ORIGINAL ARTICLE

Long-Term Medical and Social Consequences of Preterm Birth

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ABSTRACT

BACKGROUND

Advances in perinatal care have increased the number of premature babies who survive. There are concerns, however, about the ability of these children to cope with the demands of adulthood.

METHODS

We linked compulsory national registries in Norway to identify children of different gestational-age categories who were born between 1967 and 1983 and to follow them through 2003 in order to document medical disabilities and outcomes reflecting social performance.

RESULTS

The study included 903,402 infants who were born alive and without congenital anomalies (1822 born at 23 to 27 weeks of gestation, 2805 at 28 to 30 weeks, 7424 at 31 to 33 weeks, 32,945 at 34 to 36 weeks, and 858,406 at 37 weeks or later). The proportions of infants who survived and were followed to adult life were 17.8%, 57.3%, 85.7%, 94.6%, and 96.5%, respectively. Among the survivors, the prevalence of having cerebral palsy was 0.1% for those born at term versus 9.1% for those born at 23 to 27 weeks of gestation (relative risk for birth at 23 to 27 weeks of gestation, 78.9; 95% confidence interval [CI], 56.5 to 110.0); the prevalence of having mental retardation, 0.4% versus 4.4% (relative risk, 10.3; 95% CI, 6.2 to 17.2); and the prevalence of receiving a disability pension, 1.7% versus 10.6% (relative risk, 7.5; 95% CI, 5.5 to 10.0). Among those who did not have medical disabilities, the gestational age at birth was associated with the education level attained, income, receipt of Social Security benefits, and the establishment of a family, but not with rates of unemployment or criminal activity.

CONCLUSIONS

In this cohort of people in Norway who were born between 1967 and 1983, the risks of medical and social disabilities in adulthood increased with decreasing gestational age at birth.

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Recent advances in the care of premature infants have resulted in increasing rates of survival. However, the increased prevalence of medical disabilities, learning difficulties, and behavioral and psychological problems among surviving preterm infants has raised concerns that these infants may have difficulties in coping with adult life.[1-6] Some primarily hospital-based cohorts of infants with very low birth weight who have been followed to young adulthood have shown reduced scores on cognitive and psychological tests as compared with controls with normal birth weights.[7-16] Other follow-up studies have shown more encouraging results.[17,18] However, the long-term social and behavioral outcomes of preterm birth are not well described. Most follow-up studies have focused on extremely premature infants (gestational age <28 weeks or birth weight <1000 g), but data on moderately premature babies, who comprise a larger proportion of preterm births, are also needed.

All births in Norway since 1967 have been registered in the Medical Birth Registry of Norway (MBRN). The aim of the present study was to examine the relationship between gestational age at birth and outcomes in adulthood in a national cohort by linking information from this registry to information in other national registries that include data on medical disabilities, education, income, family status, social security benefits, unemployment compensation, and criminal records.

METHODS

STUDY DESIGN

We identified in the MBRN all infants who were born alive in Norway between 1967 and 1983 and followed them until 2003, when they were between 20 and 36 years of age. Children who were born at a gestational age of at least 23 weeks according to the mother's last menstrual period and who did not have any registered congenital anomalies except congenital dislocation of the hips were included. Children with a sex-specific weight for gestational age that was more than 3 SD from the mean[19] were excluded because we assumed that the gestational age was probably recorded incorrectly.

The cohort was followed from birth to adulthood by linking compulsory national databases that include the entire population of Norway. The MBRN contains data on maternal health, pregnancy and delivery, and the health of the newborn for all babies who are born at a gestational age of 16 weeks or more.[20] The MBRN also includes information about the biologic parents of each newborn and was used to identify persons who became biologic parents during the follow-up period.

All residents of Norway are insured by the National Insurance Scheme (NIS).[21] The NIS provides disability benefits for people who have medical conditions that are of sufficient severity to be an economic burden and may include a basic benefit if a person incurs substantial expenses as a result of the disability, an attendance benefit (financial compensation for use of services or nursing), and a disability pension if a person is at least 18 years of age and his or her working capacity is permanently reduced by 50% or more. The diagnoses associated with the disability are recorded; these diagnoses are based on medical examinations and are classified according to the standard *International Classification of Diseases* (or ICD)[22] (see Table 1 in the Supplementary Appendix, available with the full text of this article at www.nejm.org). In a previous study that assessed the validity of NIS diagnoses among 27 children whose hospital records and parental reports indicated a diagnosis of cerebral palsy, the NIS correctly identified 70% of the children as having cerebral palsy and another 19% as having a disability that was potentially related to cerebral palsy (such as mental retardation or another neurologic disorder); 3 children who were not registered by the NIS as having a disability had mild cerebral palsy and may not have received any benefits. The specificity of an NIS diagnosis of cerebral palsy was 99%.[23]

Data on immigrant background, demographic characteristics, and records of social services were obtained from Statistics Norway.[24] A resident of Norway who is unable to care for himself or herself or for any dependents may receive social security benefits irrespective of medical history.[25] Data on the education level of the members of the cohort and their parents were obtained from the Norwegian National Education Database; information on job-related income from the Norwegian Tax Administration; records on unemployment from the National Employment Service; and data on criminal activity from the Central Criminal Record and Police Information System, which is run by the Ministry of Justice and the Police and includes information on all persons who receive a sentence for committing a crime in Norway.[26]

The Cause of Death Registry provided information on causes and date of death.

