Paper prepared for HESG meeting,

University of East Anglia, 8th-11th January 2008

Estimating the hospital cost of cerebral palsy during the first 10 years of life.

By

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Abstract

Introduction:

Cerebral palsy is a group of conditions causing movement problems. Cerebral palsy (CP) affects 1 in 500 UK live births.

Aims:

To estimate the incremental use and cost of hospital inpatient services in children with CP compared to children without CP within the former Oxford NHS region.

Methods:

Data were obtained on the use and cost of hospital inpatient services during the first 10 years of life of 117,191 children born in hospital between 1979-1988 in areas covered by the Oxford Record Linkage Study. Of these, 185 children were identified with CP on hospital admission records. We performed univariate analyses to estimate the effects of CP on cumulative hospital inpatient admissions and costs. Estimates were adjusted controlling for different clinical and sociodemographic covariates (e.g. gestational and maternal age at delivery, complications at birth, small for gestational age status) using generalised linear regression models.

Results:

During the first 10 years of life, children with CP had on average 11.71 (SE 0.96) inpatient admissions compared to 0.79 (SE 0.005) inpatient admissions for children without CP. The unadjusted additional cumulative cost of hospital inpatient admissions was on average £41 708 (95% CI £28 334-£55 081) higher for children with CP than for those without CP. The adjusted cumulative cost was on average £32 209 (95% CI £22 243-£42 174) higher for CP patients.

Conclusions:

Our study suggests that CP has substantial economic consequences for the NHS in the early years of life. This data can be used to inform economic evaluations of interventions in this area.

1. Introduction

Cerebral palsy (CP) describes a range of permanent disorders of the development of posture and motor impairment, causing activity limitation, that result from non-progressive disturbances that occurred in the developing fetal or infant brain. These disorders are often accompanied by other neurodevelopmental impairments such as disturbances of sensation (e.g. vision, hearing), perception, communication, cognition, and behaviour (e.g. mood disorders, sleep disturbances), epilepsy, and secondary musculoskeletal problems (e.g. spinal deformity)[Rosenbaum 2007].

The worldwide prevalence and incidence of this disease are not clearly known, with the overall reported prevalence in children aged 3-10 years averaging 2.4 per 1000 children [Koman 2004]. Although information about cerebral palsy is not routinely collected in the United Kingdom, a recent pooled analysis of data from the five CP registers (Merseyside and Cheshire, North of England, Northern Ireland, 4Child and Scotland) identified 6910 children with CP born between 1960 and 1997. The respective mean annual prevalence of CP was estimated at 2.0 per 1000 live births for birth years 1986-1996. Of the total CP cases, 91 per cent were found to be spastic CP (bilateral and unilateral) and the remainder non spastic CP [Surman 2006].

There is no cure for the condition nor it is possible to achieve normal functioning and even though CP results from a permanent static injury of the central nervous system, the clinical manifestations of this condition as well as respective management options change with growth and development of the child [Koman 2004, Krigger 2006]. Around one third of affected children develop severely impaired lower limb function, nearly a quarter have severely impaired upper limb function, up to 40% have vision impairment and 30% have severe intellectual impairment [Surman 2006]. As a result, CP management does not focus on any single clinical manifestation but on a global patient management, seeking via early and intensive management to increase the patient's functioning and capabilities, and maintain health in terms of cognitive development, independence, locomotion and

social interaction [Krigger 2006]. This places a potentially high burden upon not only the families of children with CP, but also the National Health Service (NHS).

In the United States, a recent study revealed that, children with CP had significantly higher annual total hospital costs compared to hospitalised children without CP ($16 024 vs $9 952) [Murphy 2006]. These higher costs were due to longer length of stay, more diagnoses and more procedures per hospital admission. However, to date no similar study has been performed for the UK.

