# Motor Severity in Children With Cerebral Palsy Studied in a High-Resource and Low-Resource Country

**WHAT'S KNOWN ON THIS SUBJECT:** There is variability in cerebral palsy prevalence estimates in low-resource countries, related to definitions, detection of milder cases, diagnosis age, and adequate training for clinicians. Thus, differences in prevalence and motor patterns between high- and low-resource countries remain unclear.

**WHAT THIS STUDY ADDS:** There were more children with dystonia and less with spasticity in Bangladesh compared with Australia (cerebral palsy diagnosis/motor classifications were consistent between settings). Differences in motor patterns between high- and low-resource countries have profound implications for early detection and appropriate interventions.


## abstract

**OBJECTIVES:** To compare the patterns of motor type and gross motor functional severity in preschool-aged children with cerebral palsy (CP) in Bangladesh and Australia.

**METHODS:** We used comparison of 2 prospective studies. A total of 300 children with CP were aged 18 to 36 months, 219 Australian children (mean age, 26.6 months; 141 males) recruited through tertiary and community services, and 81 clinic-attendees born in Bangladesh (mean age, 27.5 months; 50 males). All children had diagnosis confirmed by an Australian physician, and birth and developmental history collected on the Physician Checklist. All children were classified by the same raters between countries using the Gross Motor Function Classification System (GMFCS), and motor type and distribution.

**RESULTS:** There were more children from GMFCS I–II in the Australian sample (GMFCS I, $P < .01$; III, $P < .01$; V, $P = .03$). The patterns of motor type also differed significantly with more spasticity and less dyskinetic types in the Australian sample (spasticity, $P < .01$; dystonia, $P < .01$; athetosis, $P < .01$). Birth risk factors were more common in the Bangladesh sample, with risk factors of low Apgar scores (Australia, $P < .01$), lethargy/seizures (Australia, $P = .01$), and term birth (Bangladesh, $P = .03$) associated with poorer gross motor function. Cognitive impairments were significantly more common in the Bangladesh children ($P < .01$), and visual impairments more common in Australia ($P < .01$).

**CONCLUSIONS:** Patterns of functional severity, motor type, comorbidities, etiology, and environmental risk factors differed markedly between settings. Our results contribute to understanding the patterns of CP in low-resource settings, and may assist in optimizing service delivery and prioritizing appropriate early interventions for children with CP in these settings. *Pediatrics* 2014;134:e1594–e1602



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**KEY WORDS**

gross motor severity, motor type, cerebral palsy, high-resource country, low-resource country


**ABBREVIATIONS**

CP—cerebral palsy
CRP—Centre for the Rehabilitation of the Paralysed
GMFCS—Gross Motor Function Classification System
OR—odds ratio

Ms Benfer designed the modifications to the Australian study for the Bangladesh context, collected the primary data in country, analyzed and interpreted the data, and drafted the manuscript; Ms Jordan completed the gross motor ratings, analyzed and interpreted the data, and drafted the manuscript; Dr Bandaranayake assisted in the modification of the protocol to the Bangladesh context, confirmed children's diagnosis and motor type, interpreted the data, and provided critical review of the manuscript; Ms Finn completed the gross motor ratings, interpreted the data, and provided critical review of the manuscript; Dr Ware advised on statistical design of the studies and the statistical analysis of the manuscript and provided critical review of the manuscript; Prof Boyd conceptualized the Australian study, assisted in the modification of the protocol to the Bangladesh context, secured funding for the Australian study, assisted in the interpretation of data, provided editorial support for the drafting of the manuscript, and provided study supervision; and all authors approved the final manuscript as submitted. All authors agree to be accountable for all aspects of the work to ensure its accuracy and integrity.


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Cerebral palsy (CP) is the most commonly occurring childhood physical disability,[1] with an overwhelming majority of its global burden in low-resource countries.[2] It has been estimated that 80% of the global prevalence of CP is in low-resource countries, having larger populations and potentially greater incidence rates.[2,3] Children who have a disability and their families living in low-resource countries are among the most disadvantaged in their community, with a bidirectional link between disability and poverty.[2] Bangladesh is a small but densely populated country in the Indian subcontinent (~150 million people, 150 000 $km^2$ land area). Almost a third live in extreme poverty (GDP per capita = US$ 752)[4] and ~45% of children aged <5 years have chronic malnutrition.[5] Australia, in direct contrast, is a large but sparsely populated country (22 million people, land mass of 7.7 million $km^2$)[6] and a major global economy (GDP per capita = US$ 67 442).[4,7]

Over the past decade, there have been a number of efforts to standardize the diagnosis of CP and motor type classification among western high-resource countries.[8–10] The prevalence of CP from various high-resource countries has been estimated at 2.0/1000 live births, and this has remained relatively stable throughout recent decades despite advances in medical practices.[11] Spasticity is typically cited as the predominant motor type, occurring in 77% to 93% of CP cases identified by a recent review, dyskinesia in 2% to 15%, and ataxia in 2% to 8%.[11] Of the 86.5% of individuals classified with spasticity in the Australian CP Register Report, 38.8% had hemiplegia, 37.5% diplegia, and 23.7% tri/quadriplegia.[12]

