Associations of Birth Defects with Adult Intellectual Performance, Disability and Mortality: Population-based Cohort Study

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ABSTRACT

Infants born with birth defects have poorer outcomes in terms of mortality and disability, but the long-term intellectual outcome in children with birth defects is generally unknown. We assessed the long-term associations of various birth defects with mortality, disability, and intellectual performance at age 18. In this nationwide cohort study, records of 9,186 males with and 384,384 without birth defects, registered in the Medical Birth Registry of Norway (1967-1979) were linked to the National Conscript Service (1984-1999). Complete follow-up information on mortality, emigration, disability and intelligence, was obtained for 94%. Mortality and disability before military draft, and intelligence test score at conscription were the main outcome measures. Males with birth defects had a relative risk for disability of 6.0 (95% confidence interval 5.5-6.5) compared with males without defects. Disability was low within categories of birth defects associated with low mortality, and high within defect categories associated with high mortality. The relative risk for not being drafted was highest if maternal educational level was low ($p<0.05$). Heart defects ($p=0.007$) and cleft palate ($p=0.045$) were the only subgroups in which intellectual performance was lower after adjustment for maternal education, maternal age, marital status and birth order. We could not show that intellectual performance was impaired among those with multiple compared with single defects ($p=0.34$). This also applied to comparisons between single and multiple defects among men with heart defects, as well as oral clefts. Thus, for the majority of birth defect categories in the present birth cohort, intellectual performance was not impaired.

Infants with birth defects have increased perinatal and postperinatal mortality (1,2), lower birth weight (3), as well as lower survival to age 20 years; however, dependent on type of defect (1,4). Furthermore, infants with birth defects are at increased risk of childhood morbidity and disability (2,5), including reproductive failure (4), also depending on the type of birth defect.

Having a birth defect may also be associated with other long-term outcomes, such as intellectual performance. Intellectual performance is known to be associated with a number of health outcomes (6). Because intellectual performance reflects an individual's ability to learn, reason and solve problems, it may serve as a measure for comparing ability in subgroups with that in the general population. However, although a decreased cognitive function in infants with certain birth defects has been reported in clinical studies (7-13), little is known about the long-term intellectual outcome for most birth defect categories.

As studies with assessment of intellectual ability in surviving infants are lacking for several categories of birth defects, it would be efficient to evaluate this issue in a large population using overall as well as separate analyses for the various categories of birth defects.

In Norway, since 1967 medical data on all births (including stillbirths) from 16 weeks of gestation are recorded by the Medical Birth Registry of Norway (14). Data on intellectual performance are routinely recorded by the National Conscripts Service in all Norwegian men at the age of 18 years (15,16). Data on disability status are registered in the National Health Insurance Office. Our aim was to assess the long-term associations of various birth defects with mortality, disability until age 18 years, and intellectual ability among non-disabled survivors.

METHODS

Study population

From 1967 to 1979, 393,570 singleton male live births were registered in the Medical Birth Registry providing data on birth defects as well as maternal age, marital status, and birth order (including stillbirths). All Norwegian men are required to register with the draft board at age 18 years for physical and mental examinations. Only those registered in the National Health Insurance Office as being permanent disabled are exempted. By the national identification number, data from the Medical Birth Registry were linked with data on disability status from the National Health Insurance Office 1967-1997, on intellectual performance recorded by the National Conscripts Service 1984-1999, and data on mortality, as well as maternal educational level (completed years), from Statistics Norway 1967-1998.

Births were divided into those with a registered birth defect (9,186; 2.4%) and those without such a defect (384,384; 97.6%). Of the total birth cohort, 8,383 (2.1%; 1,160 with and 7,223 without a birth defect, respectively) died before military draft, 3,788 (1.0%) emigrated, 5,692 (1.4%) were not drafted due to disability (i.e. registered in the National Health Insurance Office with at least one *International Classification of Diseases, Ninth Revision* (ICD-9) diagnosis indicating disability due to chronic disease or birth defects), and 24,355 (6.2%) were untraceable at draft (Table 1) (16). Draft board medical data were obtained for 351,352 men (16). Analyses of intellectual performance were restricted to conscripts with data on intelligence testing and maternal educational level. This excluded 33,591 men, leaving 6,023 in the study cohort with a birth defect (65.6% of all males born with a birth defect), and 311,738 without a birth defect (81.1% of those born without a birth defect) for analysis. Data on maternal age, marital status, and birth order were complete for the study cohort.