Information on biologic parenthood was updated through December 31, 2003, and information on unemployment, cohabitation, divorce, and emigration was updated through 2000. All other information was updated through 2002.

Every resident in Norway has a national identification number that is used by all the registries; this number made the precise linkage of records possible. After linkage by Statistics Norway, data from which the national identification numbers were removed were transferred to the MBRN and kept within a secure computer system. The study was approved by the Norwegian Directorate of Health and Social Services, the Ministry of Social Affairs, the National Police Directorate, and the Norwegian Data Inspectorate. These institutions gave permission for the use of the data without requiring consent from the study subjects.

STATISTICAL ANALYSIS

The gestational age was divided into five categories: 23 weeks to 27 weeks 6 days, 28 weeks to 30 weeks 6 days, 31 weeks to 33 weeks 6 days, 34 weeks to 36 weeks 6 days, and 37 weeks or more (term births). Associations between gestational age and outcome measures were estimated as relative risks with 95% confidence intervals from log-binomial regression models[27] with the use of the general linear model program in SPSS software, version 15.0 for Windows. A Cox regression model was used as an alternative method when log-binomial regression did not converge and failed to produce estimates.[28] A gestational age of 37 weeks or more was used as the reference category. To test for trend, the analyses were repeated with the gestational-age categories as a continuous variable.

All analyses were adjusted for sex, year of birth, multiple births, single motherhood, maternal age, mother's and father's level of education, and immigrant status of the parents. Data on education were available for 96% of the 5357 people whose parents were born outside Norway, and for 88% of their fathers and 85% of their mothers. The corresponding figures for children with at least one nonimmigrant parent were 100%, 98%, and 99%, respectively. Education level was classified according to a national nine-level scale (ranging from no education to a doctoral degree with at least 20 years' education) and was used as a continuous variable when adjusting independently for mother's and father's level of education. Year of birth was also modeled as a continuous variable. Maternal age at the time of the birth was categorized as less than 18 years, 18 to 39 years, or 40 years or more.

Children who died before their fifth birthday were excluded from the analyses of medical disabilities. Persons who died before their 20th birthday or who received disability benefits for medical reasons were excluded from the analyses of education, income, employment, social security benefits, life partner, reproduction, and criminal activity.

In the analyses of income, only earnings from jobs were used. The 20th and 80th percentiles for income were identified for all persons who were born within the same year. A low income was defined as an income below the 20th percentile for a particular year of birth, and a high income as an income above the 80th percentile.

In the analyses of levels of education, only persons whose age made it possible to have attained a given level were included. Whereas the whole cohort was included when completion of high school was assessed, those who were born after 1980 were excluded when completion of a bachelor's degree (i.e., 3 to 4 years of education after high school) was assessed, and those who were born after 1978 were excluded when completion of a master's degree (i.e., 5 to 6 years after high school) was assessed.

Our analyses of the prevalence of schizophrenia and autism involved small numbers in some categories. We therefore performed tests for trend across the gestational-age categories with the use of exact logistic regression (Stata/SE software, version 10.0), and adjusted only for sex and year of birth (in three intervals). Because the numbers in the highest gestational-age categories were too high for exact analyses, a 5% random sample of persons in the reference category (those born at 37 weeks of gestation or later) was used in the analyses of autism, and a 2% random sample of persons in the reference category and a 25% random sample of persons in the category of 34 to 36 weeks of gestation were used in the analyses of schizophrenia. Since the results depend somewhat on the composition of the random sample, we performed 25 independent selections and report the median P value among these 25 replications. We also report 95% confidence intervals from exact logistic-regression analyses for categories with small numbers. Odds ratios are good approximations of the relative risks for these rare outcomes.

Point estimates and confidence intervals for the larger categories were based on log-binomial regression.

Additional analyses of medical disabilities were stratified according to the year of birth, with the use of the time intervals of 1967 to 1972, 1973 to 1978, and 1979 to 1983, and analyses of medical disabilities and outcomes reflecting social function were stratified according to sex. Autism and schizophrenia were not included in these stratified analyses because the numbers in the subgroups were too small.