In low-resource countries there continues to be large variability in prevalence estimates, related to CP definitions, ability to detect milder cases, age at diagnosis (with CP prevalence influenced by survival rates), and adequate training for health staff.[3] Three population-based studies in low-resource countries have estimated prevalence as low as 1.6/1000 in urban China,[13] 2.8/1000 in India (4.4/1000 in children aged <4 years),[14] and as high as 4.0/1000 in Bangladesh (29.0/1000 in Dhaka district).[15] Studies of clinic attendees in these settings have reported high rates of spasticity similar to that in high-resource countries, from 70% to 90%.[14,16–20] Studies have tended to identify higher rates of quadriplegia than those reported in the west (60% to 86%),[16,17,20] although the only population-based study found a high rate of spastic diplegia (72.9%).[14]

Differences in prevalence and motor patterns between high- and low-resource countries reported in the literature remain unclear; however, the etiology has been reported to differ markedly. Owing to improved medical care in high-resource countries, it is now thought that birth asphyxia accounts for only 6% to 8% of CP cases,[1] with an increased proportion of preterm births (45%).[12] In low-resource countries there is poor survival of preterm infants, and home deliveries by unskilled birth attendants continue to dominate.[17] Birth asphyxia and low birth weight are reported as the prevailing causes of CP in low-resource countries,[16,17] along with kernicterus and postnatal causes such as meningitis and cerebral malaria.[3,14]

The motor outcomes of children in high-resource countries have been well described based on their level of gross motor function (Gross Motor Function Classification System [GMFCS]). Motor outcomes are impacted by a wide array of factors, including intrinsic child characteristics, family dynamics and functioning, and availability, access, and options for interventions.[21] Despite these many influences, gross motor functional development in western children who have CP has been shown to follow predictable patterns (along motor curves) based on the child's overall motor severity.[22] Less is known about the role of these environmental factors on motor outcomes in low-resource settings, where children may be in poverty, with less family knowledge and fewer resources to support their child's development, cultural differences in parental interaction style, and lower/delayed access to health services.[21,23]

Owing to these differences in neonatal risk factors and environmental influences between high- and low-resource countries, the severity and motor patterns of children who have CP in these 2 contexts is thought to differ. This study is the first to our knowledge to explore 2 cohorts of children who have CP in high- and low-resource settings using the same diagnostic and classification methods for each. It also aims to document differences in motor outcomes between settings with reference to gross motor function and motor type. This study will enhance our understanding of risk factors for CP and associated motor outcomes as well as contributing information to understand primary prevention priorities, and providing health ministries with data to plan optimal services.

## METHODS

This article compares 2 cross-sectional prospective studies of children who have CP aged 18 to 36 months. The first sample is a cohort of children born in Queensland, Australia, and the second is a sample of clinic attendees residing in Bangladesh. The Australian data represent a subset of children from 2 larger longitudinal studies, Queensland CP Child Motor and Brain Development (National Health and Medical Research Council 465128)[24] and Queensland CP child: Growth, Nutrition and Physical Activity (National Health and Medical Research Council 569605).[25] It includes only initial assessments of children aged 18 to 36 months seen between January 1, 2009 and March 31, 2013.

## Patients

Participants in Queensland were referred to the study through a range of settings from parent referral to community and tertiary care. All children who had a confirmed diagnosis of CP,[9] aged 18 to 36 months corrected age at initial assessment, and born in Queensland between 2006 and 2009, were invited to participate. Children who had neurodegenerative conditions were excluded.[24,25]

The Bangladesh sample was recruited through a national rehabilitation center in Bangladesh, the Centre for the Rehabilitation of the Paralysed (CRP). The center provides services to children who have CP residing in all regions of Bangladesh as outpatients, or through a 2-week inpatient program. The inpatient program provides parent education and training, as well as individual and group therapy. Admission is not associated with illness or medical intervention. All children aged 18 to 36 months who had a confirmed diagnosis of CP attending the center from August to December 2013 were invited to participate. Children who attended as inpatients were prioritized to enable a battery of measurements to be completed (for the larger study).

## Procedures

For the Australian cohort, children attended the hospital for a diagnostic appointment with a pediatrician or child neurologist. During this appointment, diagnosis was confirmed based on published guidelines, and a detailed clinical history was taken. Children's motor type/distribution and GMFCS level were classified by 2 independent clinicians (pediatric rehabilitation physician, and an experienced physiotherapist).

In Bangladesh, children attended an initial diagnostic appointment with the primary investigator (KB) and a local pediatric physician, who collected the clinical history from the mother (in Bengali) and provided a preliminary diagnosis of CP. The written case history and a short video of the child performing functional motor tasks (including lying, rolling, sitting, standing, walking, and transitions between these) were sent to the Australian research team to provide an independent and consistent confirmation of CP diagnosis, motor type/distribution, and GMFCS.