Classification of birth defects

During the initial hospitalization (usually 5-7 days), every newborn undergoes a medical examination (including screening blood tests as well as possible additional diagnostic procedures) by a physician, usually a pediatrician. During the study period, the Medical Birth Registry has recorded birth defects that were diagnosed based on these examinations. Apart from the notification form, which is compulsory in every birth, no additional source of ascertainment was available. We defined 26 categories of birth defects on the basis of the *International Classification of Diseases, Eighth Revision* (ICD-8), as in previous studies (1,4). For most affected infants, only one single birth defect diagnosis was reported. When spina bifida was present with anencephaly, only anencephaly was counted, and when spina bifida was present with hydrocephalus, only spina bifida was counted. All other cases with multiple birth defect diagnoses were combined in one separate category. We defined separate categories for clubfoot and hip dysplasias, which were excluded from the category of limb defects. Also, we defined separate categories for isolated cleft lip and cleft palate, and for combined cleft lip and palate. Finally, Down's syndrome was separated from other recognized syndromes. The categories were mutually exclusive, 25 containing isolated defects and 1 containing multiple defects.

Intelligence testing

General intellectual performance was measured by a 53 minute validated group intelligence test, which was developed in 1953 for the Norwegian draft board, and revised in 1962. The test included time-limited sub-tests covering 3 categories of items: verbal analogues, number series (calculation) and geometrical figures. Each sub-test was organized by increasing difficulty. The test questionnaire comprised a total of 120 questions. All conscripts received standard instructions prior to the time-limited tests. The test is highly correlated with the

Wechsler Adult Intelligence Scale (r =0.73) (15). The result is presented as standard nine ("stanine") scores; i.e., single-digit standard scores (with values from 1 to 9) based on a normal distribution, in which the mean is 5.0 and the standard deviation is 1.96. In the text stanine score is termed "intelligence test score".

Statistics

Mortality was calculated as the proportion of infants within each birth defect category who died before military draft among those born alive with such a defect. Likewise, disability was estimated as the proportion of infants within each birth defect category who were registered as disabled (and not drafted) among those born alive with such a defect. Disability was calculated among survivors (i.e. excluding those who were dead before military draft). Relative risks (RR) with 95% confidence intervals (CI) for mortality, disability, and for not being drafted (due to any reason) were calculated using 2x2 tables. Intelligence test score was analyzed using analysis of variance (crude analyses) and general linear models (adjusted analyses). In these models, all independent variables were treated as categorical. Maternal age was categorized into five groups (19 years or less, 20-24 years 25-29 years, 30-34 years, and 35 years or more), marital status as married or unmarried, and birth order into 1, and 2 or more. Maternal educational level was classified into low (<10 years), medium (11-14 years), or high (>14years). Sibling dependencies were not considered. All tests were two sided, and $p < 0.05$ was chosen as the level of statistical significance. SPSS software (version 12.0.1, SPSS, Chicago, Ill.) was used for statistical analyses.

RESULTS

Among 393,570 singleton live infant males born during 1967-1979, altogether 385,187 (97.9%) survived until 1999. The proportion of birth defects was 13.8% among those who died before military draft, and 11.3% among those who were disabled, whereas in the study cohort the proportion of birth defects was 1.9%. Among boys who emigrated and those who were untraceable at draft the proportion of birth defects was 2.5% and 2.1%, respectively. Follow-up until age 18 years showed that infants with birth defects had an excess mortality rate of 10.7%, and an excess disability rate of 6.7% when compared with infants born without defects (Table 1). The RR for mortality before military draft for males with birth defects was 6.7 (95% CI: 6.3-7.1) compared with those without defects. Further, RR for disability among males with any birth defect who survived until age 18 was 6.0 (95% CI: 5.5-6.5) as compared to males without defects. Table 1 shows RRs for mortality and disability within 13 of the 26 birth defect categories. The increased RR for mortality was significant for all categories of birth defects, except for cleft lip, genitalia, hip, and skin/hair/nail, whereas RR for disability was significantly increased for all categories, except for cleft lip and skin/hair/nail, as well as respiratory defects (the latter group had no disabled cases).

Among those with birth defects who survived, 8.0% were registered as disabled, against 1.3% in the group without defects. Figure 1 shows mortality and disability for the various birth defect categories. The disability among men at 18 years was low within the categories of birth defects associated with low mortality, whereas the disability was high within birth defect categories associated with high mortality. Thus, the birth defect categories seemed to appear in two clusters. However, for eye defects, the disability was relatively high despite low mortality, and for abdominal wall defects the disability was low despite a relatively high mortality.