RESULTS

STUDY COHORT

A total of 903,402 children who were born alive between 1967 and 1983, with a gestational age at birth of at least 23 weeks and without known congenital anomalies, were identified through the MBRN. Among these, 13,582 died before their 20th birthday and 22,128 were not registered as residents in Norway as adults, leaving 867,692 in the cohort as adults (Fig. 1). Five-year survival increased from 20% for children born at 23 to 27 weeks of gestation to 99% for those born at term. The baseline characteristics of the cohort are shown in Table 1, and survival of the children by gestational age is shown in Figure 2. From 1967 to 1983, the neonatal mortality rates decreased steadily for all gestational ages (Fig. 3).

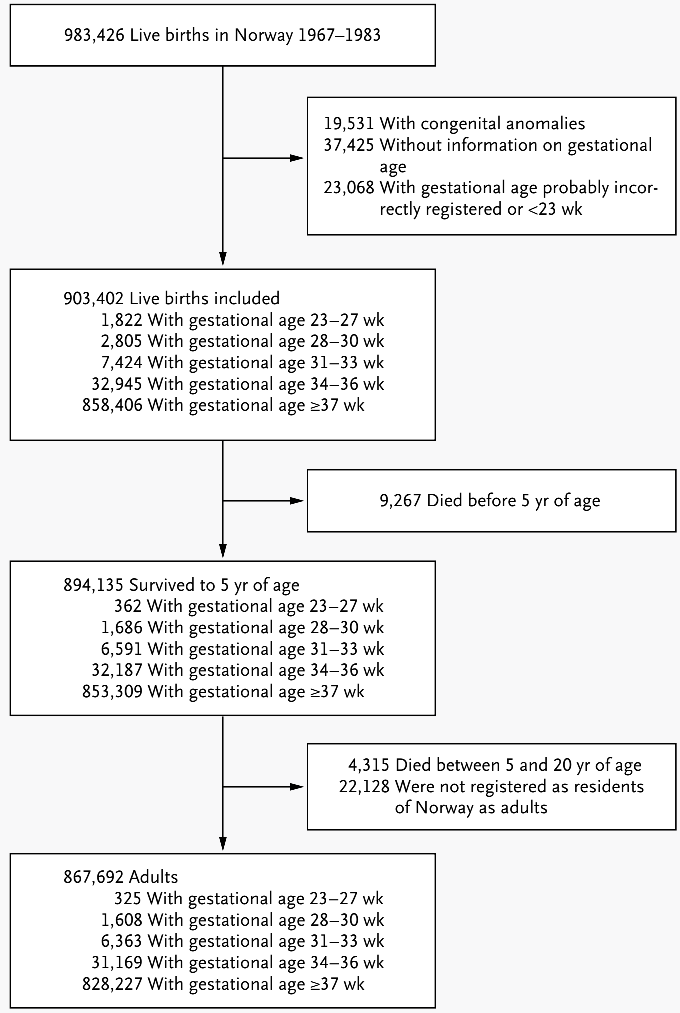

Figure 1. Establishment and Follow-up of the Cohort.

OUTCOMES

The risk of serious medical disabilities such as cerebral palsy, mental retardation, and disorders of psychological development, behavior, and emotion, as well as of other major disabilities such as blindness or low vision, hearing loss, and epilepsy increased markedly with decreasing gestational age (Table 2). We also observed a significant association of autism-spectrum disorders with very low gestational age, but these findings were based on a very small number of cases in the lowest gestational-age groups (Table 2). At 19 to 35 years of age, nearly 1 of 9 persons who had been born at 23 to 27 weeks of gestation received a disability pension, as compared with 1 of 12 who had been born at 28 to 30 weeks, 1 of 24 born at 31 to 33 weeks, 1 of 42 born at 34 to 36 weeks, and 1 of 59 born at term ($P<0.001$ by the chi-square test for trend).

Similar associations between gestational age and medical disabilities were seen within each of the subgroups that were categorized by years of birth (1967 to 1972, 1973 to 1978, and 1979 to 1983) (Table 2 of the Supplementary Appendix). Within the most preterm category (23 to 27 weeks of gestation), the absolute risk of having cerebral palsy increased significantly over time (P for trend=0.009).