## Measures

The child's clinical history was collected by using the Physician Checklist (Supplemental Information A). This was administered by physicians to parents using open-ended questions to gather information on the child's clinical presentation, birth history, comorbidities, and development. This checklist was developed in 2003 for the Australian CP Child Study,[24] and was intended as a standardized physician checklist for gathering clinical history, rather than an exhaustive list of causes. Physicians made a judgment from the clinical history regarding factors potentially associated with a diagnosis of CP. Minor modifications were made to this checklist for Bangladesh (Supplemental Information B), which was translated from English into Bengali, and back-translated to confirm accuracy. Gestational age (time between the first day of the last menstrual period and child's date of birth) was recorded, and classified as term (>37 completed weeks of gestation), preterm (32 to <37 weeks), very preterm birth (28 to <32 weeks), and extremely preterm (<28 weeks).[26] The presence of comorbidities was collected from the parent in both contexts, however, using the standardized questions of the *10 Question Screen* in Bangladesh.[27] The socioeconomic status of Australian families was classified into tertiles using scores on the Socioeconomic Indexes for Areas Index of Relative Disadvantage.[28] The Poverty-Measurement Tool was used to classify the Bangladesh sample into 5 levels from well-off to poor, and has been validated in rural Bangladesh against an asset index and other traditional poverty measures.[29] The presumed timing (judged by physicians) of the complicating event was classified as antenatal, intrapartum, postpartum, or post-neonatal, or a combination of these (as reflected in Supplemental Information A). Five-minute Apgar scores <7 or a delayed cry >5 min after birth (in the absence of Apgars) were documented as a marker of neurologic depression.[17,30] Parents were also asked to report sitting and standing ability, and the age of acquisition of these skills.

Motor type/distribution were classified according to the Surveillance of Cerebral Palsy in Europe guidelines as spasticity (unilateral or bilateral), ataxia, dystonia, athetosis, or hypotonia.[10] The GMFCS classifies children into 5 levels, with the <2-year-old and 2- to 4-year-old scales used in the current study.[31]

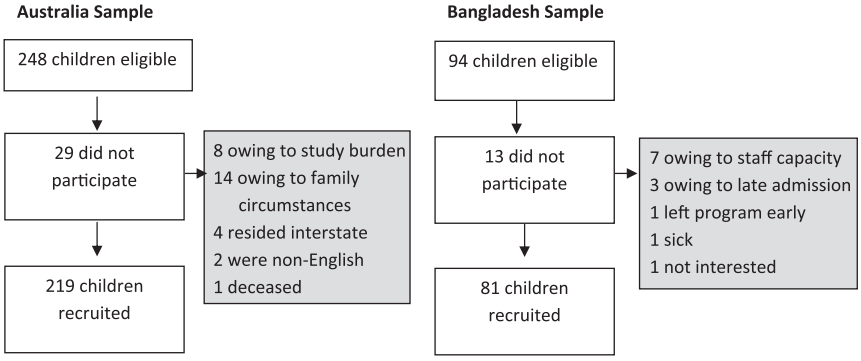


**FIGURE 1**
Recruitment pathways for Australia and Bangladesh samples.

## Ethics

All families gave written informed consent to participate. The Australian study was approved by the Children's Health Services (Royal Children's Hospital Herston HREC07/QRCH/107), Southern Health Ethics (05077C), University of Queensland (2007001784), Cerebral Palsy League of Queensland (CPLQ2008/2009-1010), and Mater Health Services (1186C). Ethics for the Bangladesh Study were gained through the University of Queensland Medical Research Ethics Committee (2013000625), the Children's Health Services District Ethics Committee (HREC/13/QRCH/69), Centre for the Rehabilitation of the Paralyzed Ethics Committee (CRP/RE/0401/55), and the International Centre for Diarrheal Disease Research Bangladesh, Ethics Committee (PR-13047).

