**Figure 1.** Flow of patients



**Table 1.** Baseline data

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|

| Characteristic | Overall, N = 3841, 2 | Dyskinetic CP, N = 581 | Hemiparetic CP, N = 521 | Mixed CP, N = 1101 | Spastic Diplegia, N = 701 | Spastic Quadriplegia,N = 921 |
| --- | --- | --- | --- | --- | --- | --- |
| Age, months | 78 (38) | 93 (42) | 72 (41) | 82 (37) | 66 (27) | 77 (41) |
|  Male | 251 (65%) | 50 (86%) | 36 (69%) | 77 (70%) | 30 (43%) | 56 (61%) |
| Gestational age |  |  |  |  |  |  |
| Mean (SD) | 37(4) | 38(3) | 37(4) | 38(2) | 33(3) | 38(3) |
| Term | 231(60%) | 43(74%) | 32(62%) | 81(74%) | 7(10%) | 66(72%) |
| Moderate to late preterm | 97 (25%) | 13 (22%) | 11 (21%) | 25 (23%) | 29 (41%) | 19 (21%) |
| Very preterm | 48 (13%) | 1 (1.7%) | 7 (13%) | 4 (3.6%) | 31 (44%) | 5 (5.4%) |
| Extremely preterm | 8 (2.1%) | 1 (1.7%) | 2 (3.8%) | 0 (0%) | 3 (4.3%) | 2 (2.2%) |
| Mode of delivery |  |  |  |  |  |  |
| Vaginal | 241 (63%) | 36 (62%) | 39 (75%) | 58 (53%) | 49 (70%) | 58 (63%) |
| LSCS | 130 (34%) | 21 (36%) | 13 (25%) | 46 (42%) | 21 (30%) | 28 (30%) |
| Instrumental | 13 (3.4%) | 1 (1.7%) | 0 (0%) | 6 (5.5%) | 0 (0%) | 6 (6.5%) |
| Birth Weight, grams | 2,343 (796) | 2,715 (709) | 2,300 (880) | 2,563 (582) | 1,451 (439) | 2,548 (752) |
| Etiology/ Risk Factors |
| Antenatal factors | 32 | 0 | 10 | 9 | 4 | 7 |
| Genetic | 23 (6.0%) | 0 (0%) | 10 (19%) | 3 (2.7%) | 1 (1.4%) | 7 (7.6%) |
| Intrauterine infections | 9 (2.3%) | 0 (0%) | 0 (0%) | 6 (5.5%) | 3 (4.3%) | 0 (0%) |
| Birth related factors | 320 | 58 | 40 | 82 | 66 | 74 |
| Hypoglycemia | 102 (26.6%) | 0 (0%) | 0 (0%) | 61 (55%) | 0 (0%) | 41 (45%) |
| Perinatal asphyxia | 90 (23.4%) | 35 (60%) | 7 (13%) | 14 (13%) | 7 (10%) | 27 (29%) |
| Prematurity | 81 (21.1%) | 2 (3.4%) | 11 (21%) | 3 (2.7%) | 59 (84%) | 6 (6.5%) |
| Neonatal sepsis | 74 (19.3%) | 7 | 0 | 35 | 10 | 22 |
| Neonatal jaundice | 24 (6.3%) | 21 (36%) | 0 (0%) | 3 (2.7%) | 0 (0%) | 0 (0%) |
| Perinatal stroke | 23 (6.0%) | 0 (0%) | 22 (42%) | 1 (0.9%) | 0 (0%) | 0 (0%) |
| Birth trauma | 17 (4.4%) | 4 (6.9%) | 1 (1.9%) | 2 (1.8%) | 1 (1.4%) | 9 (9.8%) |
| Etiological factors after neonatal period | 26 | 0 | 0 | 17 | 0 | 9 |
| Febrile encephalopathy | 13 (3.9%) | 0 (0%) | 0 (0%) | 10 (9.1%) | 0 (0%) | 3 (5.4%) |
| Surgery related hypoxia | 11 (2.9%) | 0 (0%) | 0 (0%) | 7 (6.4%) | 0 (0%) | 4 (4.3%) |
| Traumatic brain injury/ drowning | 2 | 0 | 0 | 0 | 0 | 2 |
| Unknown | 6 (1.6%) | 0 (0%) | 2 (3.8%) | 2 (1.8%) | 0 (0%) | 2 (2.2%) |