For males with any birth defect, the RR for not being drafted (due to any reason) was 2.5 (95% CI: 2.4-2.6) as compared to males with no birth defect. Stratified on maternal educational level, the RR for not being drafted among males with a birth defect as compared to those with no defect was 2.9 (95% CI: 2.7-3.1), 2.4 (95% CI: 2.3-2.5), and 2.2 (95% CI: 2.0-2.5) for sons of mothers at the low, medium, and high level, respectively. Because the CIs of the low and high levels were non-overlapping, there was an interaction between maternal education and infants with birth defects on the risk for not being drafted ($p < 0.05$).

Table 2 presents mean intelligence test score by birth characteristics among conscripts with and without birth defects. The proportion of birth defects was differently distributed across the categories of maternal education, birth order, and marital status. Birth defects were more frequent in sons of mothers with high education; however, after stratification for maternal age and birth order, the difference was not statistically significant. Of the possible confounding factors, maternal age and educational level was positively associated with intelligence test score, whereas there was a negative association with birth order and being unmarried ($p < 0.0005$ for all).

No significant difference was observed in mean intelligence test score for most categories of birth defects compared with those without defects (Fig. 2). However, males born with heart defects, cleft palate, and combined cleft lip and palate had slightly lower scores than those without defects. Also, although not statistically significant, scores for males with hydrocephalus, syndromes other than Down's, and other defects were low. In crude analyses scores for males with clubfoot and genitalia-defects were significantly higher than for those without defects. However, in analyses adjusted for maternal education, maternal age, marital

status, and birth order, only the differences for males with heart defects and cleft palate remained significant (p = 0.007 and 0.045, respectively) (Table 3).

As seen in Figure 2, there was no significant difference in mean intelligence test score for individuals with multiple defects compared with those with no defects (mean score 5.11 versus 5.22, p = 0.5). Also, there was no difference when comparing the score for males with multiple defects with the overall score for those who had one single birth defect (5.11 versus 5.22, p = 0.2; adjusted for maternal education, maternal age, marital status, and birth order) (Table 3). Within the heart defect category, the intelligence test score was not lower among those who had additional defects compared with those who had a single heart defect diagnosis (5.30 versus 4.90, p = 0.7). Similarly, within the cleft palate category, there was no significant difference in mean score when comparing males having cleft palate only with those having additional birth defects (p = 0.6). For completeness, Table 3 also includes similar comparisons for cleft lip (p = 0.07) and combined cleft lip and palate (p = 0.8).

In a post hoc analysis, birth defects (except for eye defects) were categorized according to the impression in Figure 1 of two possible clusters; one with mortality <10%, and the other with mortality >20%. The first group (consisting of nine categories of birth defects) had significantly higher intelligence test score than the group with higher mortality (mean scores 5.26 versus 5.03, p=0.002). In the group associated with mortality >20% there was no significant difference when comparing those with high (≥20%) and low (<20%) disability (p = 0.8).

DISCUSSION

Our study showed that live born males with birth defects who survived until 18 years of age, overall had a 6-fold increased risk of being disabled before military draft compared with those born without defects. The risk of not being drafted (due to any reason) was highest if maternal educational level was low. Conscripts with heart defects or cleft palate were the only subgroups in which intellectual performance were adversely affected. We could not demonstrate lower intellectual performance among those who had additional birth defects compared with those who had a single birth defect diagnosis. For the majority of birth defect categories, the results did not confirm our hypothesis that intelligence test score at conscription would be impaired.

Although some studies have documented a decreased cognitive function in children with specific birth defects (7-9), few studies have assessed the long-term impact on intellectual performance (10-12). To our knowledge, no previous follow-up study on cognitive function has included all ICD-8 codes of malformations.

A major strength of the present study was the large sample size. By using population registers, the follow-up information was almost complete; 94% of the birth cohort was traced until age 18 years. Altogether, 73.8% of all males born with a birth defect were drafted. Furthermore, using the Medical Birth Registry of Norway, a large population-based registry, we were able to evaluate all ICD-8 categories of birth defects, and isolated and multiple cases were treated separately.

A number of limitations should be noted. First, due to excess mortality and disability among infants with defects, a higher proportion (26.2%) of infants with birth defects never attended

the draft board compared with those without defects (10.4%). As expected, the proportion not drafted varied according to the severity of the birth defect. Not attending the draft board may be associated with lower intellectual performance, implying an overestimation of the mean scores among those with birth defects. Thus, if data on intellectual performance in the non drafted subgroups had been available, the observed intellectual performance in the birth defect group might have been lower. In the period 1967-1970 the proportion of drafted men with birth defects was 67.7%, against 77.7% in the period 1975-1979, whereas intelligence test score was highest in the latest period. If those with birth defects who were not drafted represented a major selection bias, this would imply that the score in the latest period should have been lowest.