**TABLE 1** Characteristics of Australian and Bangladesh Samples of Preschool-Aged Children Who Have CP

| Sample Characteristic | Australia *n* (%) | Bangladesh *n* (%) | Crude OR (CI); *P* value (Bd base) | Adjusted OR (CI); *P* value |
|---|---|---|---|---|
| Gender | | | 0.9 (0.5–1.5); .73 | 1.0 (0.6–1.7); .90 |
| Male | 140 (63.9) | 50 (61.7) | | |
| Female | 79 (36.1) | 31 (38.3) | | |
| Preterm or term birth | | | | |
| Extremely preterm | 22 (10.0) | 0 (0.0) | 17.7 (2.1 to infinity); <.01[a] | NC |
| Very preterm | 37 (16.9) | 3 (3.9) | 5.0 (1.5–16.7); .01 | 5.2 (1.5–18.0); .01 |
| Preterm | 35 (16.0) | 15 (19.5) | 0.8 (0.4–1.5); .48 | 0.6 (0.3–1.3); .22 |
| Term | 125 (57.1) | 59 (76.6) | 0.4 (0.2–0.7); <.01 | 0.5 (0.2–0.8); .01 |
| Unknown | 0 (0.0) | 4 (4.9) | | |
| Motor type | | | | |
| Spasticity | 192 (87.7) | 50 (61.7) | 4.4 (2.4–8.1); <.01 | 3.2 (1.7–6.0); <.01[b] |
| Unilateral | 71 (32.4) | 5 (6.2) | 7.3 (2.8–18.8); <.01 | 3.5 (1.2–10.4); .03[c] |
| Bilateral (2 limbs) | 49 (22.4) | 21 (25.9) | 0.8 (0.5–1.5); .52 | 0.4 (0.2–0.8); .01[d] |
| Bilateral (3 to 4 limbs) | 72 (32.9) | 24 (29.6) | 1.2 (0.7–2.0); .59 | 2.8 (1.4–5.7); <.01 |
| Dystonia | 6 (2.7) | 15 (18.5) | 0.1 (0.1–0.3); <.01 | 0.2 (0.1–0.5); <.01[e] |
| Athetosis | 3 (1.4) | 7 (8.6) | 0.2 (0.0–0.6); .01 | 0.2 (0.1–0.8); .03 |
| Ataxia/hypotonia | 18 (8.2) | 9 (11.1) | 0.7 (0.3–1.7); .44 | 0.8 (0.3–2.0); .62 |
| GMFCS | | | | |
| I | 88 (40.2) | 7 (8.6) | 7.1 (3.1–16.0); <.01 | 7.7 (3.3–17.8); <.01[f] |
| II | 37 (16.9) | 12 (14.8) | 1.2 (0.6–2.6); .70 | 1.1 (0.5–2.3); .81[f] |
| III | 30 (13.7) | 25 (30.9) | 0.4 (0.2–0.7); <.01 | 0.3 (0.2–0.6); <.01 |
| IV | 28 (12.8) | 14 (17.3) | 0.7 (0.4–1.4); .31 | 0.7 (0.3–1.4); .30 |
| V | 36 (16.4) | 23 (28.4) | 0.5 (0.3–0.9); .02 | 0.5 (0.3–0.9); .03 |
| Comorbidities | | | | |
| Epilepsy | 51 (23.4) | 38 (46.9) | 0.3 (0.2–0.6); <.01 | 0.7 (0.4–1.2); .12[g] |
| Vision | 75 (34.2) | 22 (27.2) | 1.4 (0.8–2.5); .25 | 2.6 (1.4–5.1); <.01[h] |
| Hearing | 16 (7.3) | 2 (2.5) | 3.1 (0.7–13.9); .14 | 4.4 (1.0–20.4); .06[i] |
| Speech | 91 (41.6) | 51 (63.0) | 0.4 (0.3–0.7); <.01 | 0.6 (0.3–1.0); .06[j] |
| Cognitive | 67 (30.6) | 70 (82.7) | 0.1 (0.1–0.2); <.01 | 0.1 (0.1–0.2); <.01[k] |
| Poverty status | | | | |
| Well-off | | 25 (31.6) | | |
| Moderately well-off | | 27 (34.2) | | |
| Not so well-off | | 15 (19.0) | | |
| Poor | | 7 (8.9) | | |
| Very poor | | 5 (6.3) | | |
| Unknown | | 2 (2.5) | | |
| Socioeconomic status | | | | |
| Least disadvantaged | 73 (33.3) | | | |
| Middle tertile | 54 (24.7) | | | |
| Most disadvantaged | 92 (42.0) | | | |

Adjusted OR models include covariates of GMFCS, age, gender, and preterm status, except when that variable is the main explanatory variable. Bd base, Bangladesh comparison group; CI, confidence interval; NA, not applicable to the context, therefore ORs not calculated; NC, not calculable, as no children in Bangladesh were extremely preterm.

[a] Calculated using episheet, Fisher's exact test.

[b] GMFCS significant (OR, 0.7, $P < .01$).

[c] Age (OR, 0.9, $P = .12$), GMFCS (OR, 0.3, $P < .01$), and preterm status (OR, 0.4, $P < .01$) significant.

[d] GMFCS (OR, 0.6, $P < .01$) and preterm status (OR, 3.1, $P < .01$) significant.

[e] GMFCS significant (OR, 2.6, $P < .01$).

[f] Age significantly related to GMFCS I (OR, 1.1, $P < .01$), GMFCS II (OR, 1.0, $P = .05$).

[g] GMFCS (OR, 2.0, $P < .01$) and preterm status (OR, 0.5, $P = .05$) significant.

[h] GMFCS significant (OR, 1.9, $P < .01$).

[i] GMFCS significant (OR, 1.7, $P < .01$).

[j] GMFCS (OR, 1.3, $P < .01$) and preterm status (OR, 0.6, $P = .02$) significant.

[k] Preterm status significant (OR, 0.5, $P = .03$).

## Statistical Analysis

Data analyses were performed using Stata 10.0 (Stata Corp, College Station, TX; 2007), with significance at $P < .05$. Sample characteristics were presented descriptively. Differences between countries were compared by using logistic regression (odds ratios [ORs]) for binary outcomes and linear regression for continuous outcomes, using Bangladesh as the comparison group. Presence/absence of each motor type, GMFCS level, and extent of preterm birth were explored by using binomial regression. To account for differences in sample characteristics between Australia and Bangladesh, ORs were adjusted for age, gender, GMFCS level, and preterm status (except when that variable was the main explanatory variable) for the demographics; and age, gender, and GMFCS level for models exploring birth and environmental risk factors and motor outcomes. Multinominal logistic regression analysis was used to explore associations between etiologies and the outcomes of GMFCS and motor type.