Our study aims to estimate the incremental use and cost of hospital inpatient services during the first 10 years of life of children with CP compared to children without CP within the former Oxford NHS region. Such information could be relevant to inform decisions about the allocation of research funds and their prioritisation to disease areas with the highest burden [Gross 1999], as well as providing a valuable data source for economic evaluations of interventions in this area

2. Methods

2.1. ORLS dataset

We used data from the Oxford Record Linkage study (ORLS). The ORLS study comprises linked anonymised birth registrations, death certificates and statistical abstracts of NHS hospital inpatient and day case admissions within the former Oxford NHS region, from 1 January 1963 to 31 March 1999. The area covered had a population of about 350 000 in 1963 (one health district), and it expanded to cover 900 000 from 1966 (two districts), 1.9 million from 1975 (six districts - name), and 2.5 million from 1987 (all of the former Oxford NHS region's districts: Oxfordshire, Berkshire, Buckinghamshire and Northampshire) [Goldacre 2000]. The ORLS contains information on patient date of birth, date and cause of death, sex, social class based on the male partner's occupation, marital status, as well as information on each hospital episode, including dates of

admission and discharge, specialty on admission, clinical diagnoses, source of admission, and place of discharge. Hospital data collection ceased in 1999.

2.2. Study population

Our study population comprised all children born to women living in Oxfordshire or West Berkshire and who were born in a hospital in these areas during the period 1st January 1979-31st December 1988. A delivery cutoff point of 31st December 1988 was selected to allow for a 10-year follow up period as the hospital data collection in the ORLS ceased in 1999. The population covered by the ORLS is broadly representative of England and Wales as a whole (Lee and Goldacre, 2000). Over the study period, approximately 6% of births to residents of Oxfordshire and West Berkshire took place outside of these two areas [Mutch 1992]. These were excluded from the analyses.

2.3. Children with cerebral palsy

The cohort of children with cerebral palsy was defined as having had at least one hospital admission for cerebral palsy during the first ten years of life. CP was defined using the *International Classification of Diseases*, ICD-9, categories for infantile cerebral palsy 343.0-343.9. To compare with this CP cohort, we also produced a reference cohort, which consisted of all other children with admissions for reasons other than CP and those that incurred no further hospital admission after birth during the 10 year follow up period. The use of this reference group allowed us to estimate the additional hospital inpatient resource use costs of CP over and above a normative population cohort.

2.4. Hospital costs

From the ORLS dataset, we extracted a record of hospital inpatient care between birth and 10 years of age, including the initial birth admission, for each child in the study. Each day case admission was counted as an inpatient stay of one day. The cumulative number of hospital inpatient days was estimated by summing the lengths of stay of each child's successive admissions. We valued each inpatient day using the English Department of

Health's NHS Trust Financial Returns (TFR2) for 1997-98 and 1998-99, which had been averaged over these two financial years to eliminate any random fluctuation in the data. These returns provide a weighted average cost per inpatient day specific to each specialty, which was then matched to the specialty coding of the hospital episodes to calculate costs for each hospital stay in the dataset. For hospital records with an unknown specialty code or incorrect specialty code, the average cost per inpatient day for all medical and surgical specialties was applied, depending on the approximate ORLS code range. All costs were updated to 2005-6 prices using NHS Hospital and Community Health Services pay and price deflators provided by the English Department of Health.

2.5. Statistical analyses

Descriptive statistics were generated for demographic characteristics (e.g child's gender and gestational age at delivery), hospital inpatient resource use and costs for the CP cohort and the reference cohort. Univariate statistical analyses were used to test for the association between CP status and hospital utilisation and costs during the 10 year follow-up period. A multivariate analysis was performed to estimate the association between hospital total costs and CP adjusting for several covariates (described below), using a generalised linear model (GLM) with the dependent variable (costs) following a gamma distribution (family) and the relationship between costs and explanatory variables following a linear link. The modified Parks test suggested gamma as the most efficient parametric distribution and the Box Cox model did not reject either the log or identity as link functions [Manning 2001]. Given the similar results between log and identity link (in terms of mean estimates, Akaike's AIC and deviance), for convenience to the reader we report the latter. Ramsey's RESET test was used to test for model misspecification [Wooldridge 2002].

The classical linear model can be seen as a special case of GLM (i.e. family(Gaussian) and linear link), where the values of the parameters are obtained by maximum likelihood estimation. However, the GLM does not transform the dependent variable (such as using

natural log), thus avoiding the problems associated with back transforming to a linear scale.

