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Parental decisions to divorce and have additional children among families with children with cerebral palsy: Evidence from Swedish longitudinal and administrative data

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Abstract

This study analyzes the relationship of having a child with the early-onset disability cerebral palsy (CP) and the parental decision to divorce and to have additional children. We use longitudinal matched case-control data from multiple linked Swedish National Population Registers between 2001 and 2015 and perform Cox proportional hazards regressions with interval-censoring. Although we do not find a general excess parental divorce risk on CP relative to the comparison group without CP, we find that having a child with CP increases the risk of divorce for parents with low education. We also find that having a child with CP reduces the likelihood of having additional children, especially for mothers in the older age range (maternal age at delivery >33 years) and parents with low education. The severity level of the disability, as indicated by gross motor function, is not related to the results. These findings should be understood in the Swedish context, which provides extensive welfare support (e.g., personal assistance). If future studies would find adverse results in countries with less social care and benefits, our results may indicate that it is possible to mitigate negative consequences for the family of a child with disability.

KEYWORDS
cerebral palsy, divorce, early-onset disability, family formation, register-based study

1 | INTRODUCTION

Understanding the relationship between having a child with disability and parental outcomes is important because it may motivate interventions that mitigate adverse consequences affecting, for example, health, employment, and family. Raising a child with disability can lead to higher parental emotional and financial stress, compared to raising a typically developing child (Basaran et al., 2013; Bourke-Taylor et al., 2014; Gallagher & Hannigan, 2014; Majnemer et al., 2012), and thereby may lead to adverse consequences for the family formation. Parents of a child with disability might have an increased risk of divorce, and parents who do not divorce might postpone or decide against having additional children more often than their counterparts with typically developing children. Assuming that parents of children with disabilities and typically developing children alike originally wanted, on average, the same number of children, the latter can be seen as an adverse consequence.

Children with disabilities might require more care, attention, and resources than their typically developing peers and are, thus, especially vulnerable to loss of parental time and emotional stress, which often follow divorce (Huff & Hartenstein, 2020). Divorce causes increased financial insecurity and lower socioeconomic status (Försäkringskassan, 2020), especially for women and children (Tach & Eads, 2015). This, in turn, leads to reduced childrens' educational attainment (Brand et al., 2019) and several negative long-term outcomes in terms of health and labor market achievements (Case & Paxson, 2006; Cho & Heshmati, 2015; Strenze, 2007; Wei & Feeny, 2019). Thus, having a child with disability may lead to a double burden for both the parents and the child, where the observed worse health and lower educational level among individuals with disabilities are due to both the disability itself and excessive divorce rates.

Adverse family-related consequences could potentially be mitigated by policy implementations. Thus, investigating whether parents of children with disabilities are adversely affected is of high importance. In this matched-case-control study, we combine longitudinal administrative data from Sweden and use Cox Proportional Hazards (PH) regressions with interval-censoring to investigate how having a child with cerebral palsy (CP) affects likelihood and timing of parental divorce/separation[1] as well as likelihood and timing of having additional children. The two main hypotheses tested are: (1) Having a child with CP increases the likelihood of parental divorce, and (2) Having a child with CP decreases the likelihood of having additional children. We also examine whether the observed relationship is heterogeneous across maternal age at delivery, parental education, parental marital status, and whether the child with CP was the firstborn child. Cerebral palsy makes up a large proportion of families with a child with physical disabilities, and is therefore a suitable candidate to represent how life-long physical disabilities are associated with the outcomes under study.

Cerebral palsy is one of the more common congenital or early-onset disabilities, occurring in 2.0–3.0 per 1000 live births (Westbom et al., 2007). The underlying cause is brain injury that occurs in utero-, at delivery-, or prior to age 2 years (Rosenbaum et al., 2007). It is a lifelong condition that, by definition, affects mobility. However, comorbidities and secondary conditions are frequent and includes pain, epilepsy, intellectual disability, impaired vision/hearing, and communication as well as progressive musculoskeletal complications and reduced participation in society (Graham et al., 2016; Michelsen et al., 2014). To measure severity of CP is challenging. However, the well-known gross motor function classification system (GMFCS), which is strongly correlated to communication function and manual ability (Hyun et al., 2020), is often used as a proxy of overall severity.

This study contributes mainly to the literature by (A) using a large, nationally representative, register-based data sample, which is rare in the disability literature (B) including several potentially important covariates that have not been included in previous studies, and (C) revealing which subgroups of parents face negative consequences from having children with physical disabilities.

Our results show that having a child with CP is not generally associated with a higher risk of parental divorce, but it increases the risk of divorce for parents with low education. Further, having a child with CP reduces the likelihood of having additional children. This association is especially strong for mothers in the older age range (maternal age at delivery >33 years) and for parents with low education.

The remaining part of the paper is organized as follows: Section two gives a brief overview of the literature on how having a child with disability is associated with family formation. Section three describes data and empirical strategy, and section four presents the results. The results are discussed in section five and section six concludes.

2 | BACKGROUND

Investigating consequences of having a child with disability on family formation is novel in the field of health economics as well as in the disability literature. Previous studies from medical journals have limitations, such as small sample sizes, and failure to account for factors associated with both the likelihood of having a child with disability and the outcomes under study. The consequences of having a child with disability are identified with descriptive analyses (Lundeby & Tøssebro, 2008; Tøssebro & Wendelborg, 2017), correlation analyses (Hatton et al., 2010; Seltzer et al., 2001), logistic regressions (Hartley et al., 2010; Michelsen et al., 2015; Urbano & Hodapp, 2007), and survival analyses (Hartley et al., 2010; Michelsen et al., 2015), comparing parents of children with disabilities to parents of typically developing children.

Studies investigating the consequences of having a child with disability on parental divorce risk are rare and even scarcer when it comes to children with CP. The few existing studies available find inconsistent results. Michelsen et al. (2015) include all children born 1965–1990, registered in the Danish CP Registry, and living in East Denmark at 6 years of age

to show that parents of children with CP did not stop living together more often than parents of children without CP. In line with this, Bengtsson et al. (2011) find that the risk of separation of parents with a child with disability is similar to the risk of parents with a typically developing child when investigating the parental separation rates of all 11-year-old-children with disabilities/health problems in Denmark. However, Loft (2011) uses a time hazard model for the same data and reveals increased separation levels among parents of children with disabilities. In Norway, one study shows that parents of children with disabilities are less likely to be separated compared to parents of typically developing children (Lundeby & Tøssebro, 2008). Another study finds that divorce rates among parents of children with disability are lower until the child is 8 years old; and no statistically significant differences are reported thereafter (Tøssebro & Wendelborg, 2017). However, not only Scandinavian studies are reporting contradicting findings. In the wider international literature, the majority of studies reports increased levels of divorce in families of children with intellectual and developmental disabilities (Hartley et al., 2010; Hatton et al., 2010; IASSID, 2014), although some studies find no statistically significant differences (Seltzer et al., 2001) or lower divorce rates (Urbano & Hodapp, 2007).

The scarce literature investigating how having a child with disability affects the probability of having additional children mostly suggests a reduced likelihood. Lundeby and Tøssebro (2008) show that in Norway fewer children with disabilities had siblings, compared to typically developing children. A Turkish study indicates that the desire to have an additional child is reduced after having a child with disability (Şimşek et al., 2015). Michelsen et al. (2015) reveal that the birth order of the child with disability affect the results in Denmark. Parents of children with CP who were first-born postponed or were less likely to have additional children, whereas parents of children with CP who had older siblings did not postpone having additional children.

More research is needed in the Scandinavian context in particular for three reasons. Firstly, Scandinavian studies have addressed only children at one specific age and used small samples. Secondly, contradicting results in Denmark and Norway suggest that even small contextual differences across the Scandinavian countries might be highly relevant. Thirdly, heterogeneity analyses across demographic and socioeconomic characteristics of the parents are needed to detect potential differences across subgroups. Our longitudinal research with access to extensive Swedish data to account for confounding effects will thus advance the literature in this field.

