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Cerebral palsy in Norwegian children according to birth characteristics

ORIGINAL ARTICLE

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Background and aim
The aim of this study was to examine trends in the prevalence of cerebral palsy according to birth characteristics among Norwegian children born between 2002 and 2018, as well as associations between birth characteristics, subtypes of cerebral palsy and gross motor function.

Material and method
Data from the Norwegian Quality and Surveillance Registry for Cerebral Palsy were linked with the Medical Birth Registry of Norway. The prevalence of cerebral palsy per 1000 live births was calculated for the categories gestational age at birth, birth weight and small for gestational age. Trends were analysed using logistic regression, and distributions by subtype and level of gross motor function were analysed using descriptive statistics.

Results
Among 1,006,537 live-born children, 1897 were diagnosed with cerebral palsy. Most children with cerebral palsy were born at term with a normal birthweight. The prevalence of cerebral palsy was higher among children born preterm, with a low birth weight or small for gestational age. The prevalence among term-born children decreased from 1.30 per 1000 live births in 2002 to 0.90 in 2018 (−3.4 % per year, odds ratio (OR) 0.966; 95 % confidence interval (CI) 0.954 to 0.978), while the prevalence among preterm children remained stable. Most children had spastic hemiplegia or diplegia and mild gross motor impairment across birth characteristics.

Interpretation
The prevalence of cerebral palsy in children born at term has decreased, but they still constitute the majority. Across birth characteristics, children predominantly had less severe subtypes and mild gross motor impairments.

Main findings

Most children with cerebral palsy were born at term with a normal birth weight, and the prevalence in these groups decreased during the period 2002–18.

The prevalence of cerebral palsy was highest in children born preterm, children with a low birth weight and children born small for gestational age.

Most children with cerebral palsy had mild gross motor impairments, irrespective of birth characteristics.

Cerebral palsy is a group of disorders affecting movement and posture, and it is the most common childhood-onset physical disability (1). The condition is caused by non-progressive injury or malformation in the immature brain (1). The injury occurs either during pregnancy, childbirth, or within 28 days after birth (pre-/perinatal cerebral palsy), or between 28 days after birth and two years of age (post-neonatal cerebral palsy). People with cerebral palsy often have associated impairments, such as epilepsy, as well as difficulties related to cognition, communication, pain, vision and hearing (1).

The presence of multiple risk factors increases the likelihood of cerebral palsy, including preterm birth (born before 37 weeks gestation) (2, 3) and a low birth weight (below 2500 g) (4). Studies suggest that risk factors may be part of complex causal pathways leading to cerebral palsy, but it remains unclear how the individual factors contribute and how they interact (2, 3).

In Norway, the average prevalence of cerebral palsy was 2.2 per 1000 live births during the period 1996–2018, with a substantial decline from 2.6 in 1996 to 1.5 in 2018 (5). This decline may be associated with improvements in obstetric and neonatal care (6, 7). Prevalence stratified by birth characteristics has not previously been reported in Norway, and such stratification may provide greater insight into differences in risk factors and underlying causes than overall estimates.

The primary aim of this study was to investigate trends in the prevalence of cerebral palsy according to birth characteristics in Norwegian children. A secondary aim was to analyse associations between birth characteristics, subtypes and gross motor function.

Material and method

Study design and population

This registry-based study encompasses live births in Norway during the period 2002–2018. Data on children with pre- and perinatal cerebral palsy were obtained from the Norwegian Quality and Surveillance Registry for Cerebral Palsy (NorCP) as of 31 December 2023. Children with post-neonatal cerebral palsy were excluded as the causes are related to events occurring after the neonatal period and therefore do not reflect injuries occurring before, during or shortly after birth. During the study period, approximately 95 % of all children born with cerebral palsy in Norway were included

in NorCP (5). The information in this study is based on NorCP's medical registration form completed at five years of age, when the subtype of cerebral palsy is confirmed (8). NorCP data were linked to the Medical Birth Registry of Norway.