Second, ascertainment of birth defects was not complete. Of all live born males in the present cohort, 2.4% were affected by malformations. Similar rates have been published in other studies (17,18). Not all birth defects are apparent within the first week of life. For example, clinical manifestations of many heart defects do not occur until after discharge from the maternity institution (4), and intellectual deficits may not be apparent until much later. Thus, the registered heart defects probably represent severely affected infants. However, for neural tube defects and oral clefts, the proportions of cases ascertained by the registry have been estimated at approximately 90% and 80%, respectively (19). Low ascertainment implies that there may be infants with undiagnosed birth defects in the reference group of individuals without malformations. Consequently, if having a birth defect were associated with lower intellectual performance, the observed mean intelligence score in the reference group would be marginally underestimated; and the observed differences in our study might be slightly larger.

Third, false positive cases may also represent a problem. For example, clubfoot may be diagnosed clinically at birth but be invalidated after discharge. Also, misclassification may affect the multiple defects category, i.e. infants with multiple defects may mistakenly be classified as having a single defect. In general, false positive cases will reduce the effect of the diagnosis.

Finally, although we adjusted for maternal educational level, a proxy variable for maternal intelligence and socioeconomic status, residual confounding may still be present.

Birth defects that often cause death, may also cause more serious morbidity among the survivors (1). In our study, males with birth defects who survived to adulthood had an increased risk of being disabled, and also a reduced likelihood of being drafted, compared to those without defects. The degree of disability varied according to the severity (i.e., mortality) of the defect. This probably reflects both the medical and social consequences to adult health in the individuals concerned. Unfortunately, detailed information on disability status, for example in terms of dependence on assistance in everyday life, was unavailable.

We evaluated whether birth defect categories with high mortality and high disability were associated with impaired intellectual performance at conscription. The cluster of birth defects with low mortality had significantly better intelligence test score than the cluster of defects with higher mortality. However, in the separate analyses, men with heart defects or cleft palate were the only subgroups in which intellectual performance was adversely affected. Further, the RRs for both mortality and disability were considerably higher among men with heart defects compared with cleft palate. Thus, for each specific birth defect category, the

presence of high mortality and disability in Figure 1 was not reflected in lower intelligence test scores in Figure 2.

The association between social status and birth defect is unclear (5). In our study the risk for not being drafted for males with birth defects appeared to be highest if maternal education was low. This association persisted after stratifying for maternal age (data not shown). Thus, the higher risk for not being drafted among affected sons of mothers with low education, may reflect differences in life-style factors, intellectual stimulation of offspring, and social conditions, but may also be due to the influence of maternal genes on intellectual and social abilities.

Our finding of intellectual deficits in males with heart defects is consistent with other studies (9,13,20-22). A major issue is whether the intellectual impairment is a consequence of the birth defect or its treatment. Heart defects are more frequent in syndromes associated with intellectual impairment (23). In our study cohort, the heart defects category comprised 141 cases of unspecified 'blue baby' or congenital heart murmurs; in addition, two men had transposition, 17 men had ventricular or atrial septal defect, and six men were recorded as having other specified heart defects such as dextrocardia. Since information on surgical treatment was unavailable in our registries, we could not clarify whether the deficit was caused by the birth defect or its treatment. Furthermore, information on 22q11 microdeletion (DiGeorge or Catch 22 syndrome) was lacking. This chromosomal abnormality often seen in congenital heart disease could account for intellectual impairment in the absence of other lesions.

Cognitive deficits have been documented in children with cleft lip and/or palate (7,24), whereas one study has examined cognitive outcome in adults (11). Our data support the finding that intellectual function may be affected among those with cleft palate only. Intelligence test score among conscripts having cleft palate as a single defect was not lower than among those having additional defects, but the number in the latter group was low. Previous studies have revealed that more than 40% of those registered with isolated cleft palate had associated malformations (25). Thus, bias due to misclassification may be present. Intellectual impairment has also been reported among infants with gastroschisis or omphalocele (8). In the present study these two defects were combined in the abdominal wall category; however, no significant differences were observed when comparing infants with gastrochisis or omphalocele with those without defects (data not shown). In a study by Iddon et al, cognitive function was unaffected in patients with spina bifida alone, while in patients with hydrocephalus (with or without spina bifida) the majority of test scores were lower (12). In the present study, spina bifida included cases complicated with hydrocephalus. However, intelligence test score for hydrocephalus was low, although not statistically significant, when compared with men without defects.