## RESULTS

A total of 342 children were referred to the studies, of which 300 participated, 219 in the Australian sample and 81 in the Bangladesh sample (recruitment pathways are shown in Fig 1). Children's ages ranged from 17 to 37 months, with equivalent mean ages between samples (Australia, 26.6 months, SD, 6.5; Bangladesh, 27.5 months, SD, 6.1; $P = .25$). The Australian sample was representative of a population-based sample with regards to gender ($P = .06$), GMFCS ($P = .09$), and motor type ($P = .53$).[12] There were significant differences in participant characteristics between Australia and Bangladesh, as shown in Table 1. Children from GMFCS III–V who had bilateral involvement had significantly higher odds of having visual impairment compared with children in GMFCS I–II who had unilateral/3-limb involvement in Australia (OR, 7.7, $P < .01$), but not Bangladesh (OR, 0.8, $P = .84$). The poverty status of the Bangladesh sample was not associated with GMFCS ($P = .92$) or motor type ($P = .58$).

The prevalence of birth risk factors (according to presumed timing) is presented in Table 2. Home births were more common in Bangladesh, occurring in 37 deliveries (45.6%), compared with only 4 (1.8%) in Australia. The majority of home births in Bangladesh (73.0%) were by an unskilled birth attendant, a further 21.6% by a nurse, and 5.4% by a family member. The influence of birth complications on motor severity and motor type is shown in Table 3.

Children's motor outcomes and associated environmental factors are shown in Table 4. On average, children from Bangladesh were diagnosed at age 27.5 months, despite mothers reporting concerns from age 8.8 months. Of the 23.5% of Bangladeshi children who had previous access to physiotherapy, all of their treatment was limited to passive stretching. In contrast, 92.2% of Australian children had previous access to physiotherapy, which used motor learning, functional therapy, neurodevelopmental therapy, postural management approaches, or a combination of these. Children from Bangladesh spent on average 71% of their day in passive positions (lying, sitting on mother's lap, being carried), and the amount of passive time was greater for children who had poorer gross motor function (GMFCS I–II, 46.1%; III, 52.0%; IV–V, 94.7%; r = 0.8, $P < .01$).

## DISCUSSION

The patterns of functional gross motor severity, motor type, comorbidities, birth, and environmental risk factors all differed markedly between the high- and low-resource settings. Our Australian cohort is consistent with previous published data in high-resource countries, where mild CP (GMFCS I–II) constitutes 50% to 60% of any given population.[32] This pattern was skewed in the opposite direction in our Bangladesh sample, with only 23% of

**TABLE 2** Prevalence of Birth Risk Factors for Australian and Bangladesh Samples of Preschool-Aged Children Who Have CP

| | Australia *n* (%) | Bangladesh *n* (%) | Crude OR (CI); *P* value (Bd base) | Adjusted OR (CI); *P* value |
|---|---|---|---|---|
| Home delivery | 4 (1.8) | 37 (45.7) | 0.02 (0.01–0.07); <.01 | 0.02 (0.0–0.07); <.01 |
| Antenatal (only) | 42 (19.2) | 1 (1.2) | 19.0 (2.6–140.3); <.01 | 19.5 (2.6–146.2); <.01 |
| Intrapartum (only)[a] | 34 (15.5) | 3 (3.7) | 4.8 (1.4–16.0); .01 | 5.5 (1.6–18.8); <.01 |
| Postpartum (only) | 9 (4.1) | 49 (60.5) | 0.03 (0.01–0.06); <.01 | 0.03 (0.01–0.06); <.01 |
| Apgar <7/delayed cry | 31 (14.1) | 62 (76.5) | 0.1 (0.0–0.1); <.01 | 0.1 (0.0–0.1); <.01[b] |
| Neonatal jaundice | 7 (3.2) | 19 (23.8) | 0.1 (0.0–0.3); <.01 | 0.1 (0.0–0.3); <.01 |
| Lethargy/seizures in 72 h | 48 (26.7) | 32 (41.6) | 0.5 (0.3–0.9); .02 | 0.5 (0.3–0.9); .02 |
| Antenatal plus intrapartum | 47 (21.5) | 2 (2.5) | 10.8 (2.6–45.6); <.01 | 8.7 (2.0–37.4); <.01 |
| Intrapartum plus postpartum | 17 (7.8) | 18 (8.2) | 0.3 (0.1–0.6); <.01 | 0.3 (0.1–0.7); <.01 |
| Antenatal plus postpartum | 11 (5.0) | 3 (3.7) | 1.4 (0.4–5.1); .63 | 1.6 (0.4–6.1); .50 |
| Antenatal, intrapartum, and postpartum complications | 21 (9.6) | 2 (2.5) | 4.2 (1.0–18.3); .06 | 4.9 (1.1–21.8); .04 |
| Hospital admission | 123 (55.9) | 51 (86.4) | 0.2 (0.1–0.4); <.01 | 0.2 (0.1–0.4); <.01 |
| Post-neonatal complications | 20 (9.1) | 6 (7.4) | 1.3 (0.5–3.2); .65 | 1.1 (0.4–2.9); .86 |

Adjusted OR models include covariates of age, gender, GMFCS. Bd base, Bangladesh comparison group.