Variables

Gestational age at birth and birth weight were categorised into groups based on established clinical and epidemiological classifications reflecting risk groups with differing prognoses for cerebral palsy (9). Gestational age at birth was classified as extremely preterm (< 28 weeks), very preterm (28–31 weeks), moderate preterm (32–36 weeks) and term (≥ 37 weeks). The group with gestational age ≥ 42 weeks was excluded as the number of children with cerebral palsy born post-term was fewer than five. Birth weight was also classified into four groups: extremely low (< 1000 g), very low (1000–1499 g), low (1500–2499 g) and normal (> 2499 g). Children classified as small for gestational age were defined using z-scores calculated by the Medical Birth Registry. A z-score indicates how many standard deviations a birth weight is from the mean for infants with the same gestational age and sex. We used a cut-off of −1.28, corresponding to the 10th percentile, in line with standard clinical practice and research (10,11).

Subtypes of cerebral palsy were classified based on ICD-10 diagnoses: G80.0 spastic quadriplegic, G80.1 spastic diplegic, G80.2 spastic hemiplegic, G80.3 dyskinetic, G80.4 ataxic and G80.8/G80.9 other/unspecified cerebral palsy (12). Gross motor function was classified using the Gross Motor Function Classification System, which consists of five levels. Level I describes children who walk without limitations, while Level V includes children who are dependent on a wheelchair for mobility (13). The levels were grouped into three categories: I–II representing mild impairment, III moderate impairment and IV–V severe gross motor impairment.

Statistics

Descriptive statistics (numbers and percentages) were used to describe live-born children with and without cerebral palsy, as well as the distribution of subtypes and gross motor function levels across categories of gestational age, birth weight and whether children were small or appropriate for gestational age.

The prevalence of cerebral palsy per 1000 live births, with 95 % confidence intervals (CI), was calculated according to birth characteristics. Logistic regression with year of birth as a covariate was used to estimate trends in prevalence (odds ratios (OR) with 95 % CI). Fractional polynomials were used to assess non-linear trends, with year of birth as a covariate. A sensitivity analysis was also performed for children with cerebral palsy born at term who were small for gestational age, to assess a potential association with intrauterine growth restriction (14).

Only observations with complete data were included in the analyses.

Ethics

The NorCP is a consent-based registry governed by the Regulation on Medical Quality Registries. Release of data was assessed by the data controller for NorCP and conducted in accordance with the registry's purpose and applicable data protection legislation. The study was approved by the Regional Committee for Medical and Health Research Ethics in Central Norway (reference number 2011/754).

Results

A total of 1,006,537 live-born children were included in the study. Of these, 1897 were diagnosed with cerebral palsy; 1116 (58.8 %) boys and 781 (41.2 %) girls. Most children with cerebral palsy were born at term, or had a normal birth weight, or were appropriate for gestational age (Table 1).

The prevalence of cerebral palsy was highest among children born extremely or very preterm, or with extremely low or very low birth weight (Table 1).

Trends in the prevalence of cerebral palsy

The prevalence of cerebral palsy in term-born children decreased during the study period (Figure 1d). The likelihood of a term-born child being diagnosed with cerebral palsy decreased by a factor of 0.966 per year (95 % CI 0.954 to 0.978), corresponding to an annual reduction of 3.40 %, assuming a linear model. The prevalence was stable among children who were born extremely preterm (OR 0.985; 95 % CI 0.955 to 1.016), very preterm (OR 0.998; 95 % CI 0.973 to 1.023) and moderate preterm (OR 0.986; 95 % CI 0.963 to 1.009) (Figures 1a–c).