We evaluated whether infants with multiple birth defects generally were at a disadvantage in their long-term development compared both with those having a single defect and with those born without defects. However, no differences were observed. The lack of effect in our data may be due to the biases discussed above.

In the present study, the birth defects were grouped on the basis of the organ involved. These subgroups constitute rather broad categories, and may differ from categories based on a common underlying mechanism. However, we performed sub-analyses which departed from

the organ-specific categories. For example, we could not demonstrate any significant difference in intellectual performance among infants born with midline-defects (i.e. neural tube defects without hydrocephalus, oral clefts, gastroschisis, epispadias, and hypospadias) compared with those without such defects.

Questions can be raised as to whether our findings apply to other countries and the present cases. In Norway, infants with birth defects possibly may benefit especially from the well established social welfare system, with economical, cultural and social support in addition to medical treatment, reducing possible adverse long-term effects of handicaps. Due to time trends in such support and treatment, and hence in survival for the different types of malformations, our findings may be influenced by treatment and support that have improved over the years.

With the progress in perinatal and neonatal medical care, more infants with serious birth defects may survive into adulthood. On the other hand, advances in fetal medicine may result in induced abortion of the most seriously affected fetuses, and consequently only the mild cases may survive. In either situation, research into the long-term outcomes of infants with birth defects is important. Disability and impaired intellectual function in these infants can be predictive of their later employment history and social lives. We conclude that for the majority of birth defects in the present birth cohort, infants who survived without serious disability did not run a risk of intellectual impairment.

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TABLE 1. Male live births in Norway 1967-1979 with proportions of birth defects, according to follow-up status from birth through military conscription 1984-1999

Follow-up status		Total live Births*	Dead before military draft	Disabled and not drafted	Drafted†	Study Cohort‡	RR§ mortality (95% CI)	RR disability (95% CI)
		n	*n* (%)‖	*n* (%)	*n* (%)	*n* (%)		
Birth defect category¶								
	Spina bifida	113	56 (49.6)	35 (61.4)	20 (17.7)	13 (11.5)	26.4 (21.9 to 31.8)	45.9 (37.3 to 56.5)
	Hydrocephalus	59	29 (49.2)	5 (16.7)	23 (39.0)	21 (35.6)	26.2 (20.2 to 33.9)	12.5 (5.6 to 27.7)
	Heart	445	210 (47.2)	23 (9.8)	195 (43.8)	166 (37.3)	25.1 (22.7 to 27.8)	7.3 (5.0 to 10.8)
	Cleft lip	250	6 (2.4)	3 (1.2)	227 (90.8)	202 (80.8)	1.3 (0.6 to 2.8)	0.9 (0.3 to 2.8)
	Cleft palate	151	9 (6.0)	10 (7.0)	124 (82.1)	114 (75.5)	3.2 (1.7 to 6.0)	5.3 (2.9 to 9.6)
	Cleft lip and palate	357	19 (5.3)	12 (3.6)	304 (85.2)	271 (75.9)	2.8 (1.8 to 4.4)	2.7 (1.5 to 4.6)
	Abdominal wall	206	72 (35.0)	7 (5.2)	118 (57.3)	110 (53.4)	18.6 (15.4 to 22.4)	3.9 (1.9 to 8.0)
	Genitalia	2466	48 (1.9)	67 (2.8)	2165 (87.8)	1955 (79.3)	1.0 (0.8 to 1.4)	2.1 (1.6 to 2.6)
	Clubfoot	2105	60 (2.9)	62 (3.0)	1795 (85.3)	1595 (75.8)	1.5 (1.2 to 1.9)	2.3 (1.8 to 2.9)
	Limb defects	869	48 (5.5)	49 (6.0)	709 (81.6)	601 (69.2)	2.9 (2.2 to 3.9)	4.5 (3.4 to 5.9)
	Hip	344	11 (3.2)	9 (2.7)	299 (86.9)	274 (79.7)	1.7 (1.0 to 3.0)	2.0 (1.1 to 3.8)
	Skin/hair/nail	204	5 (2.5)	5 (2.5)	185 (90.7)	170 (83.3)	1.3 (0.5 to 3.1)	1.9 (0.8 to 4.5)
	Multiple	475	214 (45.1)	69 (26.4)	169 (35.6)	146 (30.7)	24.0 (21.7 to 26.5)	19.7 (16.1 to 24.2)

No birth defect	384384	7223 (1.9)	5049 (1.3)	344573 (89.6)	311738 (81.1)	Reference	Reference
Any birth defect	9186	1160 (12.6)	643 (8.0)	6779 (73.8)	6023 (65.6)	6.7 (6.3 to 7.1)	6.0 (5.5 to 6.5)
All births	393570	8383 (2.1)	5692 (1.5)	351352 (89.3)	317761 (80.7)		

* Not all categories of defects and follow-up status are listed, so numbers do not sum to totals shown.