1Mean (SD); n (%) |
| 2Two patients from the cohort could not be classified into any of sub-categories. \* One patient with intrauterine infection also had neonatal sepsis and later developed mixed CPAbbreviations: CP: cerebral palsy; LSCS: lower segment caesarean section;  |

**Table 2.** Prevalence of comorbidities among children with cerebral palsy

| Characteristic | Overall, N = 3841, 2 | Dyskinetic CP, N = 581 | Hemiparetic CP, N = 521 | Mixed CP, N = 1101 | Spastic Diplegia, N = 701 | Spastic Quadriplegia,N = 921 |
| --- | --- | --- | --- | --- | --- | --- |
| **Functional status** |  |  |  |  |  |  |
| GMFCS |  |  |  |  |  |  |
| 1 | 30 (7.8%) | 0 (0%) | 27 (52%) | 0 (0%) | 3 (4.3%) | 0 (0%) |
| 2 | 59 (15%) | 2 (3.4%) | 18 (35%) | 2 (1.8%) | 35 (50%) | 2 (2.2%) |
| 3 | 56 (15%) | 11 (19%) | 2 (3.8%) | 9 (8.2%) | 29 (41%) | 5 (5.4%) |
| 4 | 65 (17%) | 19 (33%) | 5 (9.6%) | 24 (22%) | 3 (4.3%) | 13 (14%) |
| 5 | 174 (45%) | 26 (45%) | 0 (0%) | 75 (68%) | 0 (0%) | 72 (78%) |
| No understanding of any communication | 137 (36%) | 28 (48%) | 1 (1.9%) | 53 (48%) | 9 (13%) |
| Phrases understood | 145 (38%) | 28 (48%) | 4 (7.7%) | 45 (41%) | 28 (40%) |
| Vocabulary understood | 102 (27%) | 2 (3.4%) | 47 (90%) | 12 (11%) | 33 (47%) |
| Speech communication |
| No gestural communication | 178 (46%) | 38 (66%) | 0 (0%) | 73 (66%) | 4 (5.7%) | 62 (67%) |
| Normal verbal communication | 8 (2.1%) | 0 (0%) | 4 (7.7%) | 0 (0%) | 4 (5.7%) | 0 (0%) |
| Only gestural communication | 109 (28%) | 17 (29%) | 8 (15%) | 34 (31%) | 25 (36%) | 24 (26%) |
| Vocabulary produced with partial verbal communication | 89 (23%) | 3 (5.2%) | 40 (77%) | 3 (2.7%) | 37 (53%) | 6 (6.5%) |
| Visual impairment (data for 383) |  |
| Visual Impairment | 357 (93%) | 50 (86%) | 49 (94%) | 99 (90%) | 68 (99%) | 89 (97%) |
| Impaired Visual acuity | 246 (64%) | 29 (50%) | 27 (52%) | 71 (65%) | 52 (74%) | 66 (72%) |
| Refractive error | 94 (25%) | 6 (10%) | 13 (25%) | 37 (34%) | 14 (20%) | 24 (26%) |
| Squint | 150 (39%) | 14 (24%) | 19 (37%) | 45 (41%) | 25 (36%) | 47 (51%) |
| Fundus abnormalities | 293 (76%) | 47 (81%) | 35 (67%) | 79 (72%) | 54 (77%) | 77 (84%) |
| Abnormal VEP | 248 (72%) | 22 (42%) | 18 (44%) | 79 (77%) | 53 (88%) | 74 (86%) |
| Abnormal BERA | 113 (30%) | 36 (62%) | 2 (3.8%) | 35 (32%) | 14 (20%) | 25 (27%) |
| Social Quotient, Mean (SD) | 32 (29) | 20 (21) | 71 (22) | 15 (14) | 59 (24) | 15 (15) |
| Normal | 43 (11%) | 3 (5.2%) | 23 (44%) | 1 (0.9%) | 15 (22%) | 1 (1.1%) |