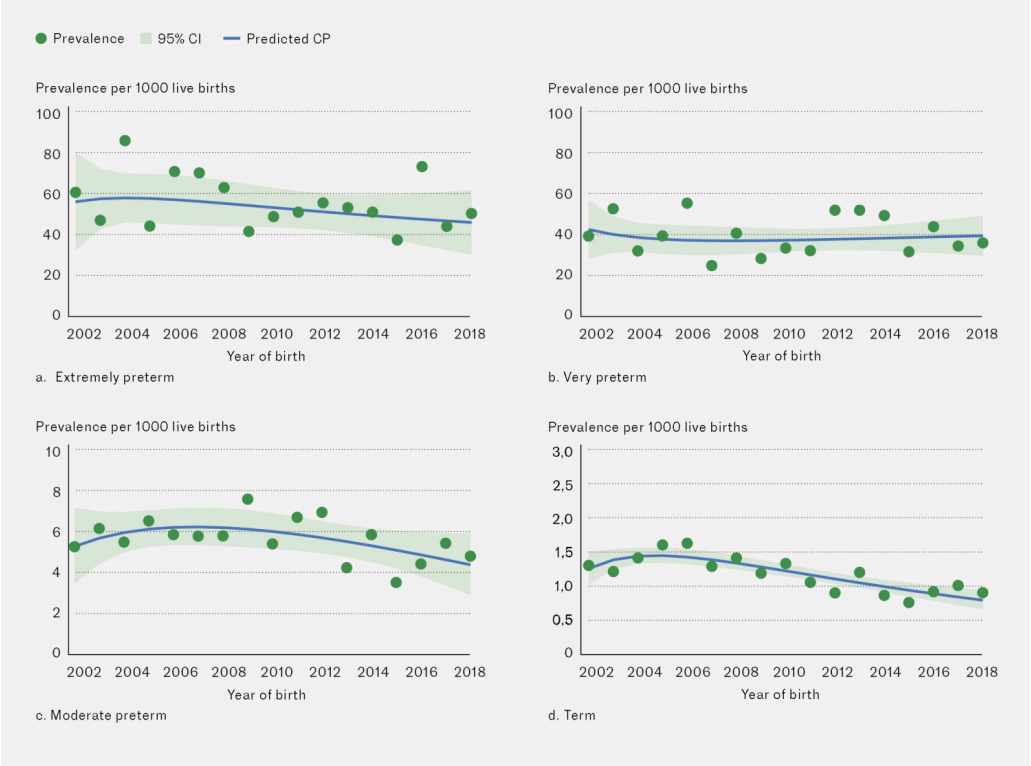

Figure 1 Trends in the prevalence of cerebral palsy (CP) per 1000 live births according to gestational age at birth: (a) extremely preterm, (b) very preterm, (c) moderate preterm and (d) term. The dots represent the observed prevalence, the solid line shows the predicted CP prevalence and the grey area indicates the 95 % confidence interval (CI).

As with gestational age, the prevalence of cerebral palsy among children with a normal birth weight decreased, from 1.43 per 1000 live births in 2002 to 0.92 in 2018, corresponding to an annual reduction of 3.63 % (OR 0.964; 95 % CI 0.952 to 0.975). A similar decline was observed among children who were appropriate for gestational age, from 1.84 per 1000 live births in 2002 to 1.42 in 2018 (OR 0.972; 95 % CI 0.962 to 0.982).

The prevalence among children with a low birth weight decreased from 9.07 per 1000 live births in 2002 to 6.55 in 2018 (OR 0.975; 95 % CI 0.954 to 0.997), while remaining stable among children with extremely low (OR 0.987; 95 % CI 0.956 to 1.020) or very low (OR 1.011; 95 % CI 0.982 to 1.041) birth weight.

The prevalence of cerebral palsy among children born small for gestational age decreased by a factor of 0.959 (95 % CI 0.938 to 0.981), corresponding to an annual reduction of 4.09 % (Figure 2a). A sensitivity analysis of children born small for gestational age at term showed a stable prevalence (OR 0.980; 95 % CI 0.951 to 1.010) (Figure 2b).