[a] Includes preterm birth.

[b] GMFCS (OR, 1.3, $P = .05$) and age (OR, 0.9, $P = .02$) significantly related on logistic regression.

**TABLE 3** Association Between Birth Risk Factors and Outcomes of Motor Severity and Motor Type in Preschool-Aged Children Who Have CP in Australia and Bangladesh

| Birth Risk Factors | Australia OR (CI); *P* value I–II, *n* = 125; III, *n* = 30; IV–V, *n* = 64 | Bangladesh OR (CI); *P* value I–II, *n* = 19; III, *n* = 25; IV–V, *n* = 37 |
|---|---|---|
| Association with motor severity | | |
| Home delivery: GMFCS I–II (base) | Reference | Reference |
| III | NC[a] | 1.0 (0.3–3.4); .97 |
| IV–V | 8.1 (0.9–73.7); .06 | 0.9 (0.3–2.6); .77 |
| Antenatal: GMFCS I–II (base) | Reference | Reference |
| III | 1.5 (0.7–3.5); .30 | 1.2 (0.2–7.7); .88 |
| IV–V | 1.2 (0.7–2.2); .59 | 0.8 (0.1–4.9); .76 |
| Intrapartum: GMFCS I–II (base) | Reference | Reference |
| III | 1.6 (0.7–3.6); .27 | 1.0 (0.3–3.7); .98 |
| IV–V | 1.2 (0.6–2.1); .66 | 0.9 (0.3–3.0); .89 |
| Preterm: GMFCS I–II (base) | Reference | Reference |
| III | 1.7 (0.8–3.8); .19 | 0.4 (0.1–1.6); .19 |
| IV–V | 0.8 (0.4–1.4); .41 | 0.2 (0.1–0.9); .03 |
| Postpartum: GMFCS I–II (base) | Reference | Reference |
| III | 3.1 (1.3–7.1); .01 | 2.8 (0.2–33.7); .41 |
| IV–V | 1.5 (0.9–3.5); .10 | 0.6 (0.1–3.3); .57 |
| Apgar <7/delayed cry: GMFCS I–II (base) | Reference | Reference |
| III | 3.4 (1.0–11.5); .05 | 0.6 (0.1–3.8); .60 |
| IV–V | 7.5 (3.0–18.9); <.01 | 0.2 (0.0–1.1); .06 |
| Neonatal jaundice: GMFCS I–II (base) | Reference | Reference |
| III | 2.9 (0.5–18.2); .26 | 0.5 (0.1–2.2); .35 |
| IV–V | 1.3 (0.2–8.2); .76 | 1.0 (0.3–3.4); .95 |
| Lethargy/seizures in 72 h: GMFCS I–II (base) | Reference | Reference |
| III | 1.0 (0.3–2.9); .97 | 1.0 (0.3–3.6); .97 |
| IV–V | 2.5 (1.2–5.2); .01 | 1.7 (0.5–5.7); .36 |
| Hospital admission: GMFCS I–II (base) | Reference | NC[a] |
| III | 1.9 (0.8–4.4); .13 | |
| IV–V | 1.5 (0.8–2.8); .18 | |
| Postneonatal complications: GMFCS I–II (base) | Reference | NC[a] |
| III | 0.7 (0.2–3.5); .71 | |
| IV–V | 1.3 (0.5–3.4); .66 | |
| Association with motor type | | |
| Home delivery: spasticity (base) | Reference | Reference |
| Dyskinetic | 11.9 (1.0–145.0); .05 | 1.4 (0.5–3.8); .53 |
| Ataxia/hypotonic | 11.9 (1.6–90.0); .02 | 1.7 (0.4–7.2); .45 |
| Antenatal: spasticity (base) | Reference | Reference |
| Dyskinetic | 1.8 (0.4–7.3); .43 | 0.9 (0.2–5.0); .91 |
| Ataxia/hypotonic | 2.5 (0.9–7.1); .09 | 1.1 (0.1–10.9); .92 |
| Intrapartum: spasticity (base) | Reference | Reference |
| Dyskinetic | 1.7 (0.4–7.1); .45 | 1.0 (0.3–3.0); .95 |
| Ataxia/hypotonic | 1.2 (0.5–3.1); .72 | 3.2 (0.8–13.7); .12 |
| Preterm: spasticity (base) | Reference | Reference |
| Dyskinetic | 0.4 (0.1–1.8); .22 | 0.3 (0.1–1.1); .71 |
| Ataxia/hypotonic | 1.2 (0.5–3.0); .76 | NC[b] |
| Postpartum: spasticity (base) | Reference | Reference |
| Dyskinetic | 1.5 (0.4–6.2); .58 | NC[b] |
| Ataxia/hypotonic | 1.8 (0.7–4.7); .27 | 0.3 (0.1–1.4); .12 |
| Apgar <7/delayed cry: spasticity (base) | Reference | Reference |
| Dyskinetic | 3.2 (0.8–13.6); .12 | 0.7 (0.2–2.1); .50 |
| Ataxia/hypotonic | 1.2 (0.3–4.4); .79 | 0.5 (0.1–2.3); .38 |
| Neonatal jaundice: spasticity (base) | Reference | Reference |
| Dyskinetic | NC[b] | 1.2 (0.4–3.6); .80 |
| Ataxia/hypotonic | 1.9 (0.2–17.1); .55 | 0.4 (0.0–3.4); .39 |
| Lethargy/seizures in 72 h: spasticity (base) | Reference | Reference |
| Dyskinetic | 4.1 (0.9–19.3); .07 | 1.0 (0.4–2.9); .97 |
| Ataxia/hypotonic | 1.9 (0.6–6.3); .27 | 1.5 (0.3–6.6); .61 |
| Hospital admission: spasticity (base) | Reference | Reference |
| Dyskinetic | 0.6 (0.2–2.3); .45 | 2.6 (0.3–23.1); .41 |
| Ataxia/hypotonic | 0.8 (0.3–2.1); .70 | 0.7 (0.1–7.7); .79 |

