Life expectancy in children with cerebral palsy

Jane L Hutton, Theresa Cooke, Peter O D Pharoah

Abstract

***Objective*—To determine life expectancy of children with cerebral palsy.**

***Design*—Cohort analysis, by means of register compiled from multiple sources of ascertainment, of all children with cerebral palsy born during 1966-84 to mothers resident in Mersey region. Status of children was determined by flagging through NHS central register.**

***Subjects*—1258 subjects with idiopathic cerebral palsy, of whom 1251 were traced and included in analysis.**

***Main outcome measures*—Effect of functional ability (ambulation, manual dexterity, and mental ability), sex, birth weight, and gestational age on survival.**

***Results*—20 year survival for whole cohort was 89·3% for females and 86·9% for males. For subjects with no severe functional disabilities 20 year survival was 99% (95% confidence interval 98% to 100%), while subjects severely disabled in all three functional groups had 20 year survival of 50% (42% to 58%). Subjects with birth weight ≤ 2500 g had 20 year survival of 92% (89% to 95%), while those with birth weight >2500 g had survival of 87% (84% to 89%). Subjects with gestational age of >37 weeks had 20 year survival of 93% (91% to 96%), while those with gestational age ≥ 37 weeks had survival of 85% (83% to 88%). Birth weight and gestational age were less predictive of survival than functional disability. Best statistical model used gestational age and number of severe functional disabilities as predictors.**

***Conclusions*—Life expectancy of this cohort of children with cerebral palsy was greater than has been suggested in some previous studies. This has important implications for social, educational, and health services.**

Introduction

Although cerebral palsy is the commonest cause of severe physical disability in children, current routine health information systems do not allow the monitoring of prevalence. Several reports from ad hoc registers of people with cerebral palsy have recorded an increase in prevalence among low birthweight infants.[1-7] Because statistics on cerebral palsy are not routinely collected there is little information on life expectancy. Such information is needed to counsel parents about a child's prognosis; to plan for the provision of medical, educational, and social services; and for medicolegal purposes relating to litigation (even though perinatal cause and effect is not proved).

Numerous studies of survival in children with cognitive and motor disabilities have been carried out, but most are of limited use for assessing current life expectancy of children with cerebral palsy. Data may have been collected many years ago, since when life expectancy is likely to have altered.[8] Alternatively, only children in long term institutional care have been assessed.[8,9] This is liable to bias the estimate of life expectancy not only because children admitted to institutions tend to be more severely affected but because institutional care itself might prejudice survival. Motor disability may have a significant effect on life expectancy, but some studies relate to children in whom mental retardation without concomitant motor disability is the main feature.[10] Others are based on small numbers and a short follow up.[11,12]

One recent study has reported on survival in a population based cohort of children with cerebral palsy born during 1970-9 in the south east of England.[13] We report on the survival of children with cerebral palsy born during 1966-84 to mothers resident in the Mersey region and examine the effect of cognitive and motor disability, birth weight, and gestational age on life expectancy. We hope that the data will be useful in planning for the future needs of children with cerebral palsy.

Subjects and methods

CEREBRAL PALSY REGISTER

The cohort consists of all children with cerebral palsy born between 1966 and 1984 to mothers whose area of residence at the time of birth was in the area administered by Mersey Regional Health Authority. The region has a population of about 2·5 million with 25 000-30 000 births a year. A register of cases was compiled from multiple data sources to ensure completeness of ascertainment as described previously.[1,2] All the subjects on the register were flagged at the National Health Service Central Register of the Office of Population Censuses and Surveys. The individuals were traced, and notifications of deaths were provided with copies of the death certificates.

The 250 cases of "acquired" cerebral palsy—where the impairment was considered to have arisen more than 28 days after birth—were excluded from the analysis. Problems arise in separating idiopathic and acquired cerebral palsy, particularly in some low birthweight infants, among whom adverse conditions may extend well into the postnatal period. Also, making a firm diagnosis early in infancy is often not possible. Only if an infant's progress was normal during the neonatal period and there was a clear cut adverse event after the 28th day did we consider the cerebral palsy to be acquired.

Once ascertained, hospital and community records were abstracted for details of the clinical type and severity of the cerebral palsy.

CLASSIFICATION OF FUNCTIONAL ABILITY

Information was sought for ambulatory ability, manual dexterity, and mental ability. Children who were too young or who died before they could be assessed, has functional ability recorded as missing.

Ambulatory ability was classified as minimal dis-

Departments of Statistics, Computational Mathematics, and Public Health, University of Liverpool, Liverpool L69 3BX
Jane L Hutton, *lecturer*

Department of Public Health, University of Liverpool, Liverpool L69 3BX
Theresa Cooke, *research assistant*
Peter O D Pharoah, *professor of public health*

Correspondence to:
Professor Pharoah.