3 | DATA, VARIABLES AND STATISTICAL ANALYSIS

3.1 | Data

This study includes all children with a diagnosis of CP living in Sweden who were born 2004–2014. Diagnostic code G80 in the combined Swedish national quality and follow-up register for Cerebral Palsy (CPUP register), the National Patient Register (PAR), and the Swedish Medical Birth Register were utilized to identify eligible individuals. As the number of individuals with CP are overestimated in patient registers (Hollung et al., 2017), we exclude individuals who do not have a clear and persistent diagnose of CP.[2] We chose to include children born between 2012 and 2014 with a CP diagnosis even though they cannot be observed at the age of four, the age when CP should officially be diagnosed. A sensitivity analysis excluding these individuals does not change the results.

A comparison group consisting of individuals without CP has also been created based on sex, municipality, and birth year of the child with CP drawn from the general population at a 5:1 ratio using the Register of the Total Population. The parents of both cases (children with CP) and comparisons (children who do not have CP) have been identified using the Swedish Multigenerational register. Yearly information for 2001–2015 from several national registers has been linked to the cases, controls, and parents. These include Statistics Sweden's Longitudinal Integrated Database for Health Insurance and Labor Market Studies and the Register of the Total Population, which include annual information on educational level, marital status, and family constellations. Diagnoses and health care utilization codes are extracted from the National PAR. The observation period after childbirth varies from one to 11 years.

Individuals who did not live with both biological[3] parents in the year of birth (2505 observations,[4] of which 822 children have CP), who are only observed in the year of birth (87 observations, of which 5 children have CP), or lack information about their severity level (199 observations) are excluded. This results in a sample of 15,181 individuals of which 13,267 do not have CP and 1914 have CP. Of the latter, the gross motor function was classified as less severely affected in 1472 individuals and more severely affected in 504 individuals.

Ethical approval has been obtained (dnr: 2018/1000 and 2021-00164).

3.2 | Variables

The main explanatory variable in this study is CP diagnosis of the child. We use the GMFCS, a well-known classification system of functional abilities for CP (Palisano et al., 2008), to differentiate children whose gross motor function is less severely affected versus more severely affected. We combined those at GMFCS levels I-III as less severely affected and those at GMFCS levels IV-V as more severely affected.

The information on GMFCS level is only available in CPUP register. However, Shevell et al. (2009) and Jonsson et al. (2019) show that CP subtypes are correlated to motor function and intellectual disability. Therefore, we assign severity based on CP subtype[5] (from PAR), as a proxy for those who do not have GMFCS-level recorded (3.7%). Although simplistic, we use the terms *mild* versus *severe* CP to improve readability. It is acknowledged that to accurately assess severity, numerous additional factors are indeed important. Because the disaggregated sample might not be representative of the population of CP severity in Sweden, the results should be seen as a description of the possible heterogeneity of family formation consequences of having a child with CP.

We examine the consequences of having a child with CP on two main outcomes: risk of divorce and likelihood of having additional children. In terms of defining divorce, a challenge is to include cohabiting parents who make up a significant part of the Swedish population. For the purposes of this study, parents are considered divorced in the first calendar year they do not reside at the same address anymore, information we identify through Statistics Sweden's family identification number. Additional information about the marital status allows us to investigate whether the consequences of having a child with CP differ between married and unmarried parents in the heterogeneity analysis. To define if and when parents have additional children, data from Statistics Sweden, including information on date of childbirth, birth order, and number of children in the household, has been used.[6] Using these variables, we can determine if parents have additional children as well as the timing of additional births, which allow us to delineate two possible pathways, that is, lower likelihood of having additional children and postponement of the next child.

The etiology of CP is diverse and often unknown. Per definition, the underlying cause is a non-progressive brain damage or injury in the developing fetal or infant brain. However, what causes the brain injury might result from an interaction of multiple risk factors and often no one identifiable cause can be found (Rosenbaum et al., 2007). Moreover, the brain injury can occur in utero, at birth, or in the first 2 years of life, highlighting the heterogeneity of etiology. In previous studies, researchers generally adjust for the sex of the child, year of birth, and parental age and education. In this study, we include a number of additional, highly relevant, variables. To avoid overspecification of our model, we investigate which of the following characteristics predicts CP in our sample: child's birth year,[7] child's sex, multiple births, firstborn child, region of residence, parental marital status, maternal age at delivery (grouped into three same-size groups: 16–29 years (mean: 25.90 years), 30–33 years (mean: 31.48 years), 34–51 years (mean: 36.80 years),[8] parental immigration status,[9] highest parental educational level attained (mandatory, secondary, higher education),[10] maternal mental health,[11] paternal mental health, maternal physical health, paternal physical health, whether the mother smoked in the three months prior to pregnancy, and whether the mother smoked during the pregnancy.[12]

The results of the prediction of CP are shown in Appendix Table A1. The likelihood ratio (LR) test reveals that including more controls than the variables included in column 1 (i.e., firstborn, multiple births, parental educational level, maternal age at delivery, maternal mental health, maternal physical health, maternal smoking behavior before and during pregnancy, and paternal physical health) does not better predict CP (p-value of the LR test = 0.982). The R^2 is very low in both models, which is in line with prior research (e.g., Rosenbaum et al., 2007); variables extracted from registers only predict CP to a low extent, and the cause of CP is largely unknown or multifaceted. Nevertheless, predicting CP with our extensive data reveals that it is not the usual variables adjusted for in previous studies (e.g., sex and birth year of child), but rather parental health variables and characteristics that are related to the birth of the child (i.e., firstborn, multiple birth) that are relevant to control for. Thus, the variables predicting CP in our sample are considered the relevant covariates in our study. We will present the results controlling for only the variables predicting the treatment (i.e., CP diagnosis), as well as all available controls, to show that the inclusion of additional controls does not change the results.

To avoid excluding numerous individuals with unavailable parental health information prior to childbirth in our sample, the health variables are grouped as yes, no, and unknown. Physical health is measured with the Charlson Comorbidity Index (CCI). Although the CCI is a disease index that was developed to predict mortality (Charlson et al., 1987), it is often used as a comorbidity summary measure (Austin et al., 2015). By differentiating between having no comorbidity (CCI = 0) and some level of comorbidities (CCI>0), this measure indicates whether the parents had some form of potentially serious condition in any of the three calendar years prior to childbirth.

Table 1 presents descriptive statistics of the sample included in the analysis. We find differences in certain characteristics in families with a child with CP (treatment group) compared to families with a child without CP (comparison group). For example, children with CP are much more often born as part of a multiple birth than children without CP. This was expected because twin births are a risk factor for CP, given that they are more often born prematurely.