Estimates were then adjusted controlling for clinical and sociodemographic covariates. The covariates included in our models were gestational age (<28 weeks, 28-31 weeks, 32-36 weeks, ≥37 weeks) and maternal age (<20, 20-35, >35 years) at delivery, small for gestational age status (no, yes) [Freeman 1995], complications at birth (no, yes), number of cigarettes smoked by the mother during pregnancy (0, 1-9, 10-19, ≥20), maternal weight at first antenatal visit (<45, 45-89, ≥89kgs), mode of delivery (spontaneous, instrumental, caesarean), year of birth (1979-82, 1983-85, 1986-88), parity, offspring (singleton, multiple birth), maternal hospitalised days during pregnancy (none, 1-10days, 11-20 days, >20days), gender (male, female), whether the child was adopted or fostered around the time of birth (no,yes), maternal operations during delivery (no, yes), social class based upon the male partner's occupation (I, II, III, IV, V) and the duration of survival during the first 10 years of life (continuous variable, years). A reduced form where not statistically significant covariates ($p>0.05$) were removed and a reduced form resulting from stepwise backward-selection estimation (0.2 significance level) are also presented. STATA 10/SE (STATA CORP, TX, USA) was used to perform all statistical analyses.

3. Results

3.1. Children with cerebral palsy

A total of 117,191 children were born in hospital in Oxfordshire or West Berkshire during the period 1st January 1979-31st December 1988, 185 of which were identified as having had at least one CP hospital admission during the first 10 years of life (1.6 per 1000 children). Of the total children diagnosed with CP, 34 were diagnosed with congenital diplegia (ICD-9 code 343.0), 20 with congenital hemiplegia (ICD-9 code 343.1), 46 with congenital quadriplegia (ICD-9 code 343.2), 11 with infantile hemiplegia (ICD-9 code 343.4), 2 with other specified infantile cerebral palsy (ICD-9 code 343.8), and 72 with unspecified cerebral palsy (ICD-9 code 343.9). During the 10 year follow-up

period, eight children had at least one other hospitalisation with a different CP specific code from the initial CP admission. Table 1 shows the characteristics of the CP cohort and the reference cohort.

Of the 185 children identified with CP, 104 (56.2%) were male and 79 (42.7%) had only one hospital admission with a CP diagnosis following the initial birth admission (mean age at CP admission: 3.99 years). The remainder had on average 5.5 (SE 0.76, max:59) hospital admissions with a CP diagnosis following the initial birth admission. 23 (12.4%) children with CP died before the end of the follow up period compared to 1 062 (0.9%) of the reference cohort. The age at which children had their first and last CP admission was on average 3.0 (SE 0.17) and 4.9 (SE 0.21) years, respectively.)

Table 1. Demographics, resource use and costs

	CP Cohort	**Reference Cohort**
Number (n)	185	117,006
Male (n,%)#	104 (56.2)	60 291 (51.4)
Dead during follow up period (n,%)*	23 (12.4)	1 039 (0.91)
Social class of male partner's occupation (valid n) #	177	109 067
I (professional)	20 (11.3)	15 653 (14.4)
II (managerial/technical)	43 (24.3)	30 267 (27.8)
III-NM (skilled non manual)	64 (36.2)	23 653 (21.7)
III-M (skilled manual)	18 (10.2)	8 252 (7.6)
III (skilled unspecified)	10 (5.7)	15 423 (14.1)
IV (partly skilled)	16 (9.0)	12 018 (11.0)
V (unskilled)	6 (3.4)	3 669 (3.4)
Other (armed forces, students and inadequate description)	0	132 (0.1)
Gestational age at delivery (valid n)	150	95 750
<28 weeks*	13 (8.67)	224 (0.2)
28-31 weeks*	20 (13.3)	569 (0.8)
32-36 weeks*	31 (20.7)	4 810 (5.0)
≥37 weeks*	86 (57.3)	90 147 (94.2)
Mean length of stay in days (n,SE)**	108.433 (10.204)	7.195 (0.039)
Mean hospital admissions (SE)**	11.71 (0.96)	0.79 (0.005)
Total costs over 10 year period (SE)**	£44 333 (£4358)	£2 625 (£16)

* Statistically significant at $p<0.01$ (X^2 test)
# Not statistically significant at $p<0.05$ (X^2 test)

**Statistically significant at p<0.01 (t-test)

3.2. Hospitalisations

During the first 10 years of life, 40% (46 937) of all children had at least one further recorded hospital admission after the initial admission for birth. Children with CP had on average 11.71 (SE 0.96) inpatient admissions, compared to 0.79 (SE 0.005) inpatient admissions for children without CP. Excluding the length of stay associated with the initial birth admission, children with CP spent 4.5 (SE 0.59) more days in hospital per admission than other hospitalised children. Table 2 reports the mean number of hospitalisation diagnoses per child. As a child can have up to four recorded diagnoses per hospital admission, the mean number of hospital diagnosis is slightly higher than the number of hospital admissions (the proportion of missing data concerning the second, third and fourth diagnosis per admission was 71%, 92% and 97%, respectively). Figures 1 and 2 show the mean number of hospital inpatient admissions and hospital inpatient days, following the initial birth admission, per year of life in both cohorts.