BMJ 1994;309:431-5

ability—able to run and climb stairs but with less than usual dexterity and speed (category 1); limited—difficulty experienced in climbing stairs, able to walk only short distances without a rest and at a slow pace (category 2); walking aids required during normal everyday activities (category 3); wheelchair required, which can be propelled by child (category 4); and wheelchair required and assistance is needed for propulsion (category 5). Manual dexterity was classified as normal—upper limbs unaffected (category 1); mild—some clumsiness of fine movements but able to feed and dress without assistance (category 2); moderate—able to feed and dress with difficulty (category 3); and severe—unable to feed and dress without assistance (category 4). Mental ability was categorised according to the intelligence quotient (IQ) as normal—IQ ≥ 85 (category 1); mild learning disability—IQ 70-84 (quotient 2); moderate learning disability—IQ 50-69 (category 3); and severe learning disability—IQ < 50 (category 4).

Most of the subjects had had a formal assessment of IQ by a variety of standard tests. Usually the assessment had been made by an educational psychologist to determine the child's need for special education. If there had been more than one assessment, the most recent one was used in the analysis. A few children (mainly normal or with mild learning disability) were classified according to a subjective assessment of the child's paediatric records.

STATISTICAL ANALYSIS

We calculated the subjects' ages in days: age at death for those who died and age at 31 July 1993 for those who were still alive. The most recent receipt of notifications of deaths was on 31 March 1994, and we therefore assumed notification of all deaths up to 31 July 1993 to be complete.

We produced tables of survival according to grouped categories of functional disability, birth weight, and gestational age by means of the life table method with intervals of one year. A log-logistic accelerated life model, which is a fully parametric model of survival time, was applied to determine which covariates to use. Accelerated life models based on the log-logistic distribution were significantly better than those using exponential, Weibul, or Gamma models.[14]

Likelihood ratio tests[15] were used to determine whether the categories of functional disability could be grouped. Categories not significantly different at the 5% level were combined. The explanatory values of the combined categories for the functional disability groups, with birth weight and gestational age as continuous variables, were then studied. The comparison of non-nested models (for example, one with three covariates indicating severe ambulatory, manual, and mental disabilities and one in which three covariates indicated the number of severe disabilities) was done by means of Akaike's information criterion.[16] The maximum number of individuals with complete data was included for each of the analyses, which were performed with the SAS software package.[17]

Results

Altogether 1508 cases of cerebral palsy (1258 idiopathic and 250 acquired) were submitted to the National Health Service Central Register for flagging. Of the idiopathic cases, seven were excluded (three children had emigrated and four could not be traced). Of the 1251 children included in the analysis, 1101 were still alive, 143 had died, and seven were assumed to be alive because, although they were not on the National Health Service Central Register, notification would have been made of any death.

Table I summarises the characteristics of the 1251 subjects. The ratio of males to females was 1·3:1 (709:541), 437 of the subjects had a birth weight of 2500 g or less, and 432 had a gestational age of 37 weeks or less. About a third (424) of the subjects had a quadriplegia, another third (397) had a hemiplegia, and a quarter (276) had a diplegia. The remainder had other conditions, such as dyskinesias and ataxias. Almost a quarter (274) had severe ambulatory disability, over a fifth (255) had severe manual disability, and a third (398) had an IQ of 50 or less. Deaths were concentrated in these groups with the most severe disabilities.

TABLE I—*Characteristics of 1251 subjects with idiopathic cerebral palsy*

Characteristic	No (%) of subjects	No of subjects with missing data	No of subjects who died
Sex:		1	
Female	541 (43)		55
Male	709 (57)		88
Birth weight (g):		61	
≤ 1500	134 (11)		7
1501-2500	303 (26)		26
> 2500	753 (63)		95
Gestational age (weeks):		111	
< 32	192 (17)		6
31-36	240 (21)		21
≥ 37	708 (62)		97
Type of cerebral palsy:		26	
Hemiplegia	397 (33)		7
Diplegia	276 (23)		9
Quadriplegia	424 (35)		108
Other	128 (10)		11
Year of birth:		0	
1966-9	250 (20)		34
1970-3	260 (21)		42
1974-7	207 (17)		21
1978-81	277 (22)		25
1982-4	257 (21)		21
Functional disabilities			
Ambulation (category No):		30	
Minimal disability (1)	624 (51)		7
Limited mobility (2);	93 (8)		3
Walking aids (3)	177 (15)		5
Self propelled wheelchair (4)	53 (4)		4
Other wheelchair (5)	274 (22)		115
Manual dexterity (category No):		39	
Normal (1)	106 (9)		3
Mild disability (2)	649 (54)		12
Moderate disability (3)	202 (17)		9
Severe disability (4)	255 (21)		109
Mental ability (category No):		42	
Normal (1)	521 (43)		8
Mild disability (2)	113 (9)		1
Moderate disability (3)	162 (13)		5
Severe disability (4)	398 (33)		102
Too young (5)	17 (1)		17
No of severe disabilities:		72	
None	739 (63)		7
One	189 (16)		12
Two	63 (5)		9
Three	188 (16)		87

