Social, Environmental and Biological Determinants of Cerebral Palsy in Children with Intellectual Disabilities (ID) in India

Lakhan R[1]

[1] Doctoral Candidate in Epidemiology, School of Health Science, College of Public Service, Jackson State University, 350, West Woodrow Wilson Drive, Jackson, MS 39213

Original Article

Corresponding Author
Ram Lakhan, BMR, MS
Doctoral Candidate in Epidemiology
School of Health Science, College of Public Service
Jackson State University, 350
West Woodrow Wilson Drive
Jackson, MS 39213
Email Id: ramlakhan15@gmail.com

Abstract

Background

Cerebral palsy (CP) is a global public health problem affecting 2.12 to 2.45 per 1000 live birth across the world. Cerebral palsy is an upper motor neuron, non-progressive disorder commonly associated with intellectual disability. The presence of cerebral palsy effects person's overall life.

Objectives

This study primarily sought predictive capacity of social, environmental and biological determinants of CP in ID.

Materials and Methods

This is a cross-sectional study design. A total of 262 children, aged 3 to 18 years, with ID were assessed for cerebral palsy and diagnosed on basis of clinical examination in a community based rehabilitation project in Barwani, India. Information was collected by parent interviews, on social, environmental and biological determinants. A logistic regression model has been applied between determinants and CP.

Results

Logistic regression demonstrated that likelihood of CP in ID children can be predicted on bases of their age (odd ratio = 0.856, CI 95% - 0.76-0.95), intelligence quotients (IQ) (odd ratio = 0.782, CI 95% - 0.73-0.83) and family history of intellectual disabilities (odd ratio = 0.051, CI 95% - 2.36 - 0.99) and epilepsy (odd ratio = 0.008, CI 95% - 2.58-1.28). Comorbid conditions of downs syndrome and epilepsy also predicts likelihood of CP in ID.

Conclusion

Likelihood of CP in ID children can be predicted by their age, IQ, family history of intellectual disability, epilepsy and comorbid conditions of downs syndrome and epilepsy. Gender, socio-economic status and population (tribal versus non-tribal) determinants have no predictive relation with CP in the group.

Keywords: cerebral palsy, intelligence quotient, intellectual disability, mental illness, epilepsy, downs syndrome, enuresis, behavior disorders

List of Abbreviations:

CP Cerebral palsy

IQ Intellectual quotient

ID Intellectual disability

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MI Mental illness

DS Down syndrome

FO Family history

CBR Community-based Rehabilitation

CBRW Community-based Rehabilitation worker

AGT Ashagram Trust

LAMI Low-and middle-income

DST Developmental Screening Test

VSMS Vineland Social Maturity Scale

DV Dependent variable

IV Independent variable

OR Odd ratio

NIMH-DDS National Institute for the Mentally Handicapped Developmental Screening Schedule

Introduction

Cerebral palsy (CP) is a global public health problem affecting 2.12 to 2.45 per 1000 live birth across the world 1-4. Population based studies conducted in India and China shows prevalence of CP from 2-2.8 per 1000 live births, which is very close to the prevalence in western settings5. Cerebral palsy is an upper motor neuron, non-progressive disorder. It is the most common physical disability among children6.

Classification of cerebral palsy is based on the involvement of body parts. Spastic hemiplegia refers to spasticity on one side of body such as an arm or an arm with a leg, spastic diplegia –is when lower limbs are involved with little or without involvement of upper body. Spastic quadriplegia is usually most serious form of CP that involves both upper and lower limbs. Ataxia is observed between 5-10% of all cases of CP. It affects balance, and muscle coordination of arms, legs and trunk. This type of CP is caused due to damage in cerebellar structure, while damage to cortical motor and underlying white matter is the cause for spastic CP. Athetoid/dyskinetic cerebral palsy happens due to damage in basal ganglia during brain development due to bilirubin encephalopathy and hypoxia7-9. Athetoid/dyskinetic form of cerebral palsy is commonly considered to be movement disorders. It exhibits both hypotonia and hypertonia and affects an individual's ability to control muscle tone10. Individuals with cerebral palsy have a higher mortality rate than the general population. In a study conducted on Californian population on cause of mortality in CP. The causes were attributed to brain cancer, respiratory, circulatory and digestive diseases11.

