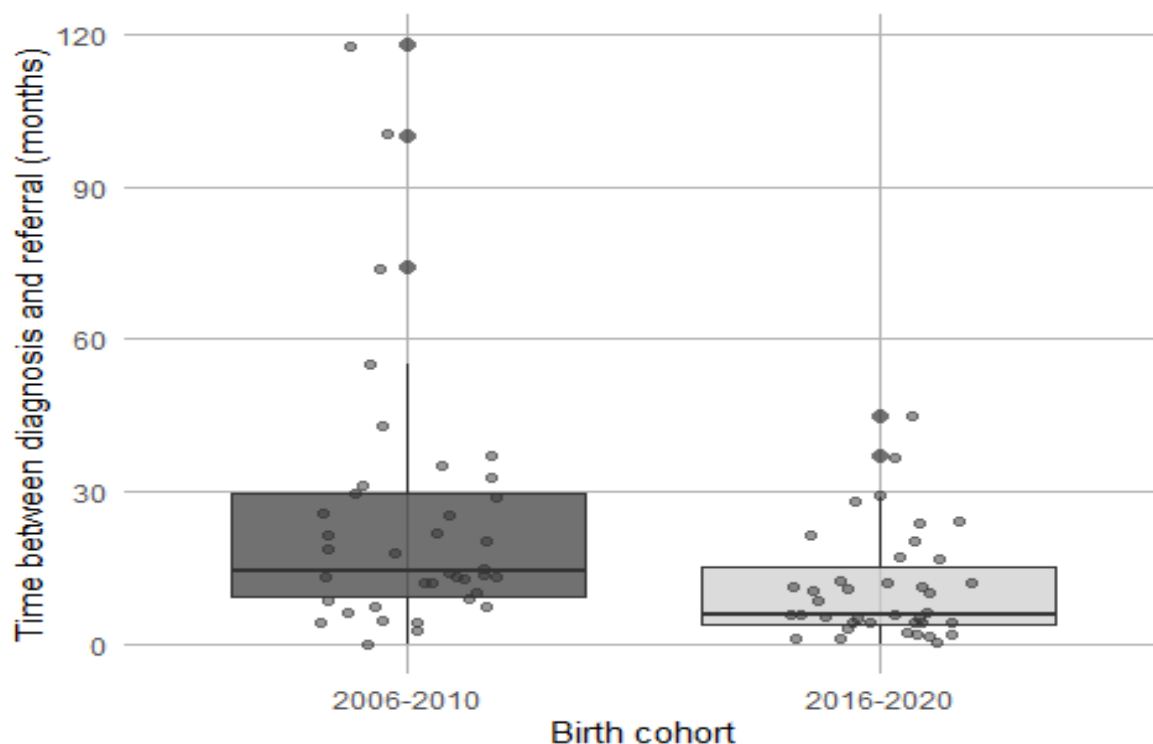


FIGURE 4: Time between diagnosis and referral by birth cohort. Boxplots showing the interval (in months) between cerebral palsy (CP) diagnosis and referral to the CP reference center for the 2006-2010 and 2016-2020 birth cohorts. Each dot represents an individual child, the bold horizontal line indicates the median, the upper and lower lines represent the interquartile range (IQR).

severe motor impairment (higher GMFCS levels) were diagnosed earlier, likely because clinical signs are more apparent and developmental deviations more pronounced in infancy. This association between functional severity and earlier diagnosis has been consistently reported in literature, including by McIntosh (26). This finding underscores the ongoing challenge of timely identification of children with milder motor impairments, who may present with subtler signs and are therefore at higher risk of delayed diagnosis. The relatively high proportion of examinations documented as normal at discharge should also be interpreted cautiously, as these were routine, non-standardised clinical assessments performed by a neonatologist or paediatric resident. Subtle neurological abnormalities may therefore not have been detected or documented at that time.

The distinct diagnostic peak at 9 months corrected age may partly reflect the timing of scheduled assessments within the national prematurity follow-up program, which provides standardised assessments for infants born before 31 weeks of gestation and/or below 1500 g. Consistent follow-up at predefined intervals facilitates early recognition of motor difficulties. However, the clustering of diagnoses around the nine-month assessment also suggests that scheduled visits may influence the timing of diagnosis. Earlier risk-based assessments using recommended standardised tools could allow selected high-risk infants to be identified before nine months, although our study was not designed to determine the optimal timing or

frequency of follow-up assessments. Supporting the value of systematic follow-up, Hubermann et al. found that children with a history of NICU admission received a CP diagnosis at a younger age compared to those without NICU hospitalization, highlighting the added value of systematic follow-up after intensive care (27).