TABLE II—*Categories of functional disability of subjects with cerebral palsy by birth weight. Values are numbers (percentages)*

Category of disability	Birth weight (g)		
	≤ 1500	1501-2500	> 2500
Ambulation			
Minimal disability (n = 599)	62 (47)	131 (44)	406 (55)
Limited mobility (n = 92)	17 (13)	28 (9)	47 (6)
Walking aids (n = 169)	23 (18)	63 (21)	83 (11)
Self-propelled wheelchair (n = 53)	7 (5)	21 (7)	25 (3)
Other wheelchair (n = 260)	22 (17)	56 (19)	182 (24)
Total (n = 1173)	131	299	743
Manual dexterity			
Normal (n = 102)	19 (15)	28 (9)	55 (7)
Mild disability (n = 628)	70 (54)	161 (54)	397 (54)
Moderate disability (n = 193)	24 (18)	59 (20)	110 (15)
Severe disability (n = 241)	17 (13)	50 (17)	174 (24)
Total (n = 1164)	130	298	736
Mental ability			
Normal (n = 496)	66 (51)	135 (46)	295 (41)
Mild disability (n = 109)	11 (9)	36 (12)	62 (9)
Moderate disability (n = 160)	19 (15)	40 (14)	101 (14)
Severe disability (n = 384)	33 (26)	83 (28)	268 (37)
Total (n = 1149)	129	294	726

TABLE III—*Survival of male and female subjects with cerebral palsy compared with that for general population of England and Wales in 1970-2 census*

	Female			Male		
		Subjects with cerebral palsy			Subjects with cerebral palsy	
Age (years)	% Survival of general population*	Effective No of subjects at risk†	% Survival (95% confidence interval)	% Survival of general population	Effective No of subjects at risk‡	% Survival (95% confidence interval)
1	98·5	541·0	98·7 (97·8 to 99·7)	98·0	709·0	99·3 (98·7 to 99·9)
2	98·4	534·0	98·0 (96·8 to 99·2)	97·9	704·0	97·9 (96·8 to 98·9)
3	98·3	530·0	96·9 (95·4 to 98·3)	97·8	694·0	97·0 (95·8 to 98·3)
4	98·3	524·0	96·3 (94·7 to 97·9)	97·8	688·0	95·6 (94·1 to 97·1)
5	98·2	521·0	95·7 (94·0 to 97·4)	97·7	678·0	94·8 (93·1 to 96·4)
6	98·2	518·0	94·8 (93·0 to 96·7)	97·7	672·0	94·2 (92·5 to 95·9)
7	98·2	513·0	94·3 (92·3 to 96·2)	97·6	668·0	93·5 (91·7 to 95·3)
8	98·1	510·0	94·1 (92·1 to 96·1)	97·6	663·0	92·9 (91·1 to 94·8)
9	98·1	503·0	93·7 (91·7 to 95·8)	97·5	648·0	92·1 (90·1 to 94·1)
10	98·1	473·0	92·7 (90·5 to 94·9)	97·6	607·5	91·8 (89·8 to 93·8)
11	98·1	431·0	92·1 (89·8 to 94·4)	97·5	562·5	91·8 (89·8 to 93·8)
12	98·0	393·0	91·8 (89·5 to 94·2)	97·4	523·5	90·9 (88·8 to 93·1)
13	98·0	358·0	90·6 (88·0 to 93·1)	97·4	485·5	90·3 (88·1 to 92·6)
14	98·0	317·0	90·3 (87·7 to 92·9)	97·4	452·5	89·9 (87·7 to 92·2)
15	98·0	286·0	90·3 (87·7 to 92·9)	97·3	416·5	88·2 (85·7 to 90·8)
16	97·9	270·0	89·6 (86·8 to 92·4)	97·3	377·5	87·8 (85·1 to 90·4)
17	97·9	252·5	89·2 (86·4 to 92·1)	97·3	347·0	87·2 (84·6 to 89·9)
18	97·9	237·0	89·2 (86·4 to 92·1)	97·1	315·5	87·2 (84·6 to 89·9)
19	97·8	220·0	88·8 (85·9 to 91·8)	97·0	284·0	86·9 (84·2 to 89·7)
20	97·8	196·5	88·8 (85·9 to 91·8)	96·9	253·0	86·6 (83·8 to 89·4)
21	97·7	170·0	88·8 (85·9 to 91·8)	96·8	223·0	85·0 (81·9 to 88·2)
22	97·7	146·5	88·8 (85·9 to 91·8)	96·7	187·5	84·1 (80·8 to 87·5)
23	97·6	125·0	88·8 (85·9 to 91·8)	96·6	152·0	84·1 (80·8 to 87·5)
24	97·6	102·0	88·0 (84·6 to 91·3)	96·5	118·0	84·1 (80·8 to 87·5)
25	97·6	72·5	88·0 (84·6 to 91·3)	96·4	83·0	84·1 (80·8 to 87·5)
26	97·5	44·0	88·0 (84·6 to 91·3)	96·3	51·0	84·1 (80·8 to 87·5)
27	97·5	23·5	88·0 (84·6 to 91·3)	96·3	25·5	84·1 (80·8 to 87·5)