| Borderline | 10 (2.6%) | 0 (0%) | 5 (9.6%) | 0 (0%) | 5 (7.2%) | 0 (0%) |
| Mild | 41 (11%) | 1 (1.7%) | 11 (21%) | 2 (1.8%) | 24 (35%) | 3 (3.3%) |
| Moderate | 49 (13%) | 10 (17%) | 10 (19%) | 8 (7.3%) | 17 (25%) | 4 (4.3%) |
| Severe | 43 (11%) | 6 (10%) | 3 (5.8%) | 20 (18%) | 3 (4.3%) | 11 (12%) |
| Profound | 198 (51%) | 38 (66%) | 0 (0%) | 79 (72%) | 5 (7.2%) | 73 (79%) |
| Dental caries | 182 (48%) | 25 (43%) | 31 (60%) | 53 (48%) | 45 (64%) | 28 (30%) |
| Difficulty in biting | 204 (53%) | 32 (55%) | 6 (12%) | 75 (68%) | 23 (33%) | 66 (72%) |
| Insufficient chewing | 202 (52%) | 36 (62%) | 3 (5.8%) | 76 (69%) | 20 (29%) | 65 (71%) |
| Persistent drooling | 217 (57%) | 38 (66%) | 14 (27%) | 70 (64%) | 29 (41%) | 65 (71%) |
| Lack of appetite | 105 (27%) | 18 (31%) | 0 (0%) | 36 (33%) | 12 (17%) | 38 (41%) |
| Swallowing difficulties | 205 (53%) | 33 (57%) | 11 (21%) | 62 (56%) | 25 (36%) | 72 (78%) |
| Nasal regurgitation | 42 (11%) | 9 (16%) | 3 (6.2%) | 20 (18%) | 0 (0%) | 10 (11%) |
| Coughing while feeding | 140 (36%) | 35 (60%) | 3 (5.8%) | 43 (39%) | 10 (14%) | 47 (51%) |
| Vomiting | 50 (13%) | 8 (14%) | 0 (0%) | 6 (5.5%) | 11 (16%) | 24 (26%) |
| Abdominal pain/ colic | 56 (15%) | 8 (14%) | 0 (0%) | 13 (12%) | 12 (17%) | 23 (25%) |
| ≥2 episodes of wheezing requiring hospitalization | 83 (22%) | 11 (19%) | 5 (9.6%) | 23 (21%) | 14 (20%) | 29 (32%) |
| Bowel frequency |  |  |  |  |  |  |
| >3 times a week | 25 (6.5%) | 7 (12%) | 2 (3.8%) | 2 (1.8%) | 1 (1.4%) | 11 (12%) |
| 2-3 times a week | 109 (28%) | 20 (34%) | 4 (7.7%) | 49 (45%) | 12 (17%) | 24 (26%) |
| ≤1 times a week | 250 (65%) | 31 (53%) | 46 (88%) | 59 (54%) | 57 (81%) | 57 (62%) |
| Meal duration (minutes per meal) | 38 (18) | 39 (20) | 25 (10) | 39 (20) | 35 (12) | 44 (17) |
| Overall GI dysfunction |  |  |  |  |  |  |
| Normal | 88(23%) | 7 (12%) | 38 (73%) | 6 (5.5%) | 34 (49%) | 3 (3.3%) |
| Mild dysfunction | 72(19%) | 19 (33%) | 12(23%) | 9 (8.2%) | 23 (33%) | 9 (9.8%) |
| Moderate dysfunction | 134 (35%) | 12 (21%) | 1 (1.9%) | 58 (53%) | 13 (19%) | 49 (53%) |
| Severe dysfunction | 90 (23%) | 20 (34%) | 1 (1.9%) | 37 (34%) | 0 (0%) | 31 (34%) |
| **Pain** |  |  |  |  |  |  |
| Significant pain | 230 (60%) | 37 (64%) | 9 (17%) | 88 (80%) | 22 (31%) | 72 (78%) |
| **Epilepsy** |  |  |  |  |  |  |
| Epilepsy | 245 (64%) | 27 (47%) | 24 (46%) | 88 (80%) | 24 (34%) | 81 (88%) |
| Age of onset of seizures | 8 (15) | 4 (14) | 17 (21) | 7 (16) | 16 (23) | 5 (8) |