Table 2. Mean number of major ICD-9 diagnoses recorded in admissions over 10 year follow up period

ICD 9 codes	CP	No CP
Diseases of digestive system	0.762 (0.126)	0.071 (0.0009)
Infectious diseases, endocrine diseases, and diseases of the blood	0.741 (0.114)	0.066 (0.0021)
Neoplasms	1.778 (1.255)	0.018 (0.0018)
Disease of respiratory system	1.859 (0.214)	0.179 (0.0019)
Mental and behavioural disorders	1.286 (0.443)	0.004 (0.0009)
Diseases of nervous system	7.324 (1.224)	0.146 (0.0019)
Disease of congenital anomalies	2.513 (0.413)	0.179 (0.0022)
Disease of certain conditions originating in perinatal period	3.562 (0.212)	0.956 (0.0038)
P<0.001		

Figure 1. Hospital inpatient <u>admissions</u> of children with and without CP excluding initial birth admission (means and 95%CIs)

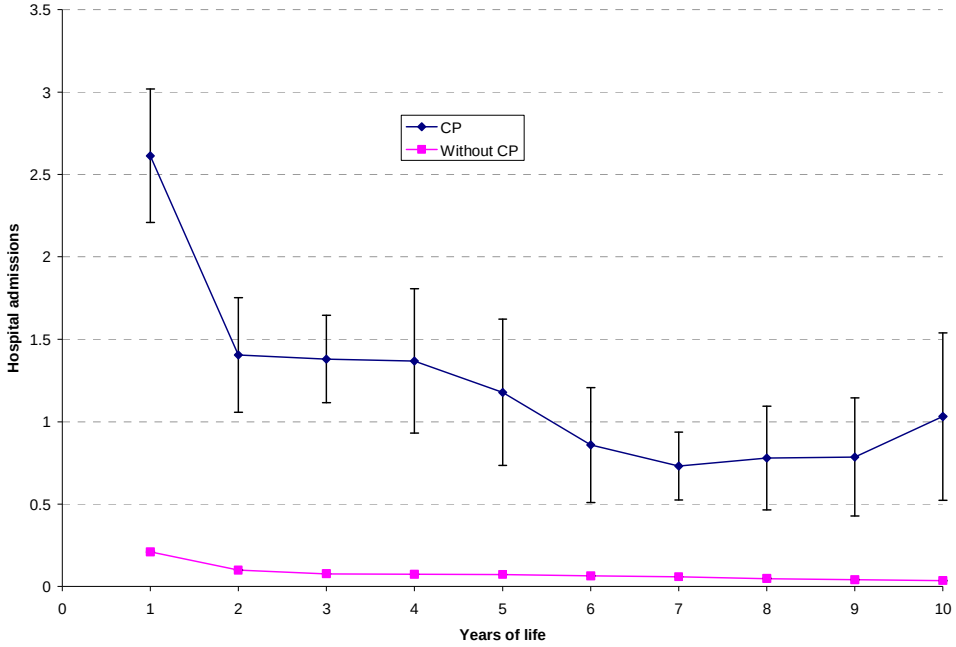
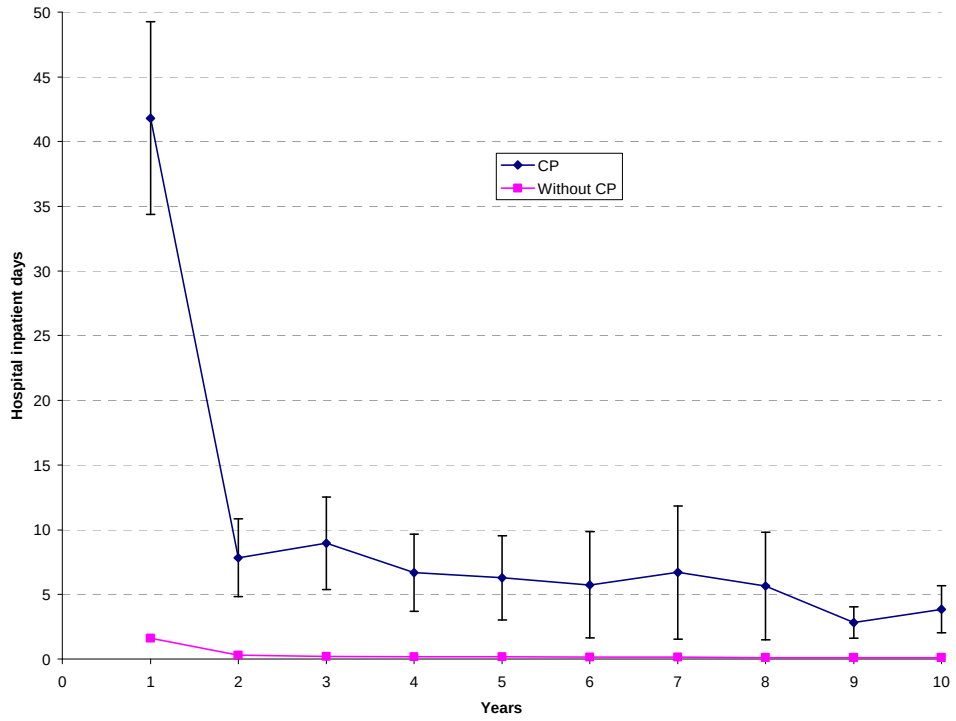