*From Office of Population Censuses and Surveys.[18]
†55 deaths. ‡88 deaths.

Table II shows the types of functional ability by birth weight. The group with normal birth weight (>2500 g) contained the highest proportion of subjects with disabilities categorised as severe in each functional ability group: 24% (182/743) were confined to a wheelchair that was not self propelled (compared with 17% (22/131) of those with a birth weight ≤1500 g); 24% (174/736) had severe manual disability (compared with 13% (17/130) of the lowest birthweight group); and 37% (268/726) had severe mental disability (compared with 26% (33/129) of the lowest birthweight group).

SURVIVAL

Table III shows the subjects' sex-specific survival to 1 year of age and subsequent ages. About 85-90% of the subjects survived to 20 years of age compared with the 97% 20 year survival reported for the population of England and Wales in 1970-2.[18]

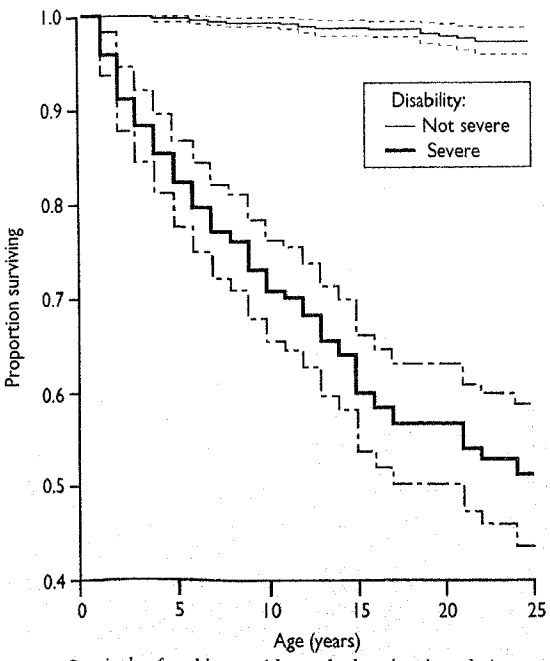

FIG 1—*Survival of subjects with cerebral palsy in relation to ambulatory ability. (Dotted lines represent 95% confidence interval)*

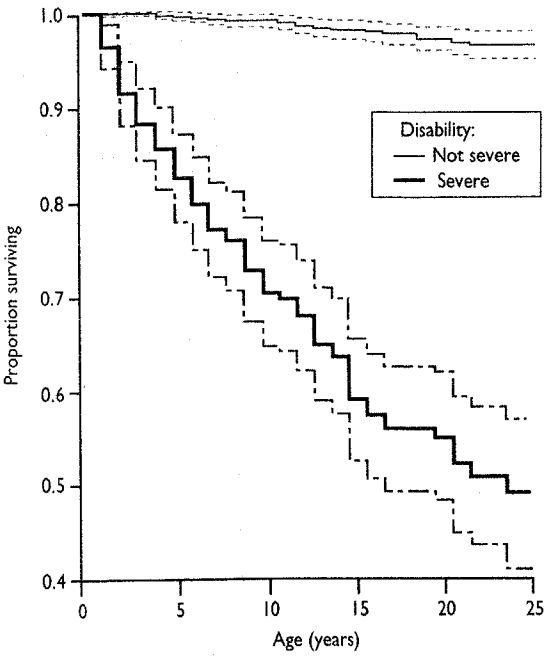

FIG 2—*Survival of subjects with cerebral palsy in relation to manual dexterity. (Dotted lines represent 95% confidence interval)*