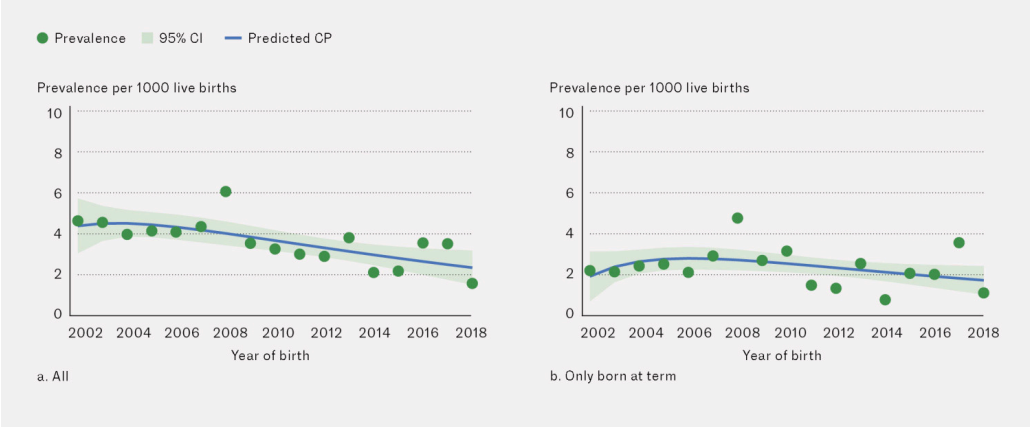

Figure 2 Trends in the prevalence of cerebral palsy (CP) per 1000 live births among children born small for gestational age. (a) all children born small for gestational age and (b) only children born small for gestational age at term. The dots represent the observed prevalence, the solid line shows the predicted CP prevalence and the grey area indicates the 95 % confidence interval (CI).

Clinical characteristics of cerebral palsy

Among children with cerebral palsy who were born either at term or with a normal birth weight, more than half had spastic hemiplegia (Table 2). Children who were appropriate for gestational age and those born small for gestational age most commonly had spastic hemiplegia, but the proportion was lower among the latter. In contrast, children born preterm or with a low birth weight most commonly had spastic diplegia. Most children with spastic quadriplegia, dyskinetic or ataxic cerebral palsy, or those classified as having other/unspecified cerebral palsy were born at term and/or with a normal birth weight (Table 2).

Most children had mild gross motor impairment and constituted the largest proportion across all categories of birth characteristics (Table 3).

Discussion

Most children with cerebral palsy were born at term, or had a normal birth weight, or were appropriate for gestational age; however, the prevalence in these groups has decreased over time. The prevalence was highest among extremely preterm children and declined towards term, with a similar pattern observed for birth weight, where prevalence decreased with increasing weight. Although the prevalence among children born small for gestational age decreased, it remained stable among term-born children who were small for gestational age.

Spastic subtypes and mild gross motor impairment predominated across all categories of birth characteristics. Children born at term had less severe motor impairment, as spastic hemiplegia was most common in this group. Spastic diplegia occurred more frequently in preterm children and those with a lower birth weight.

Internal validity

The study included prospective data from two national registries. The Medical Birth Registry of Norway includes all births in Norway, and NorCP had an approximate coverage of 95 % during the study period (5), which strengthens the representativeness of the findings. In addition, all subtypes were confirmed at five years of age. NorCP uses internationally recognised and validated criteria in its data collection, which reduces information bias and enables comparison with international studies.

Given the large study population, it is unlikely that the findings in the largest groups are due to random variation. However, some categories had fewer children, particularly the rarer subtypes and the subgroups of children born preterm or with the lowest birth weights. Findings in these groups should therefore be interpreted with caution.

Comparison with other studies

A decline in the prevalence of cerebral palsy among term-born children has also been reported in Sweden (15–17). A Danish study identified an increase in the prevalence among preterm children (18), which the authors attributed to reduced neonatal mortality and a more proactive approach to obstetric and neonatal care. In Australia and Canada, declines have been observed in both preterm and term-born children (19,20), with advances in neonatal care highlighted as a key factor underlying increased survival without a corresponding rise in cerebral palsy.