Figure 2. Hospital inpatient <u>days</u> of children with and without CP excluding initial birth admission (means and 95%CIs)



3.3. Hospitalisation inpatient costs

During the first 10 years of life, we estimated the mean hospital cost per child with CP to be £44 333 (95% CI £35 734-£52 931), compared to £2 625 (95% CI £2 593 - £2 656) for a child without diagnosed CP. CP costs were quite high during the first year of life, £22 921 (95% CI £19 708-£26 135), but then averaged £2 379 (95% CI £1 644 - £3 114) per year thereafter. In the CP cohort, there was a significant difference in hospital costs between the first and subsequent years of life but not from the second year of life onwards. The unadjusted additional cumulative cost of hospital inpatient admissions was on average £41 708 (95% CI £28 334-£55 081) higher for children with CP than for those without CP. Excluding birth costs, the unadjusted difference in hospital inpatient costs becomes £38 600 (95% CI £37 815-£39 384). Table 3 shows the adjusted cumulative inpatient cost to be on average £32 209 (95% CI £22 243-£42 174) higher in CP patients (in the reduced form).

The following covariates were also found to be statistically significant: size for gestational age, gender, maternal hospitalised days during pregnancy, maternal operations before birth, multiple birth, parity, complications and mode of delivery, gestational age, social class of head of household, duration of survival and year of birth.

Table 3. Adjusted cumulative costs over the first 10 years of life.

Variables	Coef. (robust std err.)	P>z	Coef. (robust std err.)	P>z	Coef. (robust std err.)	P>z
	Full model		Reduced model		Stepwise reduced	
Cerebral Palsy						
- No						
- Yes	32720 (5673)	<0.001	32209 (5084)	<0.001	32215 (5087)	<0.001
Size for gestational age						
- Normal						
- Small	830 (69)	<0.001	823 (66)	<0.001	826 (66)	<0.001
Gender						
- Male						
- Female	-388 (27)	<0.001	-384 (26)	<0.001	-382 (26)	<0.001
Maternal hospitalised days during pregnancy						
- None						
- 1-10 days	148 (30)	<0.001	139 (29)	<0.001	140 (29)	<0.001
- 11-20 days	901 (174)	<0.001	958 (173)	<0.001	967 (174)	<0.001
- >20 days	1475 (248)	<0.001	1516 (246)	<0.001	1523 (246)	<0.001
Cigarettes smoked by mother during pregnancy						
- None						
- 1-9 cigarettes	29 (46)	0.52	39 (44)	0.372		
- 10-20 cigarettes	304 (83)	<0.001	298 (75)	<0.001	295 (76)	<0.001
- >20 cigarettes	298 (65)	<0.001	302 (62)	<0.001	299 (61)	<0.001
Maternal weight at first antenatal visit						
- <45kgs	267 (169)	0.113				
- 45-89 kgs						
- ≥89kgs	94 (104)	0.367				
Maternal operations before birth						
- No						
- Yes	227 (61)	<0.001	199 (57)	<0.001	202 (57)	<0.001
Offspring						
- Singleton						
- Multiple births	976 (152)	<0.001	980 (147)	<0.001	984 (147)	<0.001
Social class of head of household at time of birth						
- Social class I (and other)	-152 (35)	<0.001	-159 (33)	<0.001	-157 (33)	<0.001
- Social class II	-73 (36)	0.041	-71 (34)	0.035	-70 (34)	0.04
- Social class III						
- Social Class IV	92 (47)	0.049	86 (43)	0.047	85 (43)	0.05
- Social Class V	406 (125)	0.001	399 (120)	0.001	399 (119)	0.001
Parity grouping						
- First birth						
- Subsequent birth	-177 (28)	<0.001	-190 (27)	<0.001	-18 (27)	<0.001
Complications of delivery						