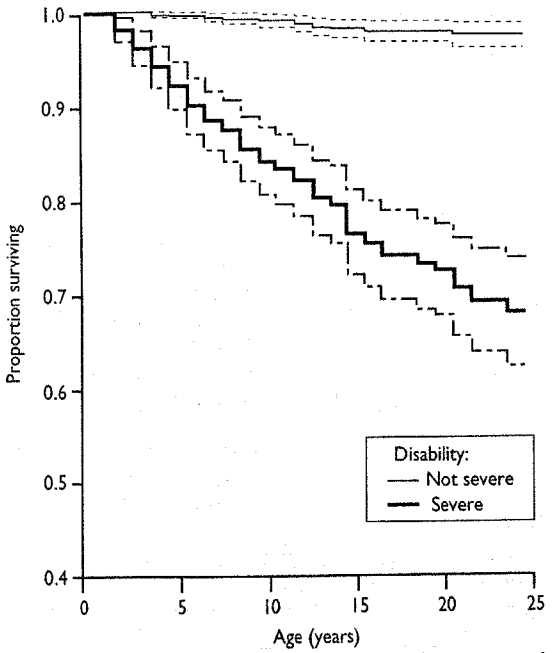

FIG 3—*Survival of subjects with cerebral palsy in relation to mental ability. (Dotted lines represent 95% confidence interval)*

Ambulatory ability could be reduced from five to two categories for predicting survival. Mildly affected subjects (categories 1-4) had a 97·5% probability of surviving to the age of 20, while only 56·4% of those with severe ambulatory disability (category 5) reached the age of 20 (fig 1).

Manual dexterity could also be reduced to two groups (categories 1-3 and category 4): 54·8% of the subjects with severe manual disability (category 4) survived to the age of 20 compared with 97·1% of the remainder (categories 1-3) (fig 2).

Mental ability was less useful for prognosis: the subjects with IQ <50 (category 4) had a 72·5% probability of surviving to the age of 20 whereas the subjects with IQ ≥50 (categories 1-3) had a 98·0% probability, which is similar to that of the normal population (fig 3).

The clinical type of cerebral palsy was considerably

less informative for prognostic purposes than the categories of functional disability. However, both birth weight and gestational age were strongly associated with survival. Figure 4 shows the survival for low (≤2500 g) and normal (>2500 g) birthweight babies; the 20 year survival rates were 91·6% and 86·4% respectively. Comparison of the two gestational

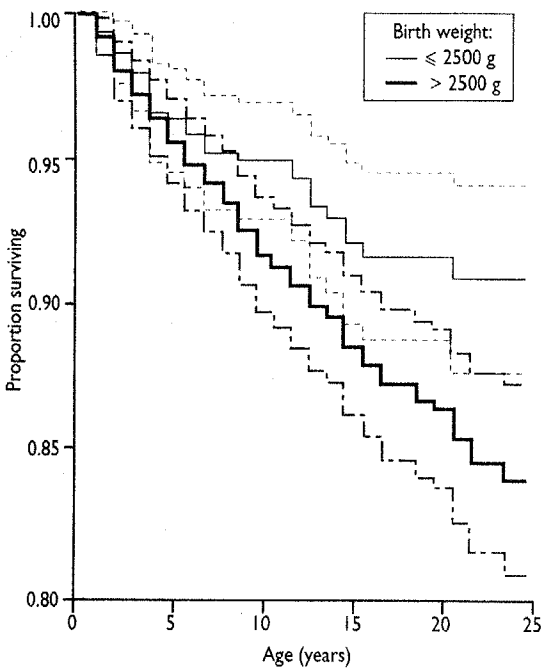

FIG 4—*Survival of subjects with cerebral palsy in relation to weight at birth. (Dotted lines represent 95% confidence interval)*

age groups gave similar results: 20 year survival for those born at 37 weeks or less was 93·2% and for those born at more than 37 weeks was 85·3%. There was no evidence of a birth cohort trend in survival during 1966-84: 10 year survival was 92·1% for those born before 1980 and 92·2% for those born from 1980 onwards.

MULTIFACTORIAL ANALYSIS

Analysis of the survival of the 1179 subjects (of whom 115 had died) with complete data on ambulatory ability, manual dexterity, and mental ability showed that ambulation in three categories was most informative and manual dexterity in two categories was almost as informative. Combining the three types of functional disability increased the ability to predict survival. Four combination categories were defined depending on whether the subjects were classed as having no, one, two, or three severe functional disabilities (that is, ambulation category 5, manual dexterity category 4, and mental ability category 4). This model was simpler though not significantly better than one that analysed the three severe types of functional disability separately.