| Types of seizures |  |  |  |  |  |  |
| Generalized seizures  | 119 (31%) | 13 (22%) | 13 (25%) | 48 (44%) | 7 (10%) | 38 (41%) |
| Focal seizures  | 120 (31%) | 23 (40%) | 22 (42%) | 33 (30%) | 13 (19%) | 28 (30%) |
| Multifocal seizures  | 225 (59%) | 26 (45%) | 15 (29%) | 85 (77%) | 18 (26%) | 80 (87%) |
| Myoclonic seizures | 157 (41%) | 18 (31%) | 2 (3.8%) | 61 (55%) | 7 (10%) | 68 (74%) |
| Drug resistant epilepsy | 163 (42%) | 17 (29%) | 7 (13%) | 67 (61%) | 6 (8.6%) | 65 (71%) |
| West syndrome | 145 (38%) | 18 (31%) | 2 (3.8%) | 61 (55%) | 7 (10%) | 56 (61%) |
| Lennox Gastaut syndrome | 128 (33%) | 14 (24%) | 0 (0%) | 61 (55%) | 5 (7.1%) | 47 (51%) |
| Seizure free for 2 years | 22 (5.7%) | 2 (3.4%) | 3 (5.8%) | 6 (5.5%) | 7 (10%) | 4 (4.3%) |
| **Sleep related comorbidities** |
| Sleep impairment | 176 (60.7%) | 38 (66%) | 8 (15%) | 70 (64%) | 6 (8.6%) | 54 (59%) |
| Bedtime resistance | 28 (9.7%) | 12 (21%) | 8 (15%) | 5 (4.5%) | 3 (4.3%) | 0 (0%) |
| Sleep onset delay | 126 (43.4%) | 37 (64%) | 13 (25%) | 53 (48%) | 7 (10%) | 16 (17%) |
| Impaired sleep duration | 102 (35.2%) | 34 (59%) | 11 (21%) | 36 (33%) | 10 (14%) | 11 (12%) |
| Sleep anxiety | 40 (13.8%) | 23 (40%) | 7 (13%) | 6 (5.5%) | 2 (2.9%) | 2 (2.2%) |
| Night waking | 106 (36.6%) | 36 (62%) | 11 (21%) | 39 (35%) | 6 (8.6%) | 14 (15%) |
| Parasomnia | 8 (2.8%) | 2 (3.4%) | 5 (9.6%) | 0 (0%) | 1 (1.4%) | 0 (0%) |
| Sleep disordered breathing | 80 (27.6%) | 21 (36%) | 5 (9.6%) | 29 (26%) | 5 (7.1%) | 20 (22%) |
| Day time sleepiness | 106 (36.6%) | 25 (43%) | 5 (9.6%) | 44 (40%) | 3 (4.3%) | 29 (32%) |
| Internalizing score ≥84th centile  | 132 (34%) | 23 (40%) | 6 (12%) | 53 (48%) | 14 (20%) | 34 (37%) |
| Externalizing score ≥84th centile | 70 (18%) | 12 (21%) | 15 (29%) | 17 (15%) | 13 (19%) | 13 (14%) |
| Total score ≥ 84th centile | 165 (43%) | 29 (50%) | 17 (33%) | 57 (52%) | 21 (30%) | 39 (42%) |
|  |  |  |  |  |  |  |

**Table 3.** Univariable analysis of risk of comorbidities based on diagnosis and GMFCS

|  |  |  |
| --- | --- | --- |
| **Variable** | **Odds Ratio (95% Confidence Interval)** | **p** |
| *Regression analysis, based on underlying type of CP, with reference to hemiparetic CP* |
| **Type of Cerebral palsy** | **Hemiparetic CP** | **Spastic Diplegia** | **Dyskinetic CP** | **Mixed CP** | **Spastic quadriplegia** |  |
| GMFCS | Reference | 24.1(7.68, 107) | >2.5 x 109(0, Inf) | >2.5 x 109(0, Inf) | >2.5 x 109(0, Inf) | <0.001 |