When persons with medical disabilities were excluded from the analyses, there were significant but weaker associations between gestational age and proportions of people who attained a higher level of education and had well-paying jobs or who received social security benefits (Table 3). A lower gestational age at birth was associated with a reduced likelihood of completing high school ($P=0.003$), of receiving a bachelor's degree ($P=0.009$), of receiving a postgraduate degree

Table 1. Birth Data and Demographic Characteristics of the Cohort.*

Characteristic	Gestational-Age Group				
	23 Wk to 27 Wk 6 Days (N=325)	28 Wk to 30 Wk 6 Days (N=1608)	31 Wk to 33 Wk 6 Days (N=6363)	34 Wk to 36 Wk 6 Days (N=31,169)	37 Wk or More (N=828,227)
Gestational age at birth — wk	26.5±0.8	29.3±0.8	32.3±0.8	35.4±0.8	40.1±1.4
Birth weight — g	1053±198	1445±304	2056±459	2785±547	3553±481
Male sex — %	52.3	54.6	54.9	55.1	50.9
Multiple births — no. (%)	25 (7.7)	241 (15.0)	998 (15.7)	3404 (10.9)	10,738 (1.3)
Single mother — %	14.8	18.6	16.6	14.1	9.9
Maternal age at birth — %					
<18 yr	3.4	3.8	3.8	3.1	1.8
≥40 yr	2.5	1.4	1.7	2.1	1.4
Level of mother's education†	3.5±1.5	3.3±1.4	3.4±1.4	3.4±1.4	3.5±1.4
Level of father's education†	3.6±1.6	3.6±1.5	3.6±1.5	3.6±1.6	3.8±1.6
Immigrant parents — %‡	1.2	1.4	0.7	1.0	0.6

* All members of this cohort were alive at 20 years of age and registered as residents of Norway as adults. Plus–minus values are means ±SD.
† Level of education was classified according to national standards on a 9-level scale in which 0 indicates no formal education and 8 the highest level of university degree (doctoral degree). A level of 3 indicates a total of 11 to 12 years at school, and a level of 4 indicates 13 years at school.
‡ Both parents were born outside Norway.

(P=0.006), and of having a high income (P<0.001) and with an increased likelihood of having a low income (P<0.001) and of receiving social security benefits (P<0.001). There was, however, no significant association between gestational age and unemployment rates. Decreasing gestational age was also associated with a lesser likelihood of finding a life partner (P<0.001) and of having children (P<0.001) but was not associated with receiving a sentence for violent behavior or criminal damage, a drug felony, or overall criminal activity (Table 3).

Although the overall prevalence of problems was different for men and women, and higher for men for most of the outcomes studied (Tables 3 and 4 of the Supplementary Appendix), the associations of various outcomes with gestational age did not differ significantly according to sex.

DISCUSSION

In this national cohort, which included children who were born at a wide range of gestational ages and who were followed until adulthood, the risk of severe medical disabilities increased sharply with decreasing gestational age at birth. This association was true with respect to the risk of having cerebral palsy, mental retardation, and several other disorders and with respect to receiving a disability pension. Among those who were recorded as not having medical disabilities, the proportions of people who achieved higher education, held well-paying jobs, established a family, and did not receive social security benefits were slightly but significantly lower for those who were born prematurely than for those who were born at term.

These findings are consistent with those of previous studies that showed that very preterm birth is associated with specific difficulties in the areas of motor, cognitive, behavioral, psychological, and social function among preschool and school-age children.[1-6] A recent study involving toddlers showed an association of preterm birth with features of the autism spectrum[29]; we also found an increased risk of autism-spectrum disorders among the infants who were born very prematurely, although caution is warranted in interpreting this finding given the small number of cases in the very premature groups. Our findings are also consistent with the results of smaller studies of children who were born very prematurely and were followed to young adulthood[11,17] and with data on the social outcomes of prematurity in a Swedish national co-

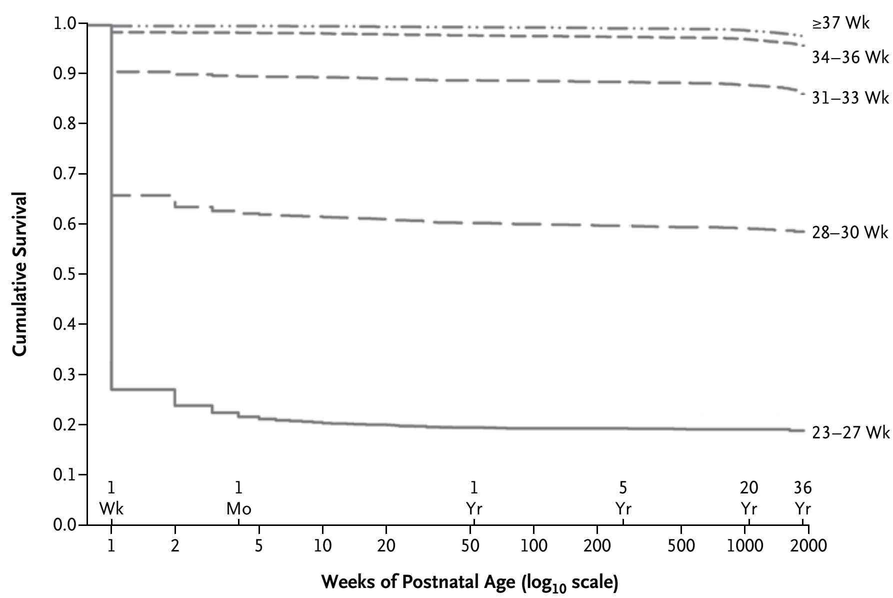

Figure 2. Survival Curves According to Gestational Age.