Table IV shows the survival of the 1179 subjects with complete data on disability function. For those who had no functional disability in the severe category 20 year survival was 98·8%, decreasing to 93·5% for those with one, 84·7% for those with two, and 50·3% for those with all three disability functions in the severe category. About 40% (28) of the 77 children for whom data on at least one functional disability were missing died before the age of 4 years.

Analysis of the 1054 subjects with complete data on functional disability, birth weight, and gestational age showed that birth weight and gestational age had substantially and significantly less explanatory value than functional disability. Birth weight added no information when gestational age was known. The best model used gestational age and number of severe disabilities as predictors.

TABLE IV—*Percentage survival (95% confidence interval) of subjects with cerebral palsy by number of severe disabilities*

Age (years)	No of severe disabilities			
	None*	One†	Two‡	Three§
1	100	100	100	100
2	100	100	100	96·3 (93·6 to 99·0)
3	100	100	100	92·0 (88·1 to 95·9)
4	99·6 (99·6 to 199)	100	98·4 (95·3 to 100)	88·8 (84·3 to 93·3)
5	99·9 (99·6 to 100)	100	95·2 (90 to 100)	85·1 (80·0 to 90·2)
6	99·9 (99·6 to 100)	98·9 (97·5 to 100)	95·2 (90 to 100)	81·4 (75·8 to 86·9)
7	99·7 (99·4 to 100)	98·9 (97·5 to 100)	93·7 (87·6 to 99·7)	78·2 (72·3 to 84·1)
8	99·7 (99·4 to 100)	97·9 (95·8 to 99·9)	92·1 (85·4 to 98·7)	77·1 (71·1 to 83·1)
9	99·7 (99·4 to 100)	97·9 (95·8 to 99·9)	92·1 (85·4 to 98·7)	72·8 (66·5 to 79·2)
10	99·7 (99·4 to 100)	96·8 (94·3 to 99·3)	92·1 (85·4 to 98·7)	70·0 (63·4 to 76·6)
11	99·7 (99·4 to 100)	96·2 (93·5 to 99·0)	90·4 (83·0 to 97·7)	69·4 (62·7 to 76·0)
12	99·4 (98·8 to 100)	96·2 (93·5 to 99·0)	90·4 (83·0 to 97·7)	66·7 (59·8 to 73·6)
13	99·0 (98·2 to 99·8)	96·2 (93·5 to 99·0)	90·4 (83·0 to 97·7)	62·4 (55·1 to 69·6)
14	99·0 (98·2 to 99·8)	95·5 (92·4 to 98·6)	90·4 (83·0 to 97·7)	60·9 (53·5 to 68·2)
15	99·0 (98·2 to 99·8)	95·5 (92·4 to 98·6)	90·4 (83·0 to 97·7)	54·5 (46·7 to 62·3)
16	98·8 (97·8 to 99·7)	95·5 (92·4 to 98·6)	90·4 (83·0 to 97·7)	52·0 (44·1 to 60·0)
17	98·8 (97·8 to 99·7)	95·5 (92·4 to 98·6)	88·1 (79·7 to 96·5)	50·3 (42·2 to 58·3)
18	98·8 (97·8 to 99·7)	95·5 (92·4 to 98·6)	88·1 (79·7 to 96·5)	50·3 (42·2 to 58·3)
19	98·8 (97·8 to 99·7)	93·5 (89·4 to 97·6)	88·1 (79·7 to 96·5)	50·3 (42·2 to 58·3)
20	98·8 (97·8 to 99·7)	93·5 (89·4 to 97·6)	84·7 (74·4 to 95·1)	50·3 (42·2 to 58·3)
21	98·8 (97·8 to 99·7)	92·2 (87·4 to 96·9)	80·5 (67·8 to 93·2)	47·8 (39·4 to 56·1)
22	98·8 (97·8 to 99·7)	90·6 (85·1 to 96·2)	80·5 (67·8 to 93·2)	46·4 (37·8 to 54·9)
23	98·8 (97·8 to 99·7)	90·6 (85·1 to 96·2)	80·5 (67·8 to 93·2)	46·4 (37·8 to 54·9)
24	98·8 (97·8 to 99·7)	90·6 (85·1 to 96·2)	80·5 (67·8 to 93·2)	44·2 (35·1 to 53·4)
25	98·8 (97·8 to 99·7)	90·6 (85·1 to 96·2)	80·5 (67·8 to 93·2)	44·2 (35·1 to 53·4)
26	98·8 (97·8 to 99·7)	90·6 (85·1 to 96·2)	80·5 (67·8 to 93·2)	44·2 (35·1 to 53·4)
27	98·8 (97·8 to 99·7)	90·6 (85·1 to 96·2)	80·5 (67·8 to 93·2)	44·2 (35·1 to 53·4)

*739 subjects, 7 deaths. †189 subjects, 12 deaths. ‡63 subjects, 9 deaths. §188 subjects, 87 deaths.