In the available medical records, communication of motor developmental concerns to parents was documented at a significantly earlier age among children with available data in the 2016-2020 cohort. This communication was also documented for a substantially higher proportion of children in the more recent cohort, suggesting more consistent recording in the medical files. However, the comparison of timing should be interpreted cautiously, as this information was missing for most children in the 2006-2010 cohort. It therefore remains unclear whether the observed difference reflects earlier communication itself, changes in documentation practices, or both. Early communication of developmental concerns, when it occurs, may facilitate timely referral and intervention, while also providing parents with earlier psychosocial support and reducing uncertainty. Furthermore, referral to the CP reference centre occurred significantly earlier, and the interval between diagnosis and referral was shorter, suggesting improved coordination and accessibility to specialised care.

Despite earlier documented communication of motor developmental concerns in the more recent cohort, physiotherapy was not initiated earlier. However,

physiotherapy was nearly universal and was already initiated at a young, corrected age in both cohorts, leaving limited room for further reduction in age at initiation. Moreover, because information on the timing of communication was unavailable for many children, the temporal relationship between communication and initiation of physiotherapy could not be reliably assessed. In contrast, CIMT was initiated both more frequently and at an earlier age. Only 5 infants in the 2006-2010 cohort received CIMT, whereas its more frequent use in the later cohort may reflect the growing body of evidence supporting its effectiveness in improving hand function and bimanual activities, as well as its inclusion in international guidelines (7, 28, 29). In our cohort, CIMT was used in children with unilateral CP and in selected children later classified as having bilateral CP with marked asymmetry of upper-limb involvement.

Taken together, several components of the diagnostic and care pathway differed favourably in the more recent cohort. However, these changes cannot be attributed to structured neonatal follow-up alone. During the study interval, awareness of early CP detection increased, international diagnostic and early-intervention guidelines were disseminated, rehabilitation practices evolved, and local documentation and referral pathways may have changed. The observed differences may therefore reflect the combined influence of structured follow-up and broader developments in early CP care.

A major strength of this study is the comparison of two birth cohorts a decade apart, enabling evaluation of temporal changes in diagnostic timing and follow-up practices. Despite recommendations, standardised tools such as HINE, GMs, and HAI were infrequently used in both cohorts, indicating room for improvement in local practice. This finding aligns with the conclusions of Hidalgo-Robles et al., who identified major implementation barriers, including limited training, staffing constraints, and lack of coordinated pathways, despite widespread agreement on the clinical value of these tools (30). Our findings therefore provide an important benchmark for evaluating the impact of future implementation of early detection guidelines. One example is that, since 2021, standardized HAI assessments have been implemented in the clinical follow-up program at UHL for children at risk for developing unilateral CP, and CIMT has been initiated as early as 4 months of age. As implementation continues, further improvements in early diagnosis, intervention, and outcomes may be expected. The findings are directly relevant for clinicians involved in high-risk infant follow-up programs and support the alignment of local care pathways with international early detection guidelines. Limitations include the retrospective design and reliance on the completeness of medical records. Missing data affected several variables and were more pronounced for some outcomes in the earlier cohort, potentially introducing information and documentation

bias and limiting the reliability of comparisons between cohorts. Assessments, interventions, or communications occurring outside the available medical records may have been missed, and the absence of documentation cannot be interpreted as evidence that these did not occur. Additional limitations include the potential underrepresentation of children diagnosed outside our reference centre and the single-centre setting. The relatively small sample size, combined with the considerable variability in age at diagnosis, particularly in the earlier cohort, may have limited the ability to detect a modest but potentially clinically relevant difference between cohorts. Larger, preferably multicentre studies are therefore needed to evaluate changes in diagnostic timing with greater statistical precision. Because cohort allocation was based on calendar period, the potential contribution of structured neonatal follow-up could not be separated from other concurrent changes in clinical practice and documentation. Nevertheless, these results provide a realistic reflection of diagnostic practice in a tertiary NICU setting and highlight key opportunities for advancing early CP detection.

Conclusion

This study provides insight into how the diagnostic process of cerebral palsy (CP) in a high-risk neonatal population has evolved over time. In contrast to our initial hypothesis, no significant reduction in age at diagnosis was observed between the two birth cohorts. Nevertheless, the median age at diagnosis in the most recent cohort was comparable to that reported in international programs with full implementation of early detection guidelines.

The more recent cohort was characterized by more frequent documentation of communication about motor concerns, earlier referral to specialised care, and more timely initiation of interventions such as CIMT and home guidance. Among children with available data, communication was also documented at an earlier age, although this finding should be interpreted cautiously because of substantial missing data in the earlier cohort. While causal relationships cannot be established, these findings suggest improvements in clinical practice and care organisation over time.