† Among those drafted, data on intelligence test score or maternal educational level were missing for n=451with birth defects, and for n=33,140 without birth defects.

‡ Conscripts with complete data on birth characteristics, intelligence test score and maternal educational level.

§ Relative risk

|| Percent of all live births in each birth defect category

¶ Defects are defined according to the *International Classification of Diseases, 8th Revision.*

** Calculated among survivors (i.e. excluding those who were dead before military draft).

TABLE 2. Mean intelligence test score (IQ) by birth characteristics among 317,761 male conscripts with and without birth defects. Medical Birth Registry of Norway, 1967-1979, linked with the National Conscripts Service, 1984-1999, and Statistics Norway, 1967-1998

	With birth defect		Without birth defect		
Birth characteristics	*n* (%)	Mean IQ (SD)*	*n* (%)	Mean IQ (SD)*	*P* value (X^2-test) †
Maternal educational level					
Low	1391 (1.7)	4.42 (1.82)	81490 (98.3)	4.47 (1.73)	
Medium	3907 (2.0)	5.33 (1.80)	199254 (98.0)	5.34 (1.75)	
High	725 (2.3)	6.44 (1.61) ‡	30994 (97.7)	6.36 (1.66) ‡	< .0005
Maternal age (y)					
<20	440 (1.9)	4.76 (1.82)	23024 (98.1)	4.77 (1.73)	
20-24	2130 (1.9)	5.11 (1.80)	110765 (98.1)	5.09 (1.79)	
25-29	2084 (2.0)	5.40 (1.90)	104274 (98.0)	5.36 (1.82)	
30-34	957 (1.9)	5.45 (1.95)	49498 (98.1)	5.37 (1.83)	
>34	412 (1.7)	5.34 (1.81) ‡	24177 (98.3)	5.29 (1.85) ‡	.06
Birth order					

1	2964 (2.3)	5.44 (1.84)	128088 (97.7)	5.42 (1.81)	
2+	3059 (1.6)	5.08 (1.88) ‡	183650 (98.4)	5.07 (1.80) ‡	< .0005
Marital status					
Unmarried	615 (2.2)	4.73 (1.76)	26747 (97.8)	4.82 (1.78)	
Married	5408 (1.9)	5.32 (1.87) ‡	284991 (98.1)	5.25 (1.81) ‡	< .0005
Total	6023	5.26 (1.87)	311725	5.22 (1.82)	

* Analysis of variance (overall test of mean intelligence test score by categories of the listed maternal characteristics)

† Chi square test (in a 2 x X - table, testing whether proportion of any birth defect distributes differently by each of the listed maternal characteristics)

‡ $P < .0005$

TABLE 3. Mean intelligence test score with 95% confidence interval (CI) of conscripts with single and multiple birth defects. 317,761 male infants, Medical Birth Registry of Norway, 1967-1979, linked with the National Conscripts Service, 1984-1999

Birth defect category		*n*	Mean intelligence test score (95%CI)	*P* values	
				Comparing single with additional defects Adjusted*	Comparing single with no defect Adjusted*
No defect		311738	5.22 (5.21 to 5.22)		
Heart					
	single defect	166	4.90 (4.60 to 5.20)		.007
	additional defect(s)	10	5.30 (4.42 to 6.18)	.7	
Cleft palate					
	single defect	114	4.83 (4.48 to 5.19)		.045
	additional defect(s)	11	4.82 (3.50 to 5.13)	.6	
Cleft lip					
	single defect	202	5.17 (4.91 to 5.43)		.83
	additional defect(s)	6	5.50 (3.56 to 7.44)	.07	
Cleft lip and palate					
	single defect	271	4.96 (4.74 to 5.18)		.11
	additional defect(s)	7	4.00 (1.90 to 6.10)	.8	
All birth defects					
	single defects total	5877	5.22 (4.92 to 5.60)		.14
	multiple defects total	146	5.11 (4.77 to 5.45)	.2	

*Analyses of variance. Adjusted for maternal age (years):<20, 20-24, 25-29, 30-34, >35; maternal education (years): <11, 11-14, >14; marital status: married or unmarried; parity: 0, 1+. Reference groups: maternal age, 25-29 years; maternal education, 11-14 years; parity,1+.