TABLE 1 Summary statistics

Variables	No CP	CP	Mild CP	Severe CP
Firstborn child	5625 (42.6%)	**897 (45.4%)**	657 (44.6%)	**240 (47.6%)**
Multiple birth	33 (0.2%)	**41 (2.1%)**	**31 (2.1%)**	**10 (2.0%)**
Parental education level				
Mandatory	576 (4.4%)	82 (4.1%)	58 (3.9%)	24 (4.8%)
Secondary	4884 (37.0%)	**792 (40.1%)**	**590 (40.1%)**	202 (40.1%)
Higher	7745 (58.7%)	**1102 (55.8%)**	**824 (56.0%)**	278 (55.2%)
Maternal age at delivery				
16–29	5106 (38.7%)	732 (37.0%)	554 (37.6%)	178 (35.3%)
30–33	4007 (30.3%)	599 (30.3%)	438 (29.8%)	161 (31.9%)
34–51	4092 (31.0%)	645 (32.6%)	480 (32.6%)	165 (32.7%)
Maternal mental health diagnosis				
No	11,952 (90.5%)	**1757 (88.9%)**	1318 (89.5%)	**439 (87.1%)**
Yes	575 (4.4%)	**118 (6.0%)**	**88 (6.0%)**	30 (6.0%)
Unknown	678 (5.1%)	101 (5.1%)	66 (4.5%)	35 (6.9%)
Maternal CCI above 0				
No	12,137 (91.9%)	**1784 (90.3%)**	**1328 (90.2%)**	456 (90.5%)
Yes	334 (2.5%)	**86 (4.4%)**	**73 (5.0%)**	13 (2.6%)
Unknown	734 (5.6%)	106 (5.4%)	71 (4.8%)	35 (6.9%)
Mother smoked before pregnancy				
No	10,520 (79.7%)	**1456 (73.7%)**	**1083 (73.6%)**	**373 (74.0%)**
Yes	1871 (14.2%)	307 (15.5%)	**237 (16.1%)**	70 (13.9%)
Unknown	814 (6.2%)	**213 (10.8%)**	**152 (10.3%)**	**61 (12.1%)**
Mother smoked during pregnancy				
No	11,603 (87.9%)	**1625 (82.2%)**	**1214 (82.5%)**	**411 (81.5%)**
Yes	834 (6.3%)	142 (7.2%)	109 (7.4%)	33 (6.5%)
Unknown	768 (5.8%)	**209 (10.6%)**	**149 (10.1%)**	**60 (11.9%)**
Paternal CCI above 0				
No	12,309 (93.2%)	1822 (92.2%)	1369 (93.0%)	**453 (89.9%)**
Yes	372 (2.8%)	55 (2.8%)	34 (2.3%)	21 (4.2%)
Unknown	524 (4.0%)	**99 (5.0%)**	69 (4.7%)	**30 (6.0%)**
Female child	5455 (41.3%)	822 (41.6%)	602 (40.9%)	220 (43.7%)
Mother/father immigrated	3480 (26.4%)	530 (26.8%)	372 (25.3%)	158 (31.3%)
Parents married	6537 (49.5%)	949 (48.0%)	697 (47.4%)	252 (50.0%)
Paternal mental health diagnosis				
No	12,414 (94.0%)	**1834 (92.8%)**	1372 (93.2%)	**462 (91.7%)**
Yes	333 (2.5%)	55 (2.8%)	40 (2.7%)	15 (3.0%)
Unknown	45 (3.5%)	**87 (4.4%)**	60 (4.1%)	**27 (5.4%)**
Number of children	13,205	1976	1472	504

Note: Authors' estimates of average characteristics using linked registry data from parents and their children born 2004–2014. Significant differences (on 0.05 level) compared to the comparison group (column 1) are displayed in bold. *Mild* CP encompasses individuals at GMFCS levels I-III or individuals with subtypes of CP that are associated with lower GMFCS-levels whereas *severe* CP encompasses individuals whose gross motor function is more severely affected at GMFCS levels IV-V or individuals with subtypes of CP that are associated with higher GMFCS-levels.

Abbreviations: CP, *Cerebral Palsy*; *CCI*, Charlson Comorbidity Index.

3.3 | Statistical analysis

The questions we are posing are difficult to investigate as it can be assumed that there is a selection process into having a child with CP. Observable and non-observable factors might explain both having a child with CP and the outcomes under study. These variables can be partly known (such as education and maternal age at delivery) and partly unknown or unobservable. Although we can show that adding additional register-based controls does not improve the prediction of CP, we cannot fully rule out the risk of endogeneity in our analysis.

Our study is based on a Cox PH model (PH) for interval-censored survival-time data. Our data is interval-censored, given that we observe the year in which the event (divorce or having an additional child) happens, but not the exact date. We created spells of (1) cohabiting after childbirth, and (2) having no additional child, whose duration either ends with (1) separation, or (2) having an additional child (complete spells) or with right-censoring when the child dies, one parent dies, the family or parts of the family emigrate/s, other loss to follow-up, or the spell reaches the end of our observation window in 2015 (partial spells). The two dependent variables are the hazard ratios|hazard rates (HR) that the parents, in a particular period, (1) divorce/separate, and/or (2) have additional children. Formally, the hazard rate can be regarded as the probability:

$$h(t) = \frac{f(t)}{N(t)} \tag{1}$$

where *f(t)* is the number of (1) parental separations and (2) additional children between t and $t + 1$, and *N(t)* is the number of (1) cohabiting parents and (2) parents without an additional child at time t. The proportion of parents remaining (1) in the relationship and (2) without an additional child until time t, referred to as "survival rate", offers another way of describing variations in (1) parental separation and (2) additional children and is given by:

$$S\left(t_j\right) = S\left(t_{j-1}\right) \tag{2}$$

The Cox PH model is specified as:

$$h(t) = h_0(t)e^{\beta' x} \tag{3}$$

where $h_0(t)$ is the baseline hazard and the vector x includes the CP diagnosis and several control variables. The effect of a unit change in $x_i \in x$ is expressed as a hazard ratio $e^{\beta i}$, which is assumed to be constant across time. As shown by Basu et al. (2004), the PH assumption is crucial for a good performance of the Cox Model. To check whether the assumption is fulfilled in our study, we plot the estimated log-log survival curves for the treatment and comparison groups (adjusted for covariates). Parallel plots indicate that the PH assumption has not been violated.

In our main analysis, we stepwise include controls that may be related to both having a child with CP and the outcomes under study (see 3.2. For further details). We run the model (1) without any controls, (2) with controls that have been shown to predict CP in our sample (firstborn, multiple birth, parental education level, maternal age at delivery, maternal mental health, maternal physical health, maternal smoking behavior before and during the pregnancy, and paternal physical health), and (3) with additional controls, that have been used in previous studies. The latter, however, does not change our results. Given that previous studies in this field do not include parental health-related covariates, our study adds to the literature by investigating whether results are robust across different model specifications.

Additionally, we investigate whether having a child with CP's gross motor function classified as mild or severe matters for the outcomes under study, and present smoothed HR and cumulated failure estimates across parents of children with no CP, mild CP and severe CP over the 11-year follow-up period. Hazard and cumulative failure estimates adjust for the loss of information in the partial spells and show the likelihood of the event (i.e., divorce or having an additional child) in a certain period, given that the event did not happen in any previous period. These are therefore useful to understand the duration dependence patterns. Cumulated failure estimates display the proportion of parents who divorced or had a joint additional child in a certain period, and thereby give a better sense of the magnitude of the differences.

To test the robustness of our results to using a different model, we run parametric survival analyses with interval-censoring. We compare the Akaike information criterion (AIC) (Akaike, 1974) using statistical models that assume either an exponential, Weibull, Gompertz, loglogistic, lognormal, or generalized gamma distribution. The AIC is an estimator of the relative quality of statistical models, where the candidate model with the lowest AIC is the closest to the true model. Following the AIC, we use a parametric survival analysis model assuming a lognormal distribution to analyze the risk of divorce, and a parametric survival analysis model assuming a Gompertz distribution to analyze the likelihood of having additional children. In Tables A3 and A5 in the Appendix,

we additionally show results when using a larger sample and a longer follow-up period. We use individuals born between 1991 and 2014 and run a model that includes all covariates, except for parental health-related controls. The latter cannot be included because health-related information is only available for individuals born after 2004.[13] Since previous studies (e.g., Michelsen et al., 2015) use Cox PH models without interval censoring, we present results for a Cox PH model without interval-censoring as well.