- No						
- Yes	181 (32)	<0.001	172 (30)	<0.001	173 (30)	<0.001
Maternal age at the time of delivery						
- <20 years old	204 (66)	0.002	204 (64)	0.001	210 (63)	0.001
- 20-35 years old						
- >35 years old	26 (64)	0.683	57 (65)	0.38		
Mode of delivery						
- Spontaneous delivery						
- Instrumental delivery	249 (48)	<0.001	250 (46)	<0.001	252 (45)	<0.001
- Caesarian delivery	1411 (50)	<0.001	1424 (48)	<0.001	1427 (48)	<0.001
Child adopted/fostered around the time of birth						
- No						
- Yes	947 (467)	0.043	991 (449)	0.027	1007 (454)	0.027
Gestational age at delivery						
- 28wks	23091 (2813)	<0.001	23434 (2474)	<0.001	23429 (2473)	<0.001
- 28-31wks	19893 (1142)	<0.001	20066 (1089)	<0.001	20057 (1088)	<0.001
- 32-36wks	3852 (139)	<0.001	3899 (146)	<0.001	3896 (146)	<0.001
- ≥37wks						
Year of birth						
- 1979-82						
- 1983-85	-37 (33)	0.257	-40 (32)	0.203		
- 1986-88	-358 (33)	<0.001	-372 (31)	<0.001	-353 (27)	<0.001
Duration of survival	47 (8)	<0.001	46 (7)	<0.001	46 (7)	<0.001
Duration of survival^2	-0.01 (0.002)	<0.001	-0.01 (0.002)	<0.001	-0.013 (0.002)	<0.001
Constant	1924 (278)	<0.001	1949 (268)	<0.001	1923 (267)	<0.001
Model statistics						
- Deviance	70383.7		76817.8		76829.2	
- BIC	-756014		-829812		-829834	
- AIC	17.38947		17.38617		17.38624	

4. Discussion

Our study is the first, to our knowledge, to estimate the hospital inpatient costs of children with cerebral palsy during the first 10 years of life in the United Kingdom. We found that children with CP have significantly higher hospitalisation costs than children without CP (£44 333 vs £2 625). Furthermore, significant cost differences are maintained even after adjustment for several clinical and sociodemographic covariates. Children with CP have a higher mean number of hospital admissions and longer length of stay per admission compared to children without the syndrome. The difference in terms of hospitalisation burden between cohorts remained statistically significant for each of the first 10 years of life.

This analysis uses a large cohort of children in a geographically defined area and included a comprehensive and validated record of hospital inpatient service data [Goldacre 1988, Goldacre 2000]. The ORLS dataset is particularly useful in health economic analyses as it enables individual patient-level analyses due to linked successive hospital records for each person. It is this linkage of successive records that has enabled a variety of exercises examining hospital resource use and costs conditional on alternative patient characteristics to be performed [Petrou 2005, Henderson 2004, Seshmani 2004]. Furthermore, the ORLS dataset provided a sample size large enough to detect statistically significant differences in hospital costs between the two cohorts under analysis. We were also able to use, as the reference cohort, all children without CP, which enabled comparisons of this disease not just with non-CP hospitalised children but also with children without major chronic health problems. This makes the ORLS dataset especially suited to examine inpatient utilisation of children with CP. For example, the authors of the United States CP cost study were limited to using other hospitalised children as the comparison group and had little information on clinical and sociodemographic covariates [Murphy 2006].