LEGENDS

Fig. 1. Mortality* and disability† among males born with birth defects according to category of defect. 393,570 male infants, Medical Birth Registry of Norway, 1967-1979, linked with Statistics Norway, 1967-1998, and the National Health Insurance Office, 1967-1997. Please note that both scales are logarithmic.

*the proportion of infants within a birth defect category who were dead before military draft among those born alive with such a defect

†the proportion of infants within a birth defect category who were registered as disabled and not drafted among those born alive with such a defect, calculated among survivors (i.e. excluding those who were dead before military draft).

Fig. 2. Mean intelligence test score according to category of birth defect (with more than 5 cases). Except for the multiple category, all categories include one single birth defect diagnosis. 317,761 male infants, Medical Birth Registry of Norway, 1967-1979, linked with the Norwegian Conscripts Service, 1984-1999

Fig. 1

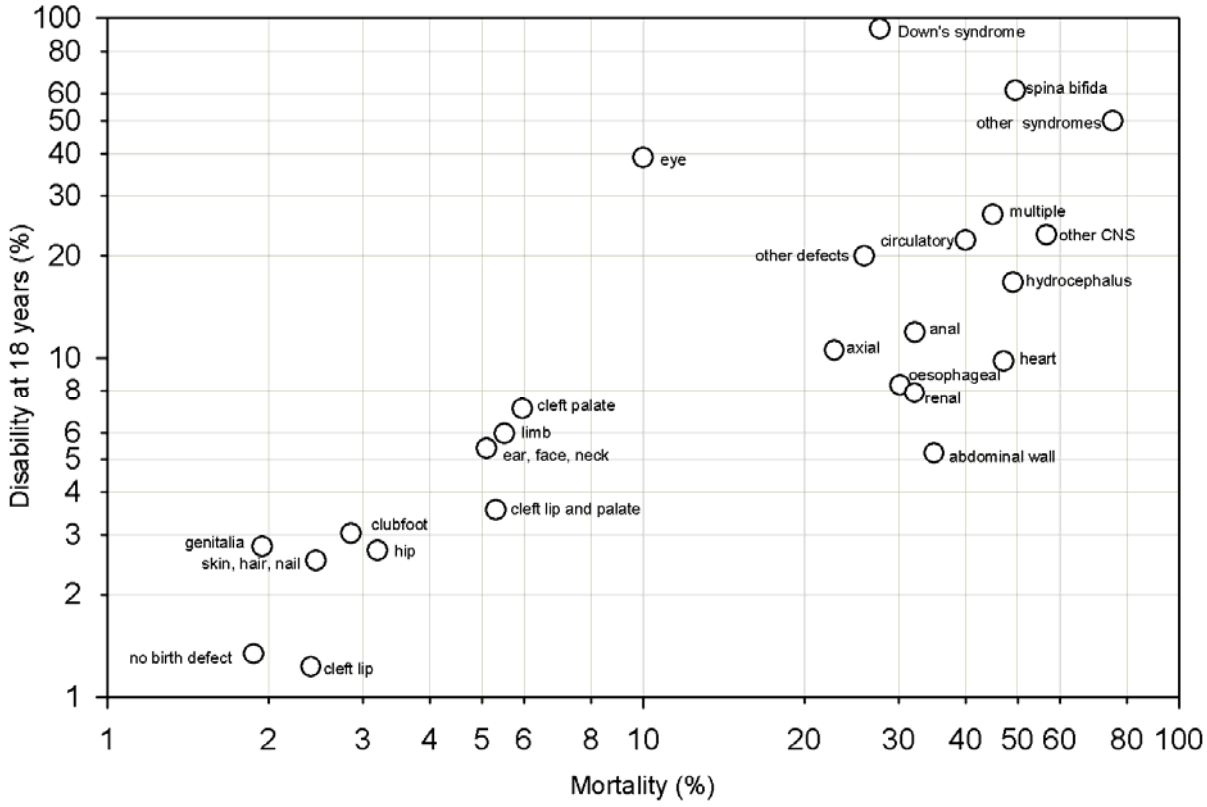
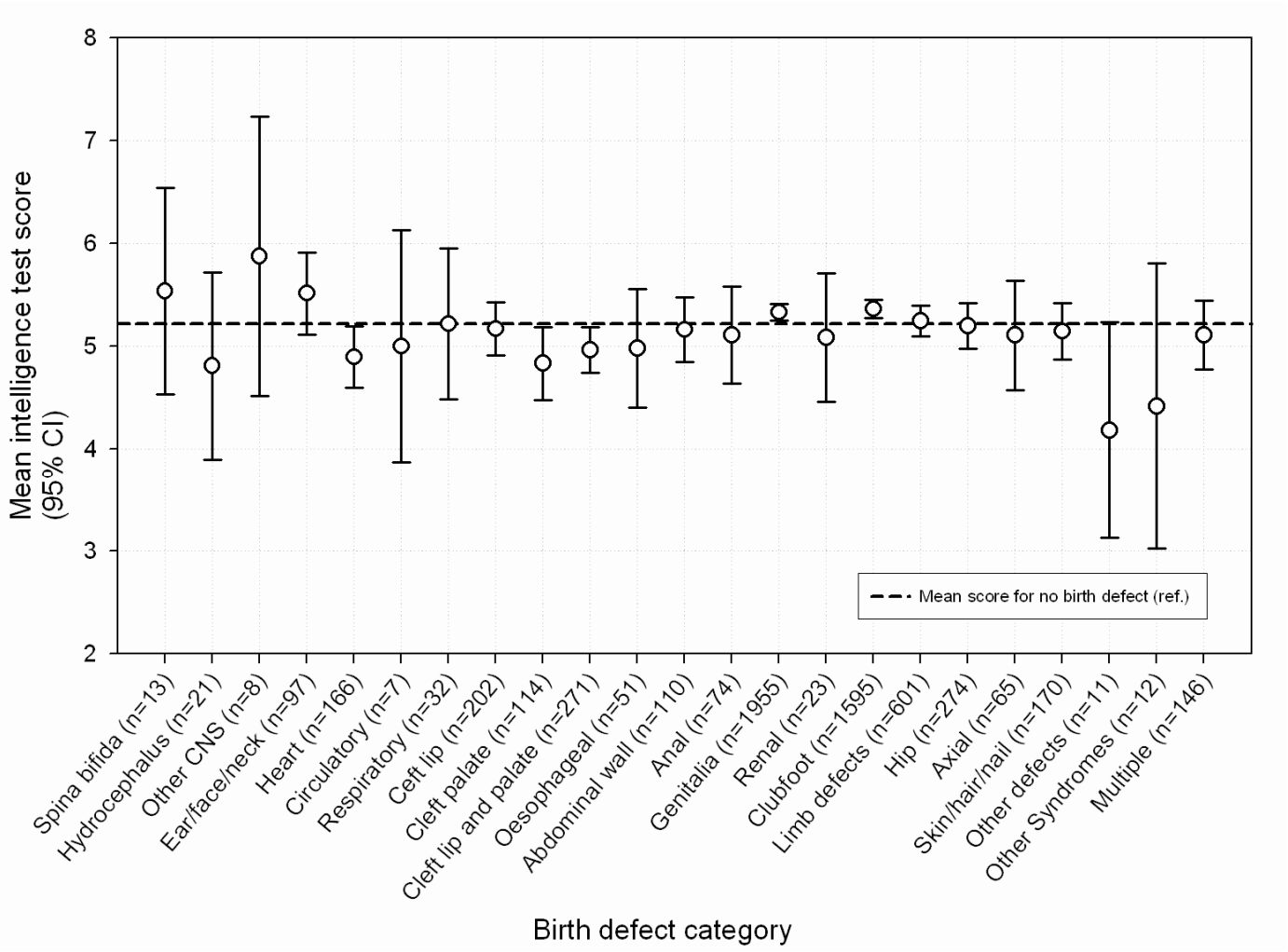