The estimated HR for having a child defined as having mild or severe CP are assumed to apply for every point in follow-up (i.e., PH) and for every combination of the covariates. To detect if the HR vary across demographic and socioeconomic characteristics of the parents, we partially relax the assumption and allow the effect of having a child with CP to differ across four covariates. We investigate differences across maternal age at delivery, parental education level, marital status, and the existence of older siblings in the household, because previous literature suggests that these covariates are associated with divorce risk and likelihood of having additional children. We use LR tests to investigate whether fitting models that interact having a child with CP with the four covariates, respectively, improves our model, and show how having a child with CP is associated with the outcomes in each subgroup separately. For each combination of the remaining covariates and at each point in the follow-up, the estimates are assumed to be identical.

All results are reported as HR with 95% confidence intervals and are considered significant with p-values <0.05. All analyses were performed using the Stata statistical package (STATA/SE 17.0).

4 | RESULTS

4.1 | Parental divorce

Figure 1 displays a parallel development of the HR for the treatment and comparison groups predicting the risk of divorce, which indicates that the PH assumption is fulfilled in our study.

Table 2 shows that having a child with CP does not increase the risk of parental divorce. The four columns display the HR for the three model specifications including: (1) no controls, (2) controls that predict CP in our sample, (3) full specification with all controls, and lastly differentiates between mild and severe CP in column 4. Table 2 displays the relationship with the main explanatory variable (see Appendix Table A2 for the full regression output). The HR of having a child with CP are insignificant and close to the reference, irrespective of model specification. Column (4) potentially indicates association in opposite directions when having a child with mild or severe CP, but statistically insignificant.

Figure 2 shows smoothed hazard estimates and cumulated failure estimates of divorce based on the analysis in column 4 of Table 2. The smoothed HR show the likelihood of divorce across the severity groups in each period, given that a divorce did

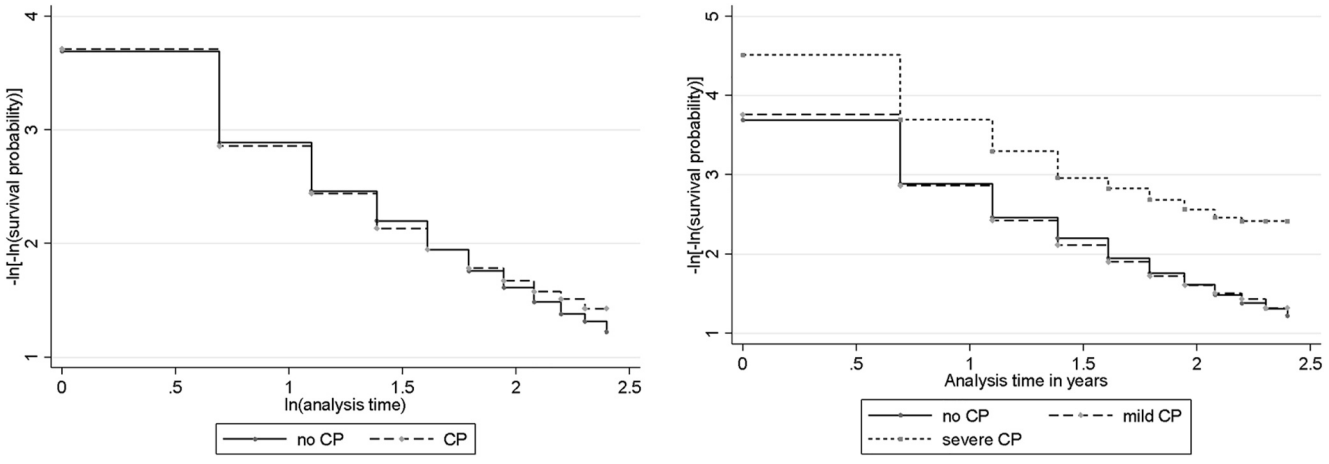

FIGURE 1 Proportional Hazards (PH) assumption test for having a child with cerebral palsy (CP) in divorce risk analysis. CP this figure shows the log-log survival curves for the treatment and comparison groups (i.e., having a child without CP or with CP on the left, and no CP, *mild* CP or *severe* CP on the right) regarding the risk of the divorce/separation. The hazard curves are adjusted for all covariates from the full specification (see columns 3 and 4 in Table 2). A parallel development of the plots indicates that the PH assumption is fulfilled. *Mild* CP encompasses individuals at gross motor function classification system (GMFCS) levels I-III or individuals with subtypes of CP that are associated with lower GMFCS-levels whereas *severe* CP encompasses individuals whose gross motor function is more severely affected at GMFCS levels IV-V or individuals with subtypes of CP that are associated with higher GMFCS-levels.

TABLE 2 Hazard ratios of time to parental divorce

	CP diagnosis	HR	*p*-value	95% CI
(1) Baseline	No CP	1.00 (Ref.)		
	CP	1.07	0.267	[0.95, 1.19]
(2) Covariates predicting CP	No CP	1.00 (Ref.)		
	CP	1.03	0.574	[0.92, 1.15]
(3) Full specification	No CP	1.00 (Ref.)		
	CP	1.03	0.617	[0.92, 1.15]
(4) Full specification accounting for severity of CP	No CP	1.00 (Ref.)		
	Mild CP	1.05	0.414	[0.93, 1.19]
	Severe CP	0.95	0.664	[0.77, 1.18]
Observations	15,181			

Note: Authors' estimates of time to divorce from Cox PH model for interval-censored survival-time data, using registry data of 15,181 children born 2004–2014 and their parents. Specification (1) to (3) stepwise include more controls to a model differentiating between parents of a child without CP or with CP. Specification (1) includes no controls, specification (2) includes variables predicting CP in our sample (i.e., firstborn child, multiple birth, parental education level, maternal age at delivery, maternal mental health, maternal CCI (Charlson Comorbidity Index), mother smoked before pregnancy, mother smoked during pregnancy, paternal CCI), and specification (3) adds child's birth year, child's sex, marital status, immigration background, region of residence, and paternal mental health to the controls used in specification (2). Specification (4) differentiates between no CP, mild CP and severe CP and includes the controls from specification (3). Mild CP encompasses individuals at GMFCS levels I-III or individuals with subtypes of CP that are associated with lower GMFCS-levels whereas severe CP encompasses individuals whose gross motor function is more severely affected at GMFCS levels IV-V or individuals with subtypes of CP that are associated with higher GMFCS-levels.

Abbreviations: CI, Confidence Interval; CP, Cerebral Palsy; HR, Hazard Ratio.