children functioning at GMFCS I–II. Although spasticity was the dominant motor type in the Bangladesh sample, it was a lower proportion than that reported in previous studies in low-resource countries,[17] and significantly lower than the rates identified in our Australian sample. There was a significantly greater number of term births in Bangladesh, consistent with other studies from low-resource settings,[14,17,20] which would be expected in settings with poorer survival of children born preterm.[3] One explanation for the differences in motor severity and type could relate to our use of consistent raters and definitions across both settings, which gives greater certainty when comparing data. Furthermore, in a recent meta-analysis, spasticity was found to be significantly lower (~14%) in term-born children who had CP compared with those born preterm.[32] Higher rates of term births with asphyxia, severe jaundice, and post-neonatal complications have also been associated with quadriplegia and dystonia.[3] Low Apgar/delayed cry, lethargy/seizures, and term birth were all associated with poorer gross motor function in our study.

Epilepsy and speech and cognitive impairments were more common in the Bangladesh cohort, and visual and hearing impairments in the Australian cohort. Only visual and cognitive impairments were different once differences in GMFCS and preterm status between samples were accounted for, which were influencing the relationship. These patterns could reflect the sensitivity of the 10-Question Screen used in the Bangladesh sample, which has strong sensitivity to detect motor, cognitive, and seizure disorders, but lower sensitivity for vision and hearing.[27] This is particularly significant as universal screening of vision/hearing does not occur in Bangladesh.[27,33] The prevalence of epilepsy and speech impairments in our Bangladesh sample were comparable

**TABLE 3** Continued

| Birth Risk Factors | Australia OR (CI); *P* value I–II, *n* = 125; III, *n* = 30; IV–V, *n* = 64 | Bangladesh OR (CI); *P* value I–II, *n* = 19; III, *n* = 25; IV–V, *n* = 37 |
|---|---|---|
| Post-neonatal complications: spasticity (base) | Reference | Reference |
| Dyskinetic | 1.3 (0.2–10.9); .82 | 0.8 (0.1–7.6); .81 |
| Ataxia/hypotonic | 1.2 (0.3–5.7); .81 | 4.5 (0.6–31.7); .13 |

[a] 0 value in base group, therefore not calculable.

[b] No children from outcome group had exposure of interest, therefore not calculable.

to previous work in a similar sample from Bangladesh; however, our estimates for visual and cognitive impairments were much higher, and lower for hearing impairments.[34] In the Australian sample, the presence of epilepsy and visual and hearing impairments was comparable to that reported in our national register report, with speech and cognitive impairments somewhat lower, perhaps owing to the younger age of our sample.[12]

Conducting research in a setting with low resources has unique challenges, particularly when aiming to provide a direct comparison with a high-resource setting. The most significant limitation to this study was the recruitment

**TABLE 4** Prevalence of Environmental Factors and Motor Outcomes in the Australian and Bangladesh Samples of Preschool-Aged Children Who Have CP