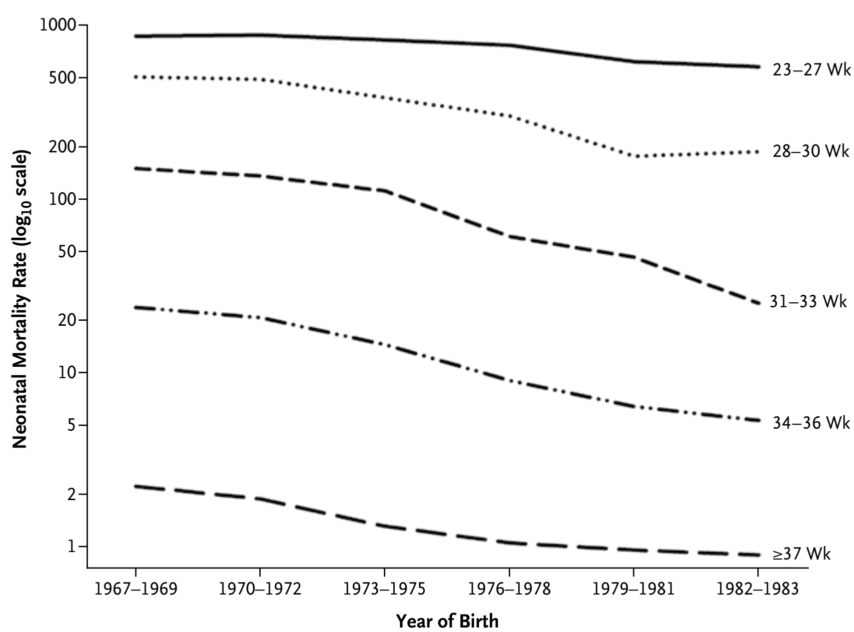

Figure 3. Secular Trend of Neonatal Mortality (per Thousand), Excluding Children with Congenital Anomalies.

hort study.[18] A lower level of academic achievement and a reduced tendency to have biologic children among persons born very prematurely, as compared with those born at term, were previously reported in a study that involved members of the cohort of the current study, but that study did not exclude those with medical disabilities from these analyses.[30]

We defined prematurity according to gestational age instead of birth weight, which is the definition that was used in many previous studies.[7-12,15-17] Although this approach resulted in the exclusion of about 4% of the births, owing to missing data on gestational age, it avoided the potential for misclassification of more mature babies who were small for gestational age as more preterm than they actually were.

Among the strengths of our study are the co-

Table 2. Medical Disabilities According to Gestational Age at Birth.*

Disability	Subjects		P Value for Trend
	no./total no. (%)	*relative risk (95% CI)*	
Cerebral palsy†			<0.001
23 Wk to 27 wk 6 days	33/362 (9.1)	78.9 (56.5–110.0)	
28 Wk to 30 wk 6 days	101/1,686 (6.0)	45.8 (37.1–56.5)	
31 Wk to 33 wk 6 days	125/6,591 (1.9)	14.1 (11.6–17.2)	
34 Wk to 36 wk 6 days	112/32,187 (0.3)	2.7 (2.2–3.3)	
≥37 Wk	1,110/853,309 (0.1)	1.0 (reference)	
Mental retardation†			<0.001
23 Wk to 27 wk 6 days	16/362 (4.4)	10.3 (6.2–17.2)	
28 Wk to 30 wk 6 days	30/1,686 (1.8)	4.2 (2.9–6.0)	
31 Wk to 33 wk 6 days	64/6,591 (1.0)	2.1 (1.7–2.8)	
34 Wk to 36 wk 6 days	223/32,187 (0.7)	1.6 (1.4–1.8)	
≥37 Wk	3,578/853,309 (0.4)	1.0 (reference)	
Schizophrenia†			0.12‡
23 Wk to 27 wk 6 days	2/362 (0.6)	4.5 (0.7–16.5)‡	
28 Wk to 30 wk 6 days	2/1,686 (0.1)	0.9 (0.1–3.2)‡	
31 Wk to 33 wk 6 days	15/6,591 (0.2)	1.4 (0.8–2.5)	
34 Wk to 36 wk 6 days	61/32,187 (0.2)	1.3 (1.0–1.7)	
≥37 Wk	1,152/853,309 (0.1)	1.0 (reference)	
Autism spectrum†			0.002‡
23 Wk to 27 wk 6 days	2/362 (0.6)	9.7 (1.5–36.2)‡	
28 Wk to 30 wk 6 days	6/1,686 (0.4)	7.3 (2.7–17.6)‡	
31 Wk to 33 wk 6 days	3/6,591 (0.05)	1.0 (0.2–3.0)‡	
34 Wk to 36 wk 6 days	11/32,187 (0.03)	0.8 (0.4–1.4)	
≥37 Wk	403/853,309 (0.05)	1.0 (reference)	
Disorders of psychological development, behavior, and emotion†			<0.001
23 Wk to 27 wk 6 days	9/362 (2.5)	10.5 (5.6–19.9)	
28 Wk to 30 wk 6 days	12/1,686 (0.7)	2.9 (1.6–5.2)	
31 Wk to 33 wk 6 days	23/6,591 (0.3)	1.4 (0.9–2.2)	
34 Wk to 36 wk 6 days	108/32,187 (0.3)	1.5 (1.2–1.8)	
≥37 Wk	1,798/853,309 (0.2)	1.0 (reference)	
Other major disabilities†§			<0.001
23 Wk to 27 wk 6 days	15/362 (4.1)	19.6 (11.9–32.2)	
28 Wk to 30 wk 6 days	37/1,686 (2.2)	9.3 (6.6–13)	
31 Wk to 33 wk 6 days	35/6,591 (0.5)	2.3 (1.7–3.3)	
34 Wk to 36 wk 6 days	110/32,187 (0.3)	1.5 (1.2–1.8)	
≥37 Wk	1,916/853,309 (0.2)	1.0 (reference)	