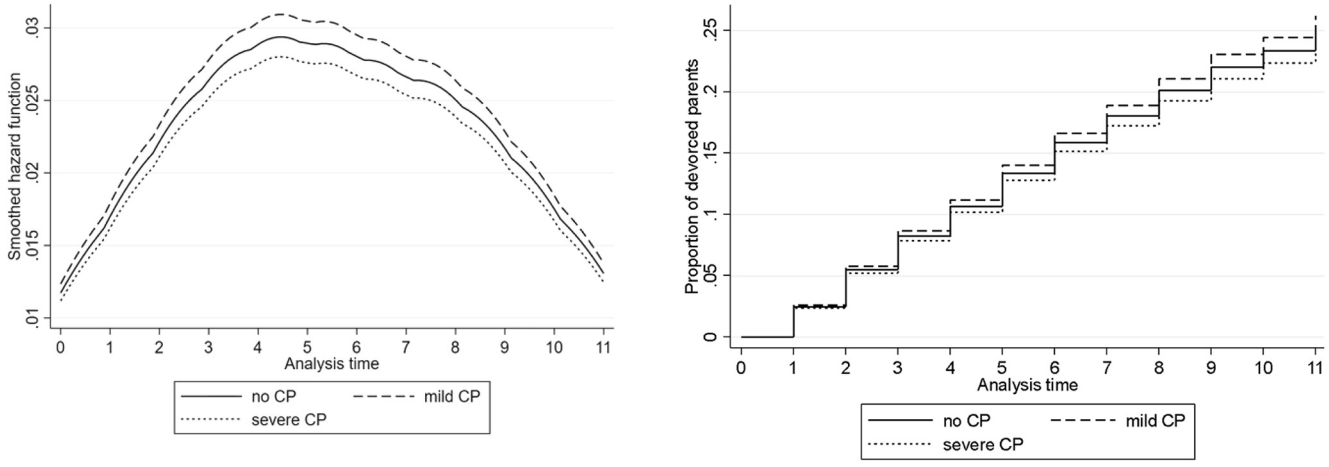

FIGURE 2 Smoothed hazard function and cumulated failure estimates of divorce. *Cerebral palsy* (CP). This figure shows smoothed hazard rates and cumulated failure estimates of divorce/separation for parents of a child with no CP, *mild* CP, or *severe* CP, based on the analysis in column 4, Table 2. The smoothed HR on the left show the likelihood of divorce/separation across the severity groups in each period, given that a divorce did not happen in any previous period. The cumulated failure rates display the proportion of divorced parents across time. *Mild* CP encompasses individuals at gross motor function classification system (GMFCS) levels I-III or individuals with subtypes of CP that are associated with lower GMFCS-levels whereas *severe* CP encompasses individuals whose gross motor function is more severely affected at GMFCS levels IV-V or individuals with subtypes of CP that are associated with higher GMFCS-levels.

not happen in any previous period. The trend in likelihood of divorce is similar across the groups, with parents of children with mild CP showing the highest likelihood and parents of children with severe CP showing the lowest likelihood of divorce over the years. Over all three groups, the likelihood of divorce increases rapidly over the first 4 years and decreases after peaking between year four and five. The cumulated failure rates show that the likelihood of divorce is very similar across the groups, with slightly higher failure rates for parents of a child with mild CP and slightly lower failure rates for parents of a child with severe CP, compared to parents of a child without CP.

TABLE 3 Sensitivity analysis: Risk of parental divorce

	(1)			(2)		
	Full specification			**Full specification accounting for severity of CP**		
	TR	***p*-value**	**95% CI**	**TR**	***p*-value**	**95% CI**
CP diagnosis						
No CP	1.00 (Ref.)			1.00 (Ref.)		
CP	0.96	0.532	[0.85, 1.09]			
Mild CP				0.94	0.377	[0.82, 1.08]
Severe CP				1.03	0.780	[0.82, 1.31]
Observations	15,181			15,181		

Note: Authors' estimates of time to divorce using registry data of 15,181 children born 2004–2014 and their parents and controls for the covariates of the full specification (see column 3 and 4 of Table 2) and displays the result when running a lognormal parametric model. *Mild* CP encompasses individuals at GMFCS levels I-III or individuals with subtypes of CP that are associated with lower GMFCS-levels whereas *severe* CP encompasses individuals whose gross motor function is more severely affected at GMFCS levels IV-V or individuals with subtypes of CP that are associated with higher GMFCS-levels.

Abbreviations: CP, Cerebral Palsy; *HR*, Hazard Ratio; *TR*, Time Ratio; *CI*, Confidence Interval.

Table 3 shows that our results are not specific to using a Cox PH model. Using a lognormal parametric model with interval-censoring shows very similar results to the main analysis in Table 2. Important to notice here is that the interpretation of the time ratio (TR), which is used in the lognormal parametric model, is opposite to the interpretation of the HR used in the Cox PH model. A TR above 1.00 shows that the time to divorce is longer than for the comparison group and is therefore in line with a HR below 1.00, which indicates that the hazard is lower than in the comparison group. Using a larger sample (i.e., children born between 1991 and 2014) and a longer follow-up period (i.e., 24 years) does not change the results considerably, and our results are not specific to using an interval-censored model (i.e., the results are similar when using a Cox PH model without interval-censoring) (see Table A3 in the Appendix).

Previous literature suggests that personal, social, and economic aspects matter for the effect of having a child with disability on parental outcomes (Barreto et al., 2020; Gugała et al., 2019; IASSID, 2014; Lee et al., 2019; Pousada et al., 2013; Tøssebro & Wendelborg, 2017). While Table 2 shows that having a child with CP does not increase the parental risk of divorce, Table 4 studies whether this differs over subgroups. The LR test shows that including an interaction of having a child with CP and parental education (specification (2)) improves the model predicting the risk of divorce, but an interaction with the maternal age at delivery, the marital status, or whether the child is the firstborn child (specification (1), (3) and (4)) does not improve the model. The only subgroup, in which having a child with CP increases the risk of divorce is the group of parents with low education. For parents with low education, having a child with CP increases the risk of divorce by 65% ($p = 0.004$). When adjusting for multiple testing following Benjamini et al. (2006), the estimate is significant on the 5% level. The association between CP and the risk of divorce was similar across severity of CP (see Table A6 in the Appendix).

4.2 | Likelihood of additional children

Figure 3 displays a parallel development of the HR for the treatment and comparison groups predicting the likelihood of having additional children, indicating that the PH assumption is fulfilled in our study. Table 5 shows that a child with CP reduces the parental likelihood of having additional children compared to having a child without CP ($p = 0.000$). The four columns display the model specifications including (1) no controls, (2) controls that predict CP in our sample, (3) full specification with all controls, and the results when differentiating between CP that was classified as mild or severe in column 4. Table 5 displays the estimated HR for the main explanatory variable (see Appendix Table A4 for the full regression output). The HRs of having a child with CP are very similar across model specifications. The analysis in column 4 reveals that a child with CP who has a GMFCS level that is classified as mild or severe reduces the likelihood of having additional children by 22 ($p = 0.000$) and 20 ($p = 0.007$) percent, respectively, compared to having a child without CP. Thus, the results does not vary considerably across severity levels.

Figure 4 shows smoothed hazard estimates and cumulated failure estimates of having additional children for parents of a child with no CP, mild CP, or severe CP, based on the analysis in column 4 of Table 5. The smoothed HR show that the likelihood of having an additional child develops similarly across the three groups. The likelihood is highest for parents of children without CP throughout the years. For all groups, the likelihood is highest in the first 4 years after childbirth and decreasing

TABLE 4 Heterogeneity analysis: Risk of parental divorce

		(1) Full specification		
		HR	***p*-value**	**95% CI**
(1)	CP diagnosis × maternal age at delivery			
	CP × 16–29 years	1.02	0.836	[0.87, 1.18]
	CP × 30–33 years	1.14	0.285	[0.90, 1.43]
	CP × 34–51 years	0.96	0.759	[0.77, 1.21]
	p-value of LR test	0.603		
(2)	CP diagnosis × parental education			
	CP × mandatory	**1.65**	0.004	[1.17, 2.33]
	CP × secondary	0.95	0.496	[0.81, 1.11]
	CP × higher	1.04	0.708	[0.86, 1.24]
	p-value of LR test	**0.028**		
(3)	CP diagnosis × parental marital status			
	CP × unmarried	1.08	0.298	[0.94, 1.23]
	CP × married	0.95	0.616	[0.79, 1.15]
	p-value of LR test	0.310		
(4)	CP diagnosis × firstborn child			
	CP × No	1.06	0.444	[0.91, 1.23]
	CP × Yes	0.99	0.933	[0.84, 1.17]
	p-value of LR test	0.568		
	Observations	15,181		

Note: Authors' estimates from Cox PH models for interval-censored survival-time data of durations to parental divorce using registry data of 15,181 children born 2004–2014 and their parents. All columns control for all covariates considered in the full model specification (see column 3, Table 2). Significant effects on 0.05 level are displayed in bold. The estimates display the linear combination of parameters (i.e., the direct effect of having a child with CP multiplied with the effect of having a child with CP interacted with maternal age at delivery, education level, marital status, firstborn child).

Abbreviations: *CI*, Confidence Interval; CP, Cerebral Palsy; *HR*, Hazard Ratio.