Together, these results indicate favourable changes over time in several components of the early recognition and management of CP. Further integration of evidence-based assessment tools such as GMs, HINE, and HAI, alongside continued optimization of follow-up pathways, may help to further enhance early detection and improve outcomes.

Conflict of interest statement

The authors declare that they have no conflicts of interest relevant to this study.

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Lung
Pediatrics

BELGIAN
RESPIRATORY
SOCIETY

NIEUW



De Belgian Respiratory Society (BeRS) organiseert de “1st Belgian Paediatric Lung Day” gewijd aan de respiratoire gezondheid van kinderen

EEN NIEUWE ONTMOETINGSPLEK VOOR DE PEDIATRISCHE PNEUMOLOGIE

Dit nieuwe Engelstalige programma, georganiseerd door de Paediatric Lung Working Group van de Belgian Respiratory Society (BeRS), vindt plaats op 11 december 2026 in het BMCC in Brugge en wil van deze eerste editie het startpunt maken van een jaarlijkse afspraak voor professionals die betrokken zijn bij de respiratoire zorg voor kinderen.

- Van astma en complexe luchtwegaandoeningen tot de zorg voor kinderen met neurologische of neuromusculaire aandoeningen: pediatrische pneumologie vereist specifieke expertise en een multidisciplinaire aanpak.
- Deze eerste editie richt zich tot kinderpneumologen, kinderartsen, pneumologen, huisartsen, kinesitherapeuten, verpleegkundigen en andere zorgprofessionals die betrokken zijn bij de respiratoire zorg voor kinderen. De deelnemers krijgen de kans om van gedachten te wisselen over de nieuwste wetenschappelijke inzichten, complexe klinische casussen en de belangrijkste uitdagingen waarmee jonge patiënten en hun families worden geconfronteerd.
- Het programma besteedt ook aandacht aan de impact van de omgeving op de respiratoire gezondheid van kinderen, waaronder roken, vaperen en het bevorderen van een rookvrije zwangerschap.

EEN SESSIE GEWIJD AAN COMPLEXE CASUSSEN

Deze interactieve sessie is gewijd aan de bespreking van complexe casussen van pediatrisch astma, met bijzondere aandacht voor diagnose, behandeling, opvolging en psychosociale aspecten.

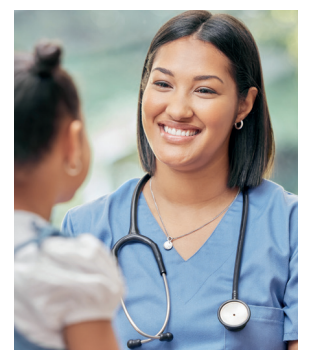
- Wilt u een casus indienen?
- Stuur uw abstract uiterlijk op 9 november 2026 naar karin.decaestecker@azdelta.be en maak kans om uw casus te presenteren en te bespreken met experts en deelnemers.



JONG WETENSCHAPPELIJK TALENT IN DE KIJKER

Heeft u een interessante klinische casus om te delen of wetenschappelijke resultaten om te presenteren?

- Grijp deze eerste editie aan om uw werk in de kijker te zetten en actief bij te dragen aan het wetenschappelijke programma.
- Dien uw abstract in binnen één van de twee categorieën: Clinical Case of Scientific Abstract.
- De geselecteerde abstracts worden mondeling gepresenteerd tijdens het congres en de beste abstract in elke categorie wordt bekroond met een prijs van € 500.
- Abstracts moeten in het Engels worden opgesteld, beperkt zijn tot 350 woorden en uiterlijk op 9 november 2026 worden verzonden naar ckempeneers@chuliege.be.



« Met deze eerste editie willen we een ontmoetingsplek creëren waar Belgische professionals die betrokken zijn bij de zorg voor kinderen met respiratoire aandoeningen hun kennis kunnen delen, van elkaar kunnen leren en samen kunnen nadenken over de uitdagingen van morgen. »

Prof. Céline Kempeneers, Chair BeRS Working Group Lung Pediatrics



PRAKTISCHE INFORMATIE

- Inschrijvingen en informatie over het indienen van abstracts vindt u op www.bers.be.
- Plaats en datum: BMCC – Brugge – Vrijdag 11 december 2026
- De deelnemers aan dit evenement krijgen eveneens toegang tot het programma van de Belgian Pneumology Days 2026, die op vrijdag 11 december gelijktijdig plaatsvinden in het BMCC.