The prevalence of cerebral palsy in children born small for gestational age decreased but remained twice as high as in children who were appropriate for gestational age. A similar trend has been observed in Canada (20). This supports the notion that being small for gestational age is a risk factor for cerebral palsy (21).

Spastic hemiplegia was most common among term-born children and those with a higher birth weight, while spastic diplegia was more common in preterm children and those in lower birth weight categories, which is consistent with findings from Denmark and Australia (18,19).

Interpretation of the findings

The decline in the prevalence of cerebral palsy among term-born children may be related to advances in obstetric and neonatal care. Improved fetal monitoring during labour, including more systematic use of cardiotocography and ST analysis for early identification of fetal distress, may have reduced the incidence of intrapartum hypoxia leading to brain injury (22–24). In 2007, therapeutic hypothermia was introduced in Norway to treat hypoxic-ischaemic encephalopathy in term-born infants. Although this treatment reduces the risk of death and cerebral palsy, the condition accounts for only a small proportion of cerebral palsy diagnoses among term-born children (25). The observed decline can therefore only be partly attributed to this intervention.

A previous Norwegian study showed an increased risk of cerebral palsy in children born post-term (≥ 42 weeks) (26). A shift towards earlier induction at term has reduced the risk of post-term complications and, consequently, the risk of cerebral palsy (27).

We cannot exclude the possibility that this may have contributed to a slight reduction in cerebral palsy diagnoses. In our dataset, fewer than five post-term children had cerebral palsy.

To date, no studies have quantified the impact of changes in prenatal diagnostics or pregnancy termination for fetal anomalies on the prevalence of cerebral palsy. Although the abortion rate in Norway has decreased (1975–2021), the proportion of second-trimester terminations due to fetal anomalies has increased in recent years (1999–2021) (28). It is unclear whether prenatal genetic testing has led to an increase in terminations in cases where the child would have developed cerebral palsy. However, the number of such instances, given the low prevalence of malformations that can lead to cerebral palsy, is likely to be very low and unlikely to have influenced the overall prevalence trends in our data.

Our study showed a stable prevalence of cerebral palsy in preterm children. Despite a decline in the proportion of preterm births and perinatal deaths in Norway, increased survival among the most preterm children – who are at highest risk of cerebral palsy – may have pushed up the prevalence. Meanwhile, advances in obstetric and neonatal care may have reduced the risk of brain injury among preterm children (29). These opposing effects may, in combination, explain the observed stable trend.

We found a decrease in cerebral palsy in children born small for gestational age. These infants are at increased risk of intrauterine growth restriction, congenital anomalies and brain injury, and many of the relevant mechanisms are of antenatal origin (21,30). In the sensitivity analysis, a decline was observed in preterm children born small for gestational age, while the prevalence was stable in term-born children who were small for gestational age. This difference is to be expected because improved management of antenatal and perinatal risk factors such as pre-eclampsia, gestational hypertension and intrauterine infections particularly affects the risk of brain injury in preterm children, whereas the risk profile of term-born children who are small for gestational age is less impacted by these mechanisms (31,32).

Preterm children had an increased risk of spastic diplegia, which is typically a result of injury to the cerebral white matter. The brain is particularly vulnerable to this type of injury early in the third trimester (33). Term-born children were more likely to have spastic hemiplegic, dyskinetic or ataxic cerebral palsy. These subtypes are usually related to brain injuries such as cerebral infarction, hypoxic-ischaemic encephalopathy or genetic variants (33).

Conclusion

The study shows that most children with cerebral palsy are born at term with a normal birth weight. The prevalence in these groups declined over the period 2002–18. Prevalence was higher in preterm children, children with a low birth weight and children born small for gestational age. Across birth characteristics, spastic hemiplegia and diplegia were the most common subtypes, and most children had mild gross motor impairments. Future research should continue to monitor changes in the prevalence of cerebral palsy, strengthen early identification and treatment of at-risk children and advance understanding of the underlying pathological mechanisms leading to the condition.

The article has been peer-reviewed.

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