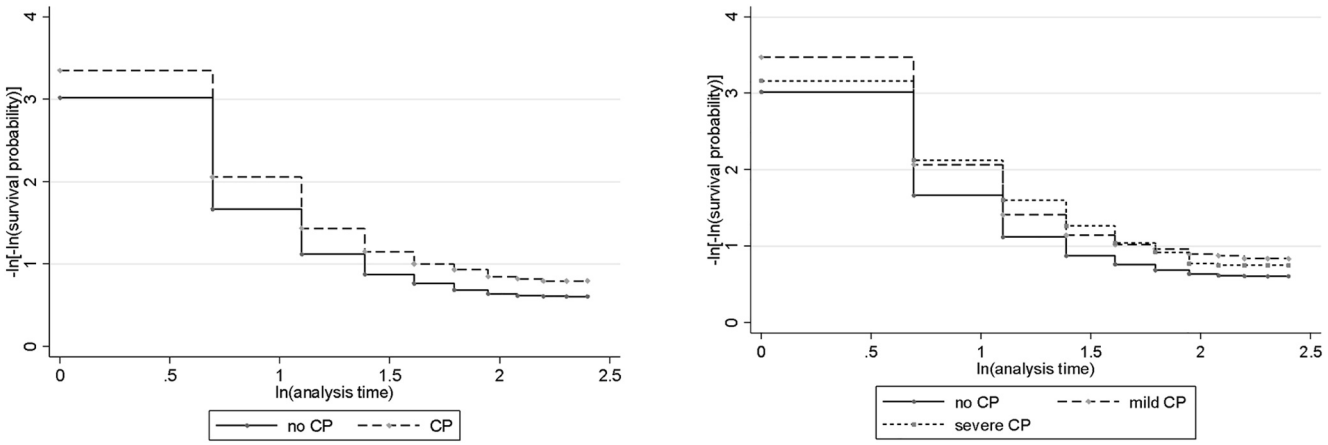

FIGURE 3 Proportional Hazards (PH) assumption test for having a child with cerebral palsy (CP) in likelihood of additional children analysis. CP this figure shows the log-log survival curves for the treatment and comparison groups (i.e., having a child without CP or with CP on the left, and no CP, mild CP or severe CP on the right) regarding the likelihood of having additional children. The hazard curves are adjusted for all covariates from the full specification (see columns 3 and 4 in Table 2). A parallel development of the plots indicates that the PH assumption is fulfilled. The decreasing hazards show that the likelihood of having additional children decreases over time. *Mild* CP encompasses individuals at gross motor function classification system (GMFCS) levels I-III or individuals with subtypes of CP that are associated with lower GMFCS-levels whereas *severe* CP encompasses individuals whose gross motor function is more severely affected at GMFCS levels IV-V or individuals with subtypes of CP that are associated with higher GMFCS-levels.

TABLE 5 Hazard ratios|hazard rates (HR) of time to additional children

	CP diagnosis	HR	*p*-value	95% CI
(1) Baseline	No CP	1.00 (Ref.)		
	CP	**0.83**	0.000	[0.77, 0.90]
(2) Covariates predicting CP	No CP	1.00 (Ref.)		
	CP	**0.79**	0.000	[0.72, 0.86]
(3) Full specification	No CP	1.00 (Ref.)		
	CP	**0.79**	0.000	[0.72, 0.86]
(4) Full specification accounting for severity of CP	No CP	1.00 (Ref.)		
	Mild CP	**0.78**	0.000	[0.71, 0.87]
	Severe CP	**0.80**	0.007	[0.68, 0.94]
Observations	15,181			

Note: Authors' estimates of time to additional children from Cox PH model for interval-censored survival-time data, using registry data of 15,181 children born 2004–2014 and their parents. Specification (1) to (3) stepwise include more controls to a model differentiating between parents of a child without CP or with CP. Specification (1) includes no controls, specification (2) includes variables predicting CP in our sample (i.e., firstborn child, multiple birth, parental education level, maternal age at delivery, maternal mental health, maternal CCI (Charlson Comorbidity Index), mother smoked before pregnancy, mother smoked during pregnancy, paternal CCI), and specification (3) adds child's birth year, child's sex, marital status, immigration background, region of residence, and paternal mental health to the controls used in specification (2). Specification (4) differentiates between no CP, mild CP and severe CP and includes the controls from specification (3). Mild CP encompasses individuals at GMFCS levels I-III or individuals with subtypes of CP that are more likely to be associated with lower GMFCS-levels whereas severe CP encompasses individuals whose gross motor function is more severely affected (GMFCS IV-V) and who require wheelchairs or individuals with subtypes of CP that are more likely to be associated with higher GMFCS-levels. Significant effects on 0.05 level are displayed in bold.

Abbreviations: CI, Confidence Interval; CP, Cerebral Palsy; HR, Hazard Ratio.

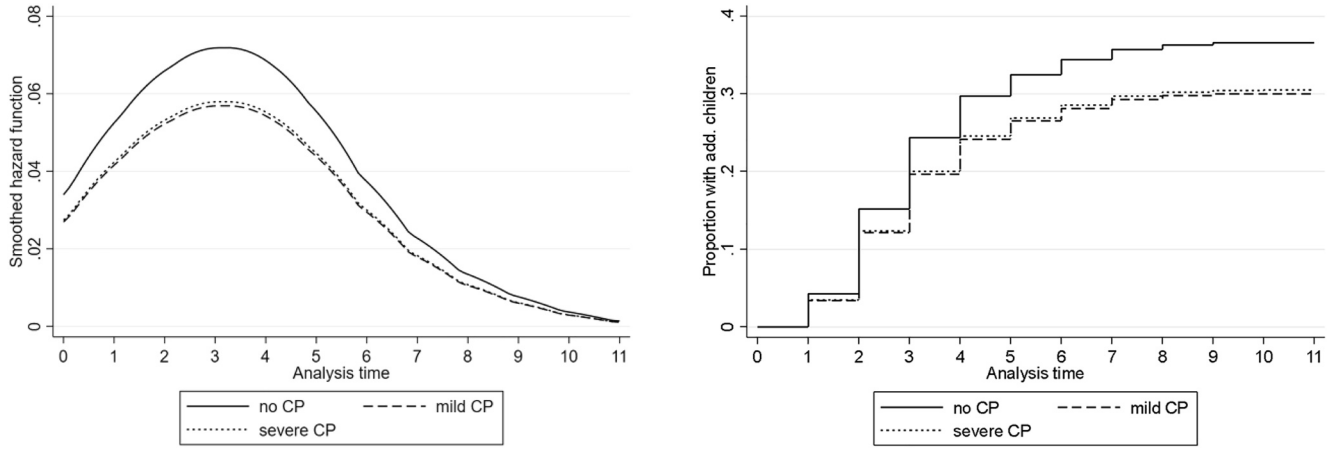

FIGURE 4 Smoothed hazard function and cumulated failure estimates of having additional children cerebral palsy (CP) this figure shows smoothed hazard ratios|hazard rates (HR) and cumulated failure estimates of divorce/separation for parents of a child with no CP, *mild* CP, or *severe* CP, based on the analysis in column 4, Table 5. The smoothed HR on the left show the likelihood of having an additional child after the birth of the child in our sample with no CP, *mild* CP, or *severe* CP in each period, given that the parents did not had an additional child in any previous period. The cumulated failure rates display the proportion of divorced parents across time. *Mild* CP encompasses individuals at gross motor function classification system (GMFCS) levels I-III or individuals with subtypes of CP that are more likely to be associated with lower GMFCS-levels whereas *severe* CP encompasses individuals whose gross motor function is more severely affected (GMFCS IV-V) and who require wheelchairs or individuals with subtypes of CP that are more likely to be associated with higher GMFCS-levels.

rapidly thereafter. The cumulated failure rates show that the likelihood of having an additional child is highest for parents of a child without CP, and similarly likely for parents of children who in this study were classified as having mild or severe CP. Whereas more than 36% of parents with a child without CP had at least one additional child over the 11-year follow-up period, the corresponding percentage for parents of children with CP is approximately 30%. Thus, the trend over time does not indicate that parents of children with CP postpone having additional children, but that the overall likelihood of additional children is reduced.