Worldwide, 80% children with disabilities live in poverty and in resource poor settings. Thus the likelihood of CP in these areas is expected to be higher5. Children with CP, especially in resource poor areas, are excluded from mainstream education12. Most often their disability restricts their mobility which becomes the greatest barrier in attending school. Further, it results into unemployment, and poor social life. Stigma and poor awareness on this disability in poor societies results in physical, social and attitudinal barriers for children with CP. They are restricted from interacting or playing with their peers and participation in social events13. This isolation affects child's self-esteem and enthusiasm for living. Lack of appropriate and accessible rehabilitation services in resource poor areas deprive CP children from maximizing their residual potential; this situation leads to more burden and stress for parents to raise a child with disability12-14.

This disorder is commonly associated with intellectual disability15. Learning and cognitive impairments are common with CP. It is estimated that 45% children with CP have intellectual disabilities. Out of those approximately 25% have moderate (IQ < 50), and lower levels of ID16. Sensory such as hearing and visual impairments are also very common with CP1. Epilepsy and behavior problems are often associated with this condition. Epilepsy can affect up to 30% of children's population with CP16-18. Studies have proven association of cerebral palsy with low IQ, age and co-occurring conditions of epilepsy, behavior problems and social factors like poverty. However, there is limited information available about family history of intellectual disabilities and epilepsy as predictors of CP. It makes relevance to explore connections of social, environmental and biological factors in predicting the likelihood of cerebral palsy in children with ID.

This study was conducted under a community-based rehabilitation (CBR) project. Presently, CBRs approach of rehabilitation of disabled people is very popular in low-and middle-income countries (LAMI) and is being implemented in more than 90 countries worldwide19. People with cerebral palsy not only need medical attention and therapeutic services, but also other forms of services such as education, and equal opportunities for participation in social events and employment. Such needs of CP individuals living in poorer communities might also be met through CBR.

Objective:

This study attempted to find out predictive capacity of social, environmental and biological determinants of CP in ID.

Material and Methods

Study design and duration:

It was a Cross-Sectional of Eight years (July 15, 1999 to July 24, 2007).

Sample size calculation:

For 95% confidence interval, α=5%, and allowable error = 3% required sample size of 211 in total 262 population of ID children. In this study we included all 262 cases.

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Study Site:

This study was conducted in the poorest district of India of Madhya Pradesh state called Barwani[20] by a non-government organization Ashagram Trust (AGT), with the financial help of Action Aid in a CBR project. This project started in January 1999 and ended in December, 2010. This project was implemented in 63 villages of Barwani block of Barwani district. Half of the villages covered in the project have tribal population[21]. Approximately 64,000 people were covered in the project from the total population studied.

Materials:

NIMH-DDS, Developmental Screening Test (DST), Vineland Social Maturity Scale (VSMS), clinical examination and parent interviews are primary instruments used in the research.

Methodology:

The population of project villages was surveyed door to door for identifying children aged 3 to 18 years with intellectual disabilities. National Institute for the Mentally Handicapped Developmental Screening Schedule (NIMH-DDS) was used for screening survey. This survey was conducted by community based rehabilitation workers (CBRWs) under supervision of a specialist in intellectual disabilities (RL). CBRWs underwent a week long training session on using an intellectual screening checklist, and on other aspects of survey including characteristics of ID. All identified cases were further assessed on two diagnostic tests, Developmental Screening Test (DST) and Vineland Social Maturity Scale (VSMS) for diagnosis[22]. A total of 262 cases were found to have ID. All 262 cases were further evaluated for CP by professionals in home, camp or clinical settings. Developmental, family, and demographic history was collected through interviewing parents after obtaining informed written or oral consent for research. Cases for other coexisting disorders were also evaluated. Collected information on social, environment and biological determinants was categorized into age, gender, IQ, family history of mental illness, intellectual disabilities, epilepsy and coexisting disorders epilepsy, downs syndrome, enuresis and behavior disorders.