We adopted a narrow health care perspective by examining solely inpatient hospital use and costs. It is expected that hospital admissions will only reflect part of the expected

total economic burden of cerebral palsy. The impact of CP on outpatient consultations, contacts with general practitioners, physiotherapists and other community health professionals, out of pocket expenses, travel costs, and use of education and social services was not estimated. This is relevant as, Beecham and colleagues calculated the extra costs associated with hemiplegic cerebral palsy in young adults (18-25 years old) to be £5 600 per person per year (1999 costs), of which only 7% was due to hospital and community health services. The remainder was attributable to education and day activities (66%), followed by accommodation and living expenses (26%) [Beecham 2001]. However, we show that despite a decrease in hospital costs after the first year of life, the use and cost of hospital inpatient services remains constantly higher throughout the first 10 years of life amongst CP children compared to the reference cohort. Furthermore, a CP database developed by NPEU at Oxford University could also be examined in order to estimate a more complete picture of NHS resource use in CP. Outpatient visit information could also be added to this.

Even though our data concerns the former Oxford NHS region, there seems to be no statistically significant difference in terms of CP prevalence between this geographical area and the rest of the country [Surman 2006]. Hence, what needs to be determined is how representative our sample is of the general population with CP. In our study, children with CP were identified using ICD-9 codes assigned as diagnosis code at admission and this may generate some concerns. First, it is possible that some children with this disease were not assigned a CP code at admission. However, this is unlikely as the ORLS recorded up to 4 diagnostic codes for each hospital admission. Second, children with milder CP who may not have incurred further hospitalisations after birth are not identified using our approach. This may explain to some extent the discrepancy of CP prevalence between the ORLS database and the UK register study (1.6 vs 2.0) [Surman 2006] as there are also likely to be cases of CP diagnosed within the community (primary care), which are less severe than our CP cohort, and may not lead to hospitalisations. Further work will explore in more detail the potential differences between our cohort of children with CP and children identified by the UK register study.

Our analysis was constrained to a delivery cutoff of 1988 to allow for a 10 year follow up period as the collection of hospitalisation data in the ORLS ceased in 1999. Despite some concerns about the relevance of these data given its relative age, the ORLS still has the most complete and up to date available data in the UK. Even if we had available more recent datasets we would still be faced with resource utilisation during the 1990s.

The dataset did not include admissions of the study population to hospitals outside the former Oxford Region. National statistics indicate that 4.7% of children aged under 15 years migrated out of the local authorities covered by the former Oxford Region during 2000-2001. Although part of this migration would have been to other local authority areas covered by the ORLS, we might have underestimated the absolute levels of hospital service utilisation and costs for our study population. Nevertheless, there is no evidence to suggest that the mean difference in care costs between the CP and non-CP groups and, consequently, the costs that can be attributed to CP, is affected by the level of migration.

Despite the narrow health care perspective, our study results have important implications for decision makers. The large cost difference between children with CP and without CP shows the need to focus research on preventive measures and better management of the several clinical consequences of this condition. In addition, our estimates could be used as inputs for economic evaluations aiming to determine the cost-effectiveness of such interventions. For example, our annual cost data could be used in decision models evaluating a variety of CP therapies may they be pharmacological approaches, such as botulinum toxin A [Heinen 2006, Lannin 2006] or baclofen [de Lissovoy 2007], surgical approaches or non-pharmacological approaches such as physiotherapy [Weindling 2007]. Furthermore, our study could be useful for health economists currently involved in the evaluation of preventive and treatment interventions in a variety of genetic, metabolic, muscular or neuronal tumor disorders that have clinical complications very similar to CP, such as Rett Syndrome, Medium Acyl CoA Dehidrogenase deficiency, Glutaric aciduria type 1, etc [Krigger 2006].

In conclusion, our study suggests that cerebral palsy has substantial economic consequences for the NHS throughout early and mid childhood.

Acknowledgments

Data collection for the ORLS was funded by the former Oxford Regional Health Authority. We thank Professor Michael Goldacre for his advice and support in using the data. SW is funded by an NIHR fellowship award and SP by an MRC fellowship award. Any views expressed in this paper are those of the authors and not attributable to either funding body.

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