TABLE 6 Sensitivity analysis: Likelihood of having additional children

	(1) Full specification			(2) Full specification with mild and severe CP		
	HR	***p*-value**	**95% CI**	**HR**	***p*-value**	**95% CI**
CP diagnosis						
No CP	1.00 (ref.)			1.00 (ref.)		
CP	**0.80**	0.000	[0.74, 0.87]			
Mild CP				**0.80**	0.000	[0.72, 0.88]
Severe CP				**0.83**	0.011	[0.71, 0.96]
Observations	15,181			15,181		

Note: Authors' estimates of time to additional children using registry data of 15,181 children born 2004–2014 and their parents and controls for the covariates of the full specification (see column 3 and 4 of Table 5) and displays the result when running a Gompertz parametric model. Mild CP encompasses individuals at GMFCS levels I-III or individuals with subtypes of CP that are associated with lower GMFCS-levels whereas severe CP encompasses individuals whose gross motor function is more severely affected at GMFCS levels IV-V or individuals with subtypes of CP that are associated with higher GMFCS-levels. Significant effects on 0.05 level are displayed in bold.

Abbreviations: CI, Confidence Interval; CP, Cerebral Palsy; HR, Hazard Ratio; TR, Time Ratio.

Our results are not specific to using a Cox PH model. Using a Gompertz parametric model with interval-censoring shows very similar results (Table 6). Using a larger sample (i.e., children born between 1991 and 2014) and a longer follow-up period (i.e., 24 years) does not change the results considerably. Our results are not specific to using an interval-censored model either, as the results are unchanged when using a Cox PH model without interval-censoring (Table A5 in the Appendix).

Table 7 displays the results of our heterogeneity analysis. The LR test shows some evidence for differences across mother's age at birth (specification (1)), where mothers in the older age range have the highest reduction in the likelihood of having additional children. Having a child with CP reduces the likelihood of having an additional child by 36% ($p = 0.000$) for mothers between 34 and 51 years at birth, by 20% ($p = 0.001$) for mothers in the younger age range (16–29 years at birth), and by 12% (borderline significant with $p = 0.098$) for mothers is in the medium age range. Even though the LR test suggests that the association between CP and the likelihood of additional children is not significantly different across parental education levels, the results in specification (2) reveal that having a child with CP reduces the likelihood of additional children especially for parents with low education (reduction by 43% ($p = 0.007$)). No heterogeneity in results was noted across marriage status and whether the child is the firstborn child. Adjusting for multiple testing following Benjamini et al. (2006) does not change any of the significance levels. The association between CP and the likelihood of additional children were similar across children whose gross motor function levels were less or more severely affected (Table A7 in the Appendix).

5 | DISCUSSION

This study contributes to the scarce literature on consequences of having a child with an early onset disability for families, specifically when having a child with CP, in multiple ways. Firstly, we use a large, nationally representative register-based data sample, which is rare in the disability and health economics literature alike. Secondly, we have access to extensive data including several potentially important covariates that have not been included in previous studies, such as parental mental- and physical health prior to the birth of the child. Because parental mental and physical health may help explain both having a child with disability and the outcomes under study, it is important to account for those covariates to produce reliable results. Thirdly, we use the well-known classification system of gross motor function abilities GMFCS in an attempt to define those children whose gross motor function ability is less or more severely affected (herein referred to as mild and severe CP). Thus, our results might be transferable to other physical disabilities that affect gross motor function similarly. Lastly, we examine differences across subgroups to investigate whether specific groups of parents may be in particular need of policy interventions.

In line with Michelsen et al. (2015) and Bengtsson et al. (2011), our results suggest that having a child with CP does not generally affect the risk of parental divorce. However, we find that having a child with CP increases the risk of divorce in the group of parents with low education. This may be explained in multiple ways. Firstly, low education and immigration background are correlated. Not being fluent in Swedish might make it difficult to navigate the system and to apply for social care and benefits. Secondly, previous literature shows that higher education helps individuals with disabilities to cope

TABLE 7 Heterogeneity analysis: Likelihood of additional children

		HR	*p*-value	95% CI
(1)	CP diagnosis × maternal age at delivery			
	CP × 16–29 years	**0.80**	0.001	[0.70, 0.91]
	CP × 30–33 years	0.88	0.098	[0.75, 1.02]
	CP × 34–51 years	**0.64**	0.000	[0.53, 0.77]
	p-value of LR test	**0.039**		
(2)	CP diagnosis × parental education			
	CP × mandatory	**0.57**	0.007	[0.38, 0.86]
	CP × secondary	**0.81**	0.003	[0.71, 0.93]
	CP × higher	**0.79**	0.000	[0.70, 0.89]
	p-value of LR test	0.270		
(3)	CP diagnosis × parental marital status			
	CP × unmarried	**0.75**	0.000	[0.67, 0.85]
	CP × married	**0.83**	0.006	[0.73, 0.95]
	p-value of LR test	0.212		
(4)	CP diagnosis × firstborn child			
	CP × No	**0.80**	0.006	[0.68, 0.94]
	CP × Yes	**0.78**	0.000	[0.71, 0.87]
	p-value of LR test	0.867		
	Observations	15,181		

Note: Authors' estimates from Cox PH models for interval-censored survival-time data of durations to having additional children using registry data of 15,181 children born 2004–2014 and their parents. All columns control for all covariates considered in the full model specification (see column 3, Table 5). Significant effects on 0.05 level are displayed in bold. The estimates display the linear combination of parameters (i.e., the direct effect of having a child with CP multiplied with the effect of having a child with CP interacted with maternal age at delivery, education level, marital status, firstborn child).

Abbreviations: CI, Confidence Interval; CP, Cerebral Palsy; HR, Hazard Ratio.

with their disability, and that this is to some extent explained by better knowledge of the social benefit system (Bengtsson & Datta Gupta, 2017). Thirdly, parents may have to stop their education after having a child with CP and therefore remain with low education. Such major changes to life plans may put additional strains on a partnership. Further studies are needed to investigate whether parents with low education receive less welfare support for their children with disabilities than parents with a higher education do. Investigating the mediators will facilitate finding policy implementations which may support this vulnerable group.

Previous literature suggests that married parents separate less often (and later) than unmarried cohabiting parents do (e.g., Wilcox & DeRose, 2017). Therefore, we expected marital status to impact the association between having a child with CP and the risk of divorce. However, we did not find that marital status impacted the results (see Table 4). We also expected differences in the relationship between CP and the risk of parental divorce across maternal age at delivery and whether the child is firstborn. Parents in the older age range may consider re-partnering after a divorce rather unlikely, especially with a child with disability and may therefore stay in their relationships. Parents who had previous children might be more experienced in caregiving or get help by older siblings and may therefore be less challenged by a child with a potential higher need of care. However, our results suggest that such differences do not exist.

The likelihood of having additional children is reduced by having a child with CP, irrespective of severity level and birth order. This is in line with previous literature that shows reduced levels of desire (Şimşek et al., 2015) and likelihood (Lundeby & Tøssebro, 2008; Michelsen et al., 2015) of additional children after having a child with disability. The association is strongest for mothers in the older age group (>33 years), which might be explained in at least two ways. Firstly, the greater risk of having a child with disability in higher ages may increase the fear of having an additional child with disability. Secondly, mothers in the older age range might be vested in their careers and do not want additional children to jeopardize that. Note that we do not have information on in vitro fertilization treatment, which is more common among older mothers and may increase the likelihood of having a child with CP (e.g., through increased risk of multiple birth), potentially introducing bias. Further, the likelihood of having additional children is especially low for parents with low education. As discussed above, one concern is that parents

with low education may receive less welfare support than parents with higher education levels do. That, in turn, could lead to both financial and time constraints and thereby reduce the likelihood of having additional children. Further studies are needed to shed light into the mechanisms increasing the risk of divorce and reducing the likelihood of additional children for parents with low education after having a child with CP.