Ethical Committee Approval:

Ethics committee comprising members of AGT, Action Aid and CBR team provided approval for study.

Statistics:

Statistical Package for the Social Sciences (SPSS) - 21 student version was used for data analysis. A correlational statistics was performed first to examine association of CP dependent variable (DV) with independent variables (IV). Pearson correlation was used with continuous IVs (age and IQ) and Spearman's with categorical variables[23]. Variables showing some sort of association with CP were analyzed as predictors of CP in logistic regression model through enter method. To reduce the effect of multicollinearity, parametric and non-parametric independent variables were analyzed separately in the model. CP was treated as a binary outcome in correlation and logistic regression. A logistic regression model is the best predictor of association between binary variables. This model has the ability to adjust independent scale variables with dichotomous dependent variables [24]. For reporting purpose, results are standardized in terms of percentage using following derivation (Odd Ratio – 1) x 100 = percentage (%) [24].

Results:

82 (31.29%) children were found with Cerebral Palsy in 262 children with ID. Table 1, illustrates their demographics, family history of illness, and comorbid disorders. Age wise distribution of CP cases in ID is mentioned in Table 2. Prevalence of CP was found to be higher among younger age group of children with ID (figure 1). Prevalence of CP was found to be considerably lower among children with higher IQ (figure 2).

Table 1: Distribution of Social, environmental and biological determinants of CP

Categories		Cerebral Palsy n = 82		Total
		No	Yes	
		n (%)	n (%)	
Gender	Female	85 (32.44)	39 (14.88)	124 (47.32)
	Male	95 (36.24)	43 (16.41)	138 (52.67)
Socio-economic status	Not poor	38 (14.50)	22 (8.39)	60 (22.90)
	Poor	142 (54.19)	60 (22.90)	202 (77.09)
Population type	Tribal	97 (37.02)	43(16.41)	140 (53.43)
	Non-tribal	83 (31.67)	39 (14.88)	122 (46.56)
F/O of Mental Illness	No	155 (59.16)	61 (23.28)	216 (82.44)
	Yes	25 (9.54)	21 (8.01)	46 (17.55)
F/O of Intellectual Disabilities	No	161 (61.45)	58 (22.13)	219 (83.58)
	Yes	19 (7.25)	24 (9.16)	43 (16.41)
F/O of Epilepsy	No	154 (58.77)	46 (17.55)	200 (76.33)
	Yes	26 (9.92)	36 (13.74)	62 (23.66)
Downs Syndrome	No	162 (61.83)	81(30.91)	243 (92.74)
	Yes	18 (6.87)	1(0.38)	19 (7.25)
Behavior Disorders	No	36 (13.74)	12 (4.58)	48 (18.32)
	Yes	144 (54.96)	70 (26.71)	214 (81.67)
Epilepsy	No	156 (59.54)	44 (16.79)	200 (76.33)
	Yes	24 (9.16)	38 (14.50)	62 (23.66)
Enuresis	No	162 (61.83)	73 (27.86)	235 (89.69)
	Yes	18 (6.87)	9 (3.43)	27 (10.30)

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Table 2: Age wise distribution of CP cases in ID children

Age (Years)	Cerebral Palsy		Total
	No	Yes	
	n (%)	n (%)	
3	6 (2.29)	22 (8.39)	28 (10.68)
4	12 (4.58)	11 (4.19)	23 (8.77)
5	12 (4.58)	4 (1.52)	16 (6.10)
6	15 (5.72)	9 (3.43)	24 (9.16)
7	13 (4.96)	5 (1.90)	18 (6.87)
8	19 (7.25)	6 (2.29)	25 (9.54)
9	13 (4.96)	5 (1.90)	18 (6.87)
10	14 (5.34)	4 (1.52)	18 (6.87)
11	10 (3.81)	3 (1.14)	13 (4.96)
12	11 (4.19)	5 (1.90)	16 (6.10)
13	11 (4.19)	2 (0.76)	13 (4.96)
14	12 (4.58)	3 (1.14)	15 (5.72)
15	6 (2.29)	2 (0.76)	8 (3.05)
16	11 (4.19)	0 (0.0)	11 (4.19)
17	4 (1.52)	0 (0.0)	4 (1.52)
18	11 (4.19)	1 (0.38)	12 (4.58)
Total	180 (68.70)	82 (31.29)	262 (100.00)