Table 2. (Continued.)

Disability	Subjects		P Value for Trend
	no./total no. (%)	*relative risk (95% CI)*	
Any medical disability severely affecting working capacity¶			<0.001
23 Wk to 27 wk 6 days	38/359 (10.6)	7.5 (5.5–10.0)	
28 Wk to 30 wk 6 days	138/1,674 (8.2)	4.8 (4.1–5.7)	
31 Wk to 33 wk 6 days	272/6,548 (4.2)	2.2 (2.0–2.5)	
34 Wk to 36 wk 6 days	781/32,062 (2.4)	1.4 (1.3–1.5)	
≥37 Wk	14,286/850,437 (1.7)	1.0 (reference)	

* All analyses are adjusted for sex, year of birth, multiple births, single motherhood, maternal age, mother's level of education, father's level of education, and whether parents were immigrants.

† This category of diagnosis is extracted from the primary medical diagnoses registered in the National Insurance Scheme as the reasons for giving disability benefits (Table 1 of the Supplementary Appendix).

‡ Relative risk, confidence interval, and P value were based on exact logistic regression, adjusting for calendar year and sex because of small numbers.

§ Other major disabilities include blindness, low vision, hearing loss, and epilepsy.

¶ Disability affecting working capacity was assessed by the National Insurance Scheme as the working capacity of a person 18 years of age or older that was permanently reduced by at least 50% owing to any medical condition. Children who died before their 18th birthday were excluded from this analysis.

hort design that included all births in the country, the linkage of comprehensive and compulsory databases that had reliable information, and the minimal loss to follow-up. Furthermore, we studied a wide range of gestational ages to assess gradients or thresholds in the relationship between the degree of prematurity and several outcomes. The weaknesses of our study include the lack of detailed information on the severity of disabilities or on any functional capacity related to cognitive and social skills that was not reflected in educational level, income, criminal records, or the ability to establish a family. The misclassification of some diagnoses is possible when NIS data are used, but it is likely that diseases or disabilities that add a substantial burden to the individual or the family are recorded in this database. During the years when this cohort was born, there were no organized follow-up programs for premature children in Norway. Furthermore, the NIS would not have released financial support to a person who had received a given diagnosis unless the functional capacity of the person was substantially reduced. Therefore, overdiagnosis of disabilities among the most premature cohort owing to an increased use of services is unlikely.

The associations we observed between preterm birth and adverse adult outcomes may represent long-term effects of subtle brain dysfunction caused by preterm birth. Underlying biologic and social factors may, however, influence both the likelihood of preterm birth and adverse adult outcomes.[31-33] Therefore, to reduce potential confounding, we adjusted all analyses for sex, year of birth, multiple births, single motherhood, maternal age at the time of the birth, mother's and father's level of education, and immigrant status of the parents. Confounding still remains possible owing to factors for which we could not adjust, such as parental IQ, other socioeconomic factors, and the use of tobacco, alcohol, or illicit drugs. Also, we cannot rule out the possibility that an underlying and unknown medical condition in some infants led to both preterm delivery and subsequent social or health problems.