Discussion

Our analysis shows that several aspects of disability could be used to predict the life expectancy of children with cerebral palsy. As expected, the severely disabled children had poorer survival.

Some of the missing data relate to children who had died at an early age before there had been any assessment of their functional disability. These missing values are unlikely to be independent of the severity of disability; the 28 infants who died aged between 1 and 40 months probably included a disproportionate number who were more severely affected. This may have led to an overestimation of life expectancy of the more severely disabled groups.

COMPARISON WITH OTHER STUDIES

It is reassuring that the results presented here are similar to those reported from the south of England.[13] The greater survival of girls compared with boys is confirmed, though the difference was not significant at 5% with a likelihood ratio test. For the southern England cohort also, it was found that the most important predictors of mortality were mobility and mental ability. Manual dexterity was not assessed as a separate variable in that study. The survival of mildly and even moderately affected children approached that of normal, unaffected children. Even severely disabled children in both studies had about 50% probability of surviving to 20 years of age.

In contrast, an analysis from the United States of people with developmental disabilities who received services from the Californian Department of Developmental Services appeared to show a much shorter life expectancy.[19,20] These results have been extensively used for medicolegal purposes, but there are problems in their interpretation and in comparisons with our results. The people included in the Californian study were in receipt of services, and the sample was assumed to include almost all people with severe mental retardation and to exclude about half of those who were moderately retarded and 90% of those who were mildly retarded. The authors did not discuss these assumptions or the potential biases that might have arisen.

Public health implications

- Cerebral palsy is the commonest cause of severe physical disability in children, and its prevalence is increasing because of improved survival of low birthweight babies
- Little information is available on life expectancy, which is needed to plan for adequate provision of services for disabled people
- We studied life expectancy of all children with cerebral palsy born in Mersey region during 1966-84
- Survival rates (to 20 years of age) of mild and moderately disabled childen were not much lower than those of unaffected children, and about half of severely disabled children survived to age of 20
- These results have important implications for provision of social, educational, and health services

The description of the statistical analysis that was performed is limited and the methods may be inappropriate. For example, it is not clear whether age, which was used to define the groups for which survival analyses were given, was age at entry to the study, age at presentation to the services, or current age.

SURVIVAL AND BIRTH WEIGHT

Our observation that children with cerebral palsy who were of low birth weight and low gestational age had longer life expectancy than those who were full term or of normal birth weight is contrary to intuition. In our cohort of children with cerebral palsy the low birthweight group had a lower proportion with severe disability, which accounts for their longer survival. This was probably due to the more severely affected low birthweight infants dying before the cerebral palsy was recognised. If this is so, as mortality among low birthweight infants improves, more severely affected infants will survive long enough for the diagnosis of cerebral palsy to be made. Consequently, future cohorts of low birthweight infants with cerebral palsy will show a higher proportion with severe disability, and life expectancy will approach that of normal birthweight children with cerebral palsy.

SURVIVAL AND BIRTH COHORT

It is perhaps surprising that we found no effect of birth cohort on survival. One possible explanation is that the cerebral palsy register was started in 1980. For the earlier period (1966-79) the register was compiled by retrospective study of several sources of information. It is possible that, among the children with cerebral palsy born in this earlier period, some may have died and their names have been deleted from the information sources. They would, therefore not have been recorded in our register. A small number of such unrecorded deaths would have a substantial impact on the estimated life expectancy of children born in the earlier period.

IMPLICATIONS OF RESULTS

The life expectancies of children with cerebral palsy that we report here show that, even for moderately affected children, survival rates were not very different from those of normal children, at least for the first 20 years. Even severely disabled children had a probability of about 50% of surviving 20 years or more. This has considerable implications for social, educational, and health services. It is imperative that an adequate routine system of monitoring morbidity must accompany the monitoring of mortality, particularly among low birthweight infants.

We gratefully acknowledge computing help from Mr Chris West and grant support from the Mersey Region Health Authority and from Children Nationwide.

Full details of the accelerated parametric life model are available from the authors.