Figure-1: Graph showing prevalence of CP with Age of ID Children

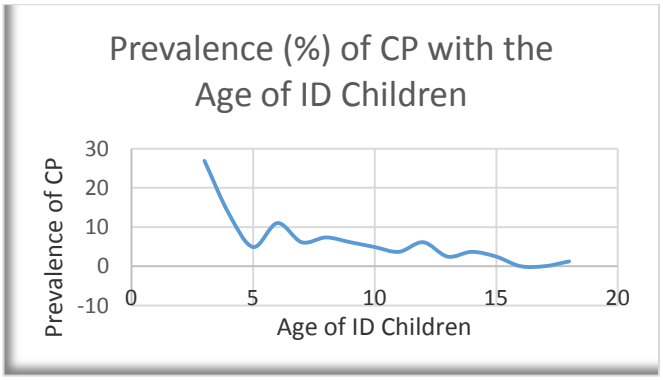

Figure-2: Graph showing prevalence of CP with IQ of ID Children

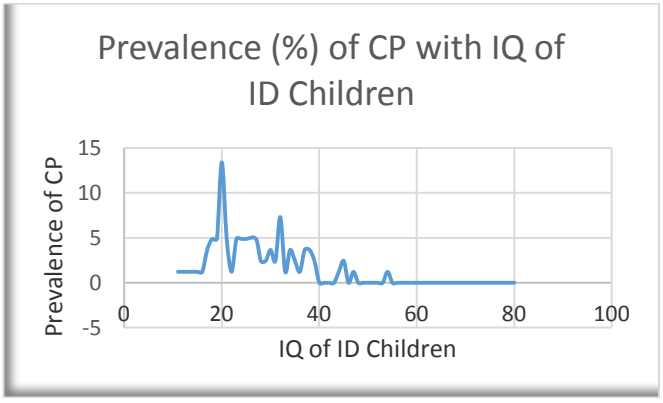

Table 3: Pearson and Spearman's correlation of CP with age, IQ, gender, socio-economic status, population, family history of mental illness, intellectual disabilities, epilepsy and epilepsy, downs syndrome, behavior disorders and enuresis

Determinants (parametric)	Pearson rho	p-value
Age	-0.0336	0.000
IQ	-0.710	0.000
Determinants (Non-parametric)	Spearman's rho	p-value
Gender	-0.003	0.960
Socio-economic status	-0.063	0.309
Population Type	0.013	0.828
F/O Mental Illness	0.143	0.021
F/O Intellectual Disabilities	0.234	0.000
F/O Epilepsy	0.321	0.000
Downs Syndrome	-0.157	0.011
Behavior Disorders	0.064	0.300
Epilepsy	0.360	0.000
Enuresis	0.015	0.811

There is inverse association of CP with age (rho = - 0.0336, p=0.001) and IQ (rho = - 0.710, p=0.001). Family history of mental illness (rho = 0.143, p=0.021), intellectual disabilities (rho = 0.234, p=0.001) and epilepsy (rho = 0.321, p=0.001) are positively associated. Similarly, comorbid conditions epilepsy was found to have positive correlation (rho = 0.361, p=0.001) and Down's syndrome had an inverse correlation (rho = - 0.157, p=0.011) with CP. Other factors such as gender, socio-economic status (poor versus not poor), population (tribal versus non-tribal), behavior disorders and enuresis are not associated (p>0.05) with CP (table 3).

Independent factors: those found associated with CP irrespective of nature of relationship were selected for logistic regression. In our first analysis, we used parametric covariates, age and IQ in logistic model. Test of goodness fit *Hosmer and Lemeshow* x^2= 9.140, p= 0.331 did not reject null, which demonstrates that logistic regression model fits well in predicting occurrence of CP by age and IQ.