The survival rates among the children with the lowest gestational ages increased over time and coincided with an increased prevalence of cerebral palsy. There was no change in diagnostic criteria or screening procedures for cerebral palsy during the study period, leaving increased survival as the most likely explanation for the increased prevalence. Neonatal intensive care has continued to improve considerably in the years since this cohort was born.[34] Among preterm survivors, the prevalence of cerebral palsy may be decreasing,[35,36] although it is uncertain whether the same trend is occurring with respect to the prevalence of less severe functional impairments such as behavioral, social, and learning difficulties among preschool and school-age children.[37] Studies have shown increased prevalences of attention deficits, with-

Table 3. Education, Employment, Income, Biologic Parenthood, Social Relations, and Criminality in Relation to Gestational Age at Birth.*

Variable and Gestational Age at Birth	Subjects		P Value for Trend
	no./total no. (%)	*relative risk (95% CI)*	
Completed high school†			0.003
23 Wk to 27 wk 6 days	170/251 (67.7)	0.9 (0.8–1.1)	
28 Wk to 30 wk 6 days	954/1,367 (69.8)	1.0 (0.9–1.0)	
31 Wk to 33 wk 6 days	4,238/5,887 (72.0)	1.0 (1.0–1.0)	
34 Wk to 36 wk 6 days	21,419/29,631 (72.3)	1.0 (1.0–1.0)	
≥37 Wk	601,364/797,457 (75.4)	1.0 (reference)	
Completed university, bachelor's degree†‡			0.009
23 Wk to 27 wk 6 days	47/187 (25.1)	0.8 (0.6–1.1)	
28 Wk to 30 wk 6 days	311/1,118 (27.8)	0.9 (0.8–1.0)	
31 Wk to 33 wk 6 days	1,540/5,041 (30.5)	1.0 (0.9–1.0)	
34 Wk to 36 wk 6 days	7,927/25,193 (31.5)	1.0 (1.0–1.0)	
≥37 Wk	234,006/675,340 (34.7)	1.0 (reference)	
Completed postgraduate degree†§			0.006
23 Wk to 27 wk 6 days	7/153 (4.6)	0.7 (0.3–1.6)	
28 Wk to 30 wk 6 days	47/966 (4.9)	0.8 (0.6–1.1)	
31 Wk to 33 wk 6 days	236/4,454 (5.3)	0.9 (0.8–1.0)	
34 Wk to 36 wk 6 days	1,364/22,306 (6.1)	1.0 (0.9–1.0)	
≥37 Wk	41,252/591,499 (7.0)	1.0 (reference)	
Low job-related income¶			<0.001
23 Wk to 27 wk 6 days	57/248 (23.0)	1.2 (0.9–1.5)	
28 Wk to 30 wk 6 days	312/1,361 (22.9)	1.1 (1.0–1.3)	
31 Wk to 33 wk 6 days	1,212/5,839 (20.8)	1.1 (1.0–1.1)	
34 Wk to 36 wk 6 days	6,112/29,370 (20.8)	1.1 (1.0–1.1)	
≥37 Wk	157,625/789,807 (20.0)	1.0 (reference)	
High job-related income‖			<0.001
23 Wk to 27 wk 6 days	39/248 (15.7)	0.8 (0.6–1.1)	
28 Wk to 30 wk 6 days	242/1,361 (17.8)	0.9 (0.8–1.0)	
31 Wk to 33 wk 6 days	1,125/5,839 (19.3)	0.9 (0.9–1.0)	
34 Wk to 36 wk 6 days	5,833/29,370 (19.9)	1.0 (0.9–1.0)	
≥37 Wk	158,078/789,807 (20.0)	1.0 (reference)	
Unemployed**			0.38
23 Wk to 27 wk 6 days	44/251 (17.5)	0.8 (0.6–1.1)	
28 Wk to 30 wk 6 days	341/1,371 (24.9)	1.0 (0.9–1.1)	
31 Wk to 33 wk 6 days	1,464/5,902 (24.8)	1.0 (1.0–1.0)	
34 Wk to 36 wk 6 days	7,268/29,711 (24.5)	1.0 (1.0–1.0)	
≥37 Wk	189,208/799,134 (23.7)	1.0 (reference)	
Received Social Security benefits			<0.001
23 Wk to 27 wk 6 days	50/251 (19.9)	1.2 (0.9–1.5)	
28 Wk to 30 wk 6 days	305/1,371 (22.2)	1.1 (1.0–1.2)	
31 Wk to 33 wk 6 days	1,220/5,902 (20.7)	1.1 (1.0–1.1)	
34 Wk to 36 wk 6 days	5,978/29,711 (20.1)	1.1 (1.1–1.1)	
≥37 Wk	140,408/799,134 (17.6)	1.0 (reference)	
Biologic parenthood † ††			<0.001
23 Wk to 27 wk 6 days	72/251 (28.7)	0.8 (0.6–1.0)	
28 Wk to 30 wk 6 days	496/1,371 (36.2)	0.9 (0.8–0.9)	
31 Wk to 33 wk 6 days	2,441/5,902 (41.4)	0.9 (0.9–1.0)	
34 Wk to 36 wk 6 days	12,691/29,711 (42.7)	1.0 (0.9–1.0)	
≥37 Wk	344,814/799,134 (43.1)	1.0 (reference)	

Table 3. (Continued.)