1 Pharoah POD, Cooke T, Rosenbloom L, Cooke RWI. Trends in the birth prevalence of cerebral palsy. *Arch Dis Child* 1987;62:379-84.
2 Pharoah POD, Cooke T, Cooke RWI, Rosenbloom L. Birthweight specific trends in cerebral palsy. *Arch Dis Child* 1990;65:602-6.
3 Hagberg B, Hagberg G, Olow I, Von Wendt L. The changing panorama of cerebral palsy in Sweden. IV: Epidemiological trends 1959-78. *Acta Paediatr Scand* 1984;73:433-40.
4 Hagberg B, Hagberg G, Olow I, Von Wendt L. The changing panorama of cerebral palsy in Sweden. V. The birth years period 1979-1982. *Acta Paediatr Scand* 1989;17:283-90.
5 Stanley FJ, Watson L. Trends in perinatal mortality and cerebral palsy in Western Australia, 1967 to 1985. *BMJ* 1992;304:1658-63.
6 Dowding VM, Barry C. Cerebral palsy: changing patterns of birthweight and gestational age (1976/81). *Ir Med J* 1988;81:25-9.
7 Riikonen R, Raumavirta S, Sinivuori E, Seppala T. Changing pattern of cerebral palsy in the southwest region of Finland. *Acta Paediatr Scand* 1989;78:581-7.
8 Dayton NA, Doering CR, Hilferty MM, Maher HC, Dolan HH. Mortality and expectation of life in mental deficiency in Massachuserts: analysis of the fourteen-year period 1917-1930. *N Engl J Med* 1932;206:555-70.
9 Balakrishnan TR, Wolf LC. Life expectancy of mentally retarded persons in Canadian institutions. *Am J Ment Def* 1976;80:650-62.
10 Baird PA, Sadovnick AD. Life expectancy in Down syndrome. *J Pediatr* 1987;110:849-54.
11 Kudrjavcec T, Schoenberg BS, Kurland LT, Groover RV. Cerebral palsy: survival rates, associated handicaps and distribution by clinical subtype. *Neurology* 1985;35:900-3.
12 Von Wendt L, Rantakallio P, Saukkonen A-L, Tuisku M, Mäkinen H. Cerebral palsy and additional handicaps in a 1-year birth cohort from northern Finland—a prospective follow-up study to the age of 14 years. *Ann Clin Res* 1985;17:156-61.
13 Evans PM, Evans SJW, Alberman E. Cerebral palsy: why we must plan for survival. *Arch Dis Child* 1990;65:1329-33.
14 Cox DR, Oakes D. *Analysis of survival data*. London: Chapman and Hall, 1984:53-56, 64-65, 80-86.
15 Cox DR, Hinkley DV. *Theoretical statistics*. London: Chapman and Hall, 1982:92.
16 Sahamoto Y, Ishiguro M, Kitagawa G. *Akaike information criterion statistics*. Tokyo: KTF Scientific, 1986.
17 SAS Institute. *SAS/STAT user's guide*. Version 6, 4th ed, vol 2. Cary NC: SAS Institute, 1989:997-1070.
18 Office of Population Censuses and Surveys. *1970-1972 life tables decennial supplement. England and Wales*. London: HMSO, 1979. (OPCS Series DS No 2.)
19 Eyman RK, Grossman HJ, Chaney RH, Call TL. The life expectancy of profoundly handicapped people with mental retardation. *N Engl J Med* 1990;323:584-9.
20 Eyman RK, Grossman HJ, Chaney RH, Call TL. Survival of profoundly handicapped people with severe mental retardation. *Am J Dis Child* 1993;147:329-36.

(Accepted 8 June 1994)

ONE HUNDRED YEARS AGO

DEATH OF MATTHEW BAILLIE'S SON.

A link with the past has been severed by the death of Mr. William Hunter Baillie, the only son of Dr. Matthew Baillie, who was Physician Extraordinary to George III. It is just a hundred years since Matthew Baillie gave his course of Gulstonian lectures. Matthew Baillie was the son of the sister of William and John Hunter, and in 1783 inherited a sum of £5,000 from Dr. William Hunter, together with the house and museum in Great Windmill Street. William Hunter Baillie, who has just died in his 98th year, was the first cousin of Sir Benjamin Brodie and nephew of Lord Chief Justice Denman. His aunt, Agnes Baillie, lived to the age of 101 years, but his father, the celebrated Dr. Matthew Baillie, when he died, in 1823, was only 62. Mr. Hunter Baillie was the owner of Long Calderwood, the place where John Hunter was born; he had in his possession a fine collection of portraits of the Hunter family; these were exhibited at the Royal College of Surgeons in July, 1893, at the celebration of the centenary of Hunter's death. The connection between Hunter and the College of Surgeons is still kept up by Captain Hunter Baillie, a son of the deceased gentleman, who is one of the Hunterian trustees. (*BMJ* 1894;ii:1498.)