Table 4: logistic regression statistics of CP with age and IQ

Predictors	*B*	SE	Wald / X^2	P value	Exp *(B)* / OR	95% C.I. for Exp*(B)*	
Constant (intercept)	9.566	1.382	47.923	0.001	14277.011	Lower	Upper
Age	-0.156	0.057	7.391	0.007	0.856	0.765	0.957
IQ	-0.246	0.034	50.938	0.001	0.782	0.731	0.837

Logistic regression equation is $Y=b_0 + B_1 X_1 + B_2 X_2$ ..... Thus we obtained the following equation for this model *y = 9.566 - 0.156 (age) – 0.246 (IQ).* The model demonstrates that increase of one unit (1 year) of age reduces likelihood of cerebral palsy by -0.156. IQ is also inversely associated. As per the model, an increase of a unit of IQ decreases chances of CP by -0.246. The Odds ratio for age = 0.856

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interpretation demonstrates that an increase of 1 year age, decreases likelihood of CP by 14.4%. Odds ratio for IQ = 0.782 means likelihood of CP decreases by 21.8% (table 4).
In the second analysis, we applied logistic regression with binary IVs. Test of goodness fit *Hosmer and Lemeshow* x^2= 3.873, p= 0.423 did not reject null, which demonstrates that the logistic regression model fits well in predicting occurrence of CP by family history of ID, Epilepsy and by presence of Down's syndrome and epilepsy in the individual.

Table 5: Logistic regression statistics of CP with family history of mental illness, intellectual disabilities, epilepsy and comorbid conditions of Down's syndrome and epilepsy

Predictors	B	SE	Wald / X^2	P value	Exp *(B)* /OR	95% C.I. for Exp*(B)*	
Constant	-1.473	0.204	52.322	0.000	0.229	Lower	Upper
F/O mental illness	0.084	0.447	0.036	0.850	1.088	0.453	2.613
F/O mental retardation	0.859	0.440	3.815	0.051	2.362	0.997	5.595
F/O epilepsy	0.950	0.357	7.082	0.008	2.585	1.284	5.204
Downs Syndrome	-2.120	1.111	3.643	0.056	0.120	0.014	1.059
Epilepsy	1.214	0.353	11.806	0.001	3.368	1.685	6.733

We obtained following equation for this model, *y = -1.473 + 0.859 (F/0 MR) + 0.950 (F/O Epilepsy) + 1.214 (epilepsy) - 2.124(downs Syndrome)*. The model demonstrates that increase of one unit of family history of intellectual disabilities increases likelihood of CP by 0.859 and epilepsy by 0.950. Increase of Epilepsy by one unit as comorbid condition also increases likelihood of CP by 1.214, while thre other comorbid condition viz. Down's syndrome was inversely associated. The increase of one unit of DS reduces likelihood of CP by -2.120. In standardized terms, family history of intellectual disabilities OR=2.362 indicates 136.2% increase in likelihood of CP, and family history of epilepsy OR = 2.585, increases likelihood of CP by 158.5%. Comorbid condition of epilepsy OR= 3.368 increases likelihood of CP by 236.8%, while Down's syndrome OR = 0.120 decreases likelihood of CP by 88% (table 5).

Discussion:

We classified our study variables in to social, environmental and biological categories. However, it is difficult to have such discrete categorization because some variables overlap between categories. Findings are discussed in light of international scenario on CP and in relevance of LAMI countries.

Cerebral palsy and social determinants:
In our study, 22.90% CP children belong to poor socio-economic status while 8.39% are not that poor. *Poor* in study are those who were solely dependent on manual labor while *not poor* are little better off than poor as they have few cattle and few families own little agricultural land. Studies conducted worldwide shown association of cerebral palsy with poverty specially in LAMI countries[5], but our findings did not match fairly with the variables selected in the analysis of poor versus not poor. However, in correlation with other studies these results should conform, because the overall population studied here was poor. 16.41% CP children belong tribal population, while 14.88% are non-tribal. It can be stated that tribal population is more vulnerable to CP, and this could be attributed to poverty and lack of health facilities in this region; however we are unable to support this observation due to lack of research evidence in this area.