Variable and Gestational Age at Birth	Subjects		P Value for Trend
	no./total no. (%)	*relative risk (95% CI)*	
Married or cohabitating			<0.001
23 Wk to 27 wk 6 days	25/251 (10.0)	0.7 (0.5–1.0)	
28 Wk to 30 wk 6 days	196/1,371 (14.3)	0.9 (0.8–1.0)	
31 Wk to 33 wk 6 days	962/5,902 (16.3)	0.9 (0.9–0.9)	
34 Wk to 36 wk 6 days	5,147/29,711 (17.3)	0.9 (0.9–1.0)	
≥37 Wk	146,095/799,127 (18.3)	1.0 (reference)	
Divorced			<0.001
23 Wk to 27 wk 6 days	2/251 (0.8)	0.5 (0.1–1.8)	
28 Wk to 30 wk 6 days	19/1,371 (1.4)	0.6 (0.4–1.0)	
31 Wk to 33 wk 6 days	117/5,902 (2.0)	0.7 (0.6–0.9)	
34 Wk to 36 wk 6 days	709/29,711 (2.4)	0.9 (0.9–1.0)	
≥37 Wk	19,765/799,134 (2.5)	1.0 (reference)	
Overall criminality			0.56
23 Wk to 27 wk 6 days	24/251 (9.6)	1.1 (0.8–1.6)	
28 Wk to 30 wk 6 days	132/1,371 (9.6)	1.0 (0.8–1.1)	
31 Wk to 33 wk 6 days	594/5,902 (10.1)	1.0 (0.9–1.1)	
34 Wk to 36 wk 6 days	2,933/29,711 (9.9)	1.0 (1.0–1.1)	
≥37 Wk	69,536/799,134 (8.7)	1.0 (reference)	
Received a sentence for violence or criminal damage			0.62
23 Wk to 27 wk 6 days	5/251 (2.0)	0.7 (0.3–2.0)	
28 Wk to 30 wk 6 days	27/1,371 (2.0)	0.8 (0.5–1.2)	
31 Wk to 33 wk 6 days	162/5,902 (2.7)	1.0 (0.9–1.2)	
34 Wk to 36 wk 6 days	760/29,711 (2.6)	1.0 (0.9–1.1)	
≥37 Wk	17,837/799,134 (2.2)	1.0 (reference)	
Received a sentence for drug felony			0.52
23 Wk to 27 wk 6 days	10/251 (4.0)	1.3 (0.7–2.5)	
28 Wk to 30 wk 6 days	45/1,371 (3.3)	1.1 (0.8–1.5)	
31 Wk to 33 wk 6 days	177/5,902 (3.0)	1.0 (0.8–1.1)	
34 Wk to 36 wk 6 days	909/29,711 (3.1)	1.0 (1.0–1.1)	
≥37 Wk	22,083/799,134 (2.8)	1.0 (reference)	

* People receiving disability benefits for medical reasons were excluded from these analyses. All analyses are adjusted for sex, year of birth, multiple births, single motherhood, maternal age, mother's level of education, father's level of education, and immigrant status of parents.

† A Cox regression model was used for estimation since log-binomial regression did not converge.

‡ Persons born later than 1980 were excluded from this analysis.

§ Persons born later than 1978 were excluded from this analysis.

¶ Low job-related income was defined as a job-related yearly income that was lower than the 20th percentile for persons born during the same year.

‖ High job-related income was defined as a job-related yearly income that was higher than the 80th percentile for persons born during the same year.

** This category includes persons who had been registered at any time as unemployed by the Norwegian Employment Service.

†† This category includes persons who were registered as a biologic mother or father in the Medical Birth Registry of Norway.

drawal, anxiety, and reduced academic and social skills among schoolchildren with low birth weight as compared with children with normal birth weight.[38,39] More recent survivors of preterm birth may therefore have difficulties similar to those of the present cohort when they become adults, although further follow-up of more recent cohorts is needed to address this question.

Despite the higher prevalence of disabilities among persons who were born prematurely, it should be recognized that a large proportion of the adults who were born prematurely and who did not have severe medical disabilities completed higher education and seemed to be functioning well.

The current study shows that there is a continuous relationship between decreasing gestational age at birth and a wide range of adverse outcomes, without any obvious threshold. Since most preterm births occur at moderate rather than extreme prematurity, most of those with special needs may be those who were born at a moderately premature gestational age. On the other hand, the survival rate of very preterm infants who are at higher risk has continued to increase. Studies are needed to identify modifiable factors that predict adult outcomes among children born prematurely in order to improve preventive and therapeutic strategies.

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