Disability at 18 years (%)
Mortality (%)
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1
1
2
3
4
5
6
8
10
20
30
40
50
60
80
100
Down's syndrome
spina bifida
other syndromes
eye
multiple
circulatory
other CNS
other defects
hydrocephalus
anal
axial
heart
oesophageal
renal
cleft palate
limb
ear, face, neck
abdominal wall
cleft lip and palate
clubfoot
genitalia
hip
skin, hair, nail
no birth defect
cleft lip

Fig. 2


Mean intelligence test score (95% CI)
8
7
6
5
4
3
2
Mean score for no birth defect (ref.)
Spina bifida (n=13)
Hydrocephalus (n=21)
Other CNS (n=8)
Ear/face/neck (n=97)
Heart (n=166)
Circulatory (n=7)
Respiratory (n=32)
Ceft lip (n=202)
Cleft palate (n=114)
Cleft lip and palate (n=271)
Oesophageal (n=51)
Abdominal wall (n=110)
Anal (n=74)
Genitalia (n=1955)
Renal (n=23)
Clubfoot (n=1595)
Limb defects (n=601)
Hip (n=274)
Axial (n=65)
Skin/hair/nail (n=170)
Other defects (n=11)
Other Syndromes (n=12)
Multiple (n=146)
Birth defect category