Cerebral palsy and environmental determinants:
8.01% of children with CP have family history of mental illness, 13.74% have family history of epilepsy and 9.16% have history of intellectual disabilities. There is a strong genetic influence and this has been reported on likelihood of developing CP in worldwide population studies[7, 25], which validates our findings. However, in prediction models genetic heterogeneity and multifactorial environmental influences are incorporated[26]. In Asian consanguineous marriages cerebral palsy is inherited high as 50% as autosomal recessive trait[7].

Cerebral palsy and biological determinants:
Findings of this study are consistent with other studies in explaining association of cerebral palsy with IQ[16], and co-occurring epilepsy[18]. A study conducted in Sweden demonstrated an association between CP and epilepsy. In that study children with tetraplegia CP has early onset of epilepsy, while many children with hemiplegia developed partial seizures later on. In this study prevalence of epilepsy was found to be higher among those had cognitive dysfunction or low level of intelligence (IQ). Thus study also makes connections between IQ and epilepsy in CP. According to that study, CP and its etiology can predict development of epilepsy and its outcome[16]. Studies conducted in European countries showed that generalized and partial epilepsy are more common in CP[27].
In the age group of 3 to 6 years, children with ID have 9.16% to 10.68% CP. This percentage reduces in the age group 7-10 years of age to 6.87%; at 11 years 4.96%, at 15 years 3.05%, down 1.52% at 17 and 4.96% for 18 years. Our results indicates lower prevalence rate of CP in older age group of children. The same tendency of lower prevalence in older age group of children was observed in a prevalence study conducted in a similarly impoverished population of another LAMI country, Nepal [28]. Emerson et al. (2012) based on World Bank report of 2010, reported in their editorial article that over 10% of children would die before their fifth birthday in LAMI countries [29-30]. Children with ID in such countries are also reported at higher risk of denial for health

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care service[31]. This may be the reason for lower prevalence among older age group of children with CP.

Occurrence of CP is not found significantly different between male and female children. In our study16.41% male and 14.88% female with ID have CP. A study conducted in South America showed similar results [32]. Down's syndrome was found to be associated with 0.38% and enuresis in 3.43% of the CP population in our study. Down's syndrome and enuresis are common genetic and biological conditions associated with CP. However, presence of enuresis cannot predict occurrence of CP in ID population. Pakula AT et al. (2009) in their review article of prevalence studies conducted worldwide reported that urogenital disorders including enuresis, and genetic disorders are common, but they are not essentially predictors of CP in ID[25].

Conclusion:

This study has public health implications in predicting the likelihood of cerebral palsy in children with ID on bases of their IQ, age, family history of intellectual disabilities, epilepsy, and co-existing disorders of epilepsy and Down's syndrome. Further studies are needed to explore reasons of low frequency (prevalence) of CP in older age groups as compared to younger children with ID. However, these findings can guide professionals involved in assessment and care for cerebral palsy and intellectual disabilities. They can provide better guidance and appropriate referrals for services to the clients with CP. Public health agencies and practitioners may incorporate findings of this study in designing programs on CP.

Limitation of the Study:

Cerebral palsy is classified into different types. In this study we covered all types of CP in one category. Analysis with different types of CP with study variables would have enriched research findings.

Further Scope of Study:

Analysis with different types of CP associated with various levels of socio –economic status, parental education and different level of family pedigree (first, second and third) and different types of epilepsy would enhance the predictive model of cerebral palsy. Environmental factors such as smoking, drinking, early age pregnancy and consanguineous marriages are very common factors in the studied population, and consideration of those ought to be included in future research.

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Conflict of interest:

The author does not have any conflict of interest arising from this study.

What this Study adds:

This study demonstrates that the likelihood of Cerebral Palsy can be predicted by the age and IQ of children with ID. Family history of intellectual disabilities and epilepsy are also strong predictors of CP among children with intellectual disabilities.

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