We further expected that the likelihood of additional children when having a child with disability would be higher for married parents than for unmarried parents. However, our results suggest that no significant differences exist. Further, our results do not show a difference across whether the child is the firstborn child or the parents have older children. In contrast, Michelsen et al. (2015) find that parents of children with CP who were firstborn postponed or did not get additional children, while parents of a child with CP who had older siblings did not postpone having additional children. This could be due to contextual differences between Sweden and Denmark or by changes over time as Michelsen et al. investigate children born 1965–1990 while the current study includes children born 2004–2014. More cross-country studies are needed to understand results like these.

Overall, our results do not support the supposition that having a child with disability leads to a double burden for the parents and the child caused by the disability itself and excessive divorce rates. However, Sweden provides extensive welfare support, which may mitigate negative consequences. Future studies should investigate the consequences of having a child with disability in relation to access to social insurance support, within or between countries.

This study has some limitations that must be considered. First, while the hazard rate helps explaining how the past impacts the future, drawing certain causal conclusions from it may be difficult. The risk of divorce/having another child in year 2–11 after childbirth is conditioned on that the individuals have not gotten divorced/had an additional child in a previous period. This implicit conditioning may lead to an inbalance in the distribution of potential confounders between individuals with CP and without CP(Aalen et al., 2015). Second, we use the simplistic terms *mild* and *severe* CP based on GMFCS levels. Because assessing severity requires numerous additional factors than gross motor function, other ways of measuring severity are conceivable. Gross motor function classification system is, however, generally correlated with different severity measures. Third, using CP subtype to define GMFCS-based severity for those individuals with missing GMFCS information is less precise and could potentially cause bias. However, only 3.7% of individuals with CP in our sample have severity information imputed based on subtype. Thus, we expect potential bias due to our classification of severity to be minor. Fourth, due to a low number of observations with severe CP, a more thorough differentiation across severity levels was not possible. A more detailed differentiation could improve insights and transferability of the results to other physical child disabilities. Fifth, to be able to control for parental health prior birth, our observation period was limited to 11 years and could not cover the whole timespan from birth to adulthood of the child. It may be that some parents are not followed for a sufficiently long time to observe an additional child or a divorce. On average, individuals whose parents did not divorce or get an additional child were observed for 6.0 years (no CP), 5.9 years (mild CP) and 5.7 years (severe CP). Lastly, even though five controls per case have been added to the study sample and with access to rich data material including a number of factors not previously adjusted for in this type of studies, there is still a possibility for unobserved heterogeneity that we cannot capture in register-based data (e.g., quality of life, lifestyle habits, physician's knowledge, and specialties).

6 | CONCLUSION

Our study reveals that parents of children with CP do not appear to run an increased risk of divorce, which might be reassuring to families consisting of a family member with CP. However, parents of children with CP with less education seem to be more vulnerable and may be in need of some form of additional support. We suggest that future studies should further explore why parents with less education are more vulnerable. Research questions that should be examined include whether parents with less education receive less welfare support (e.g., personal assistance) for their child with disability, and how social care and benefits mediate the association between having a child with CP and the parental decision to divorce and to have additional children.

ACKNOWLEDGMENT

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CONFLICT OF INTEREST

All authors declare no conflicts of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the register holders (Statistics Sweden, National Board of Health and Welfare, and the CPUP Register) after the standard application process. Restrictions apply to the availability of these data, which were used under license for this study.

ETHICS APPROVAL STATEMENT

Ethical approval has been obtained from the Lund Regional Ethical Board (dnr: 2018/1000) and the Swedish Ethical Review Authority (2021-00164 and 2022-01150-02).

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ENDNOTES

[1] Hereafter referred to as divorce.

[2] We exclude individuals that died before the age of five if they only had a CP-diagnosis at age 0 or 1. Also, individuals who exclusively have a CP-diagnosis before turning four are excluded, except for individuals born in the later years of the observation period (2012–2014) that could not be observed after the age of four. In case an acquired brain damage is diagnosed after the age of two (ICD10: G00, S061, S062, S063, S067, S068, S069. ICD9: 348B, 851, 852, 853, 584, 320), the observation is excluded unless CP is diagnosed before the acquired brain damage. Further, if diagnoses considered incompatible with CP exist (ICD10: G60, G61, G62, G71, G72, G834, G95, E71, E72, E74, E75, E76, E830, G114, G12, G31, G37, Q06, Q743. ICD9: 337, 356, 359, 358, 344G, 330, 270D, 270E, 270G, 270H, 272H, 277F, 275B, 334A, 334B, 335, 336, 728D, 742F), the individuals are excluded. Lastly, individuals who have been written off in the CPUP-register were excluded.

[3] Only eight children have two adoptive parents registered the year they were born, and nine children have one biological and one adoptive parent registered, which does not allow for separate analyses.

[4] Because individuals with foreign background are more likely to provide insufficient register data, disproportionally more of the individuals who were excluded from the analyses have foreign background.

[5] We classified children with spastic hemiplegia and ataxic CP as having mild CP. Children with spastic diplegia who at any time received a diagnosis of spastic hemiplegia, and children with dyskinetic CP who have a diagnosis of choreoathetoid (G803 B) are assumed to have less severe CP and were classified as having mild CP. Children with spastic tetraplegia CP are classified as having more severe CP. Children with dyskinetic CP (G803 A or G803X) or unknown choreoathetosis, and mixed sub-types were categorized as having more severe CP. Children with spastic diplegia without a diagnosis of choreoathetosis, hemiplegia or tetraplegia, as well as unspecific subtypes are not classified.

[6] We consider parents to have an additional child in the specific calendar year, in which the parents are still living together, the total number of children in the household (adding the different age groups from SCB together) increases and at least one child is in the youngest age group (i.e., 0–3 years old).

[7] Birth years 2013 and 2014 are combined into one group, because including birth year 2014 separately leads to omitted observations of parents with a child born in 2014.

[8] We chose three equal-sized groups to remain with a sufficiently large number of observations in each group. In each of the three age groups, the mean age at delivery is very similar for mothers of children with CP and mothers of children without CP. Maternal and paternal age at delivery are correlated. Because we investigate the heterogeneity across maternal age groups, we do not control for paternal age at delivery.

[9] Parents are considered to have immigrated to Sweden if either the mother or the father are born in another country than Sweden.

[10] If register-data provide information about the educational level for only one of the parents, this educational level is assumed to be the highest parental educational level.

[11] Maternal and paternal psychiatric mental health problems prior to birth are based on ICD-10 codes from national inpatient and outpatient registers and defined as having a diagnosis of anxiety (ICD-10 codes: F41, F42, F93.0–93.3, F06.4), other neurotic, stress-related and somatoform disorders (F40.1, F43, F44, F45, F48), depression (F30-F39), burnout (F43, Z73), sleep disorder (G47, F51.0, F51.8, F51.9), puerperium disorder (F53) and/or substance use disorders (F10-F16, F18-F19) in any of the three calendar years prior to childbirth.

[12] Smoking during the pregnancy is defined as smoking in pregnancy weeks 30–32 and/or when the pregnant woman arrives at the hospital to deliver the baby.

[13] Health-related information is available from 2001 onwards. To observe three years prior to childbirth, only children born after 2004 provide sufficient parental health information.

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