| | Australia | Bangladesh | Crude OR or $\beta$ (CI); *P* value (Bd base) | Adjusted OR or $\beta$ (CI); *P* value |
|---|---|---|---|---|
| Mean age of first concern, mo | NA | 8.8 | NA | NA |
| I–II | | 12.7 | | |
| III | | 8.8 | | |
| IV–V | | 6.8 | | |
| Mean age of diagnosis, mo | 13.3 | 27.5 | −14.2 (−16.4 to 12.0); <.01 | −14.6 (−16.6 to −12.6); <.01[a] |
| I–II | 14.5 | 26.4 | | |
| III | 14.8 | 30.6 | | |
| IV–V | 9.6 | 26.0 | | |
| Prior contact with physiotherapy, % | 92.2 | 24.1 | 37.5 (18.4 to 76.7); <.01 | 102.7 (33.9 to 310.6); <.01[b] |
| I–II | 88.8 | 5.6 | | |
| III | 93.3 | 28.0 | | |
| IV–V | 98.4 | 30.6 | | |
| Equipment: chair, % | 34.2 | 6.2 | 7.9 (3.1 to 20.4); <.01 | 22.7 (7.8 to 65.8); <.01[c] |
| I–II | 9.6 | 5.3 | | |
| III | 46.7 | 8.0 | | |
| IV–V | 76.6 | 5.4 | | |
| Equipment: mobility, % | 17.8 | 1.2 | 17.3 (2.3 to 127.7); <.01 | 17.0 (2.3 to 128.4); <.01[d] |
| I–II | 12.0 | 0.0 | | |
| III | 46.7 | 4.0 | | |
| IV–V | 15.6 | 0.0 | | |
| Able to sit, % | 55.9 | 48.1 | 1.4 (0.8 to 2.3); .22 | 0.8 (0.4 to 1.5); .45[e] |
| I–II | 69.8 | 84.2 | | |
| III | 60.0 | 80.0 | | |
| IV–V | 26.6 | 8.1 | | |
| Mean age of sitting, mo | 12.5 | 14.9 | −2.4 (−4.8 to −0.0); .05 | −1.3 (−3.4 to 0.9); .24[f] |
| I–II | 10.3 | 12.4 | | |
| III | 17.9 | 17.0 | | |
| IV–V | 18.4 | 14.7 | | |
| Able to walk, % | 35.5 | 8.6 | 5.9 (2.6 to 13.3); <.01 | 3.5 (1.3 to 9.1); .01[g] |
| I–II | 58.7 | 36.8 | | |
| III | 6.7 | 0.0 | | |
| IV–V | 3.1 | 0.0 | | |
| Mean age of walking, mo | 22.5 | 20.9 | 1.6 (−9.3 to 12.4); .77 | −1.1 (−7.1 to 4.9); .70[h] |
| I–II | 20.1 | 20.9 | | |
| III | 33.5 | NA | | |
| IV–V | NA[i] | NA | | |

Adjusted ORs include covariates of age, gender, and GMFCS (collapsed). Bd base, Bangladesh comparison group.

[a] Age ($\beta$ = 0.7, $P < .01$) and GMFCS ($\beta$ = −1.4, $P = .01$) significant.

[b] Age (OR = 0.9, $P = .01$), GMFCS (OR = 2.5, $P < .01$), and preterm status (OR = 2.8, $P = .02$) significant.

[c] GMFCS (OR = 5.2, $P < .01$) significant.

[d] Preterm status (OR = 3.2, $P < .01$) significant.

[e] GMFCS significant (OR = 0.3, $P < .01$).

[f] GMFCS ($\beta$ = 4.4, $P < .01$) and preterm status ($\beta$ = 2.9, $P < .01$) significant.

[g] GMFCS (OR = 0.1, $P < .01$) and age (OR = 1.1, $P < .01$) significant.

[h] GMFCS significant ($\beta$ = 34.7, $P < .01$).

[i] No age recorded, but parent reported walking ability.

of a sample of clinic attendees in Bangladesh, which may limit generalizability to the population, although by adjusting the models for differences in gross motor function, we were still able to compare between samples. Over 80% of eligible children attending the center in Bangladesh were recruited to our study, with no systematic bias in their selection, although this recruitment rate was low compared with national prevalence rates. The sample was skewed toward rural families (being the predominant group accessing inpatient services at the center), and included more moderately well-off and well-off families than would be expected for the country.[29] Admission as an inpatient at CRP is not associated with illness or medical interventions, and as such is unlikely to skew the sample. There was no association between the poverty status of the Bangladesh sample and motor severity/type, which suggests economic factors were not biasing the motor patterns of those attending for services. Use of parent report for gathering much of the birth history may be biased by recall in both settings. This could be confounded further in Bangladesh, where a greater number of births are unregistered and occur at home.

## CONCLUSIONS

This comparative study has implications for understanding the motor severity and patterns associated with CP. Differences in children's environment, both physical and opportunities provided in the home, may have an effect on children's motor outcomes and GMFCS level. Significantly fewer children from Bangladesh GMFCS IV–V were able to sit, and from GMFCS III able to walk, which may be reflected in their lower access to therapy and supportive equipment, as well as a large amount of time spent in passive activities. This raises questions regarding whether these children "catch up" to children of a similar level from Australia, or whether their poorer gross motor function is likely to persist. Studies using the Gross Motor Function Measure to assess specific gross motor tasks, and longitudinal studies to determine change across time, would help in understanding the applicability of motor curves and whether the prognostic aspect of the GMFCS is valid in this different cultural and economic setting.

This study provides useful information to assist with global perspectives on CP management. The high rates of term-born children who have CP in Bangladesh suggest scope for improved primary prevention, particularly through education and support of unskilled birth attendants.[3] The delayed age of diagnosis and access to appropriate treatments in Bangladesh represents an important window of opportunity for secondary prevention through early intervention. The findings from the current study suggest there is likely to be a significant subgroup of term-born children who have dystonia for whom early motor type diagnosis is more challenging. This group may also require access to different treatments, particularly the use of medications and careful consideration of the appropriateness of surgical interventions. Uptake of classification systems such as the GMFCS has been limited in Bangladesh, so improved training of health staff in such classification systems[35] as well as resources to support CP diagnosis and differential diagnosis of motor types would enable fast-tracked screening and appropriate, targeted interventions. Although there are many important factors to prioritize in low-resource countries, initiation of a centralized CP register, initially of clinic attendees, with consistent screening and definitions between centers, may assist in understanding the national picture of the diagnosis, and thereby better targeted management.

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