| Social quotient | -11(-18, -4.4) | -51(-58, -44) | -55(-61, -49) | -55(-62, -49) | <0.001 |
| Visual impairment | 4.16(0.52, 85.5) | 0.38(0.08, 1.41) | 0.55(0.12, 1.86) | 1.82 (0.33, 10.1) | 0.018 |
| Hearing impairment | 6.25(1.64, 41.1) | 40.9(11.2, 266) | 11.7(3.35, 73.9) | 9.47(2.65, 60.6) | <0.001 |
| Speech comprehension and communication | 10.5(4.04, 33.2) | 263(59.9, 1964)  | 76.8(27.7, 258) | 98.7(33.3, 357) | <0.001 |
| Epilepsy | 0.61(0.29, 1.27) | 1.02(0.48, 2.16) | 4.67(2.30, 9.70) | 8.59(3.83, 20.5) | <0.001 |
| Drug resistant epilepsy | 0.81(0.22, 2.92) | 4.13(1.31, 14.1) | 7.75(2.93, 22.5) | 9.87(3.64, 29.5) | <0.001 |
| GI Dysfunction | 0.61(0.26, 1.37) | 0.62(0.26, 1.42) | 3.37(1.32, 8.85) | 2.77(1.08, 7.30) | <0.001 |
| Pain | 1.99(0.84, 5.00) | 7.63(3.21, 19.7) | 17.3(7.61, 43.2) | 15.6(6.74, 39.5) | <0.001 |
| Sleep impairment | 0.46(0.14, 1.46) | 10.7(4.01, 31.4) | 13.9(5.60, 38.0) | 14.0(5.41, 40.1) | <0.001 |
| Internalizing score | 1.92(0.71, 5.78) | 5.04(1.95, 14.9) | 7.13(3.00, 19.8) | 4.49(1.85, 12.7) | <0.001 |
| Externalizing behavior | 0.56(0.24, 1.32) | 0.64(0.26, 1.54) | 0.45(0.20, 1.00) | 0.41(0.17, 0.94) | 0.2 |
| Total score on CBCL | 0.88(0.41, 1.92) | 2.06(0.96, 4.53) | 2.21(1.12, 4.49) | 1.51(0.75, 3.13) | 0.018 |
| *Regression analysis, based on underlying type of GMFCS level, with reference to hemiparetic CP* |
| **GMFCS** | **1** | **2** | **3** | **4** | **5** |  |
| Social quotient | Reference | -14-21, -7.7) | -38(-44, -31) | -65(-71, -59) | -70(-76, -65) | <0.001 |
| Visual impairment | 0 | 0 | 0 | 0 | - |
| Hearing impairment | 2.52(0.60, 17.3) | 7.19(1.88, 47.5) | 8.97(2.40, 58.6) | 6.94(1.99, 43.9) | <0.001 |
| Speech comprehension and communication | 4.36(1.11, 29.1) | 84(20.3, 591) | 114(27, 813) | 159(42.1, 1052) | <0.001 |
| Epilepsy | 1.44(0.54, 4.18) | 3.06(1.17, 8.77) | 7.78(2.98, 22.5) | 18.6(7.57, 51) | <0.001 |
| Drug resistant epilepsy |  |  |  |  |  |
| GI dysfunction | 2.05(0.77, 5.41) | 1.45(0.56, 3.71) | 2.51(0.94, 6.70) | 4.43(1.81, 10.6) | 0.004 |
| Pain | 0.60(0.17, 2.23) | 4.73(1.67, 15.7) | 11.2(3.94, 37.8) | 19.4(7.33, 61.5) | <0.001 |
| Sleep impairment | 1.70(0.36, 12.2) | 4.25(1.01, 29.4) | 24.3(5.99, 166) | 46.1(12.1, 305) | <0.001 |
| Internalizing score | 7.40(1.35, 138) | 10.6(1.98, 197) | 25.64.99, 470) | 20.7(4.27, 373) | <0.001 |
| Externalizing score | 0.73(0.27, 1.99) | 0.71(0.26, 1.95) | 0.38(0.13, 1.10) | 0..39(0.7, .99) | 0..14 |
| Total score | 1.29(0.51, 3.43) | 1.51(0.60, 4.02) | 2.48(1.01, 6.49) | 1.92(0.85, 4.63) | 0.2 |