Factors associated with the Dubowitz neurological examination in preterm new-borns [version 1; peer review: awaiting peer review]

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Abstract

Background: This article aims to explore the factors associated with Dubowitz neurological examination scores in preterm new-borns.

Methods: This is a cross-sectional study in which forty preterm new-borns were evaluated by using the Dubowitz neurological examination on their first outpatient visit following hospital discharge. A questionnaire was also deployed to explore parental variables.

Results: Preterm new-borns with low scores in the Dubowitz neurological examination were born at an even lower gestational age, required longer hospitalisation, and had more indicators for orotracheal intubation. Positive correlations between the subdomains of the Dubowitz neurological examination with birthweight, mother’s age, Apgar score at 5 min, maternal and paternal education, and income were also significant. Linear regression analyses explained 26% of the of the Dubowitz neurological examination global score, retaining birthweight, income, and father’s age as significant predictors.

Conclusions: Early, appropriated neurological assessments of preterm infants are critical to detect risk factors that may underpin developmental delays.

Keywords

Premature new-born, Neurological examination, Child development, Risk factors
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Introduction

The present study investigated factors associated with the Dubowitz neurological examination (DNE) in preterm new-borns (PNB). While there has been an increase in prematurity rates, advances in science have made it possible to guarantee higher survival rates for these infants (Pinto et al., 2019). Nonetheless, prematurity is still the leading cause of mortality in new-borns and is a predictor for perinatal morbidity since it is associated with neurodevelopmental delay and deficiencies in sensory-motor abilities. These deficiencies occur due to the negative impact of prematurity on sensory processing, impairing the central nervous system (CNS) in managing, integrating, and adapting information gathered by sensory organs (Stylianou-Riga et al., 2018; Torchin & Ancel, 2016).

PNB are those born at less than 37 gestational weeks and can be classified as extreme (less than 28 weeks), very (from 28 weeks to 31 weeks and six days), moderate (from 32 weeks to 33 weeks and six days) and late-terms (from 34 weeks to 36 weeks and six days) (American Academy of Pediatrics, 2017). Overall, around 15 million premature births are estimated to occur every year, which translates into approximately one in 10 births (Chawanpaiboon et al., 2018); out of these, 84.7% are usually moderate or late preterm, 10% are very preterm and 5% are classified as extremely premature (Blencowe et al., 2012). Some factors associated with prematurity might be closely related to social inequalities, including low parental education and low family income, which might impede both access to medical monitoring and to direct immediate interventions (de Paula Machado et al., 2017; Fuentefria et al., 2017). Although the value of early neurological evaluation is widely accepted, the role of reliable, ecologically-valid measurements has been explored less, particularly in developing countries (do Nascimento et al., 2011). The DNE was created in 1980 with the intention of managing, integrating, and adapting the neurological conditions and neuropsychomotor development of PNB and full-term new-borns (Dubowitz et al., 1980). Since its first applications, the DNE has been sensitive to perinatal factors such as anoxia, difficulties in deliveries, infections and other environmental influences (Dubowitz et al., 1980). Moreover, the evaluation is well tolerated by new-borns and has shown a reliability level between judges of above 96% (Dubowitz et al., 1999). In 2003, DNE scores were categorised according to gestational age (GA) (Mercuri et al., 2003).

Although there has been substantial evidence relating prematurity to a myriad of medical, sociodemographic and environmental factors, around two-thirds of these births occur without an evident risk factor, which warrants further research (Vogel et al., 2018). Hence, the current study seeks to advance the understanding of factors associated with infants’ neurological development. One of the hypotheses was that abnormalities in neurological evaluations would be correlated with neonatal, maternal, and sociodemographic factors. In particular, we hypothesised that the DNE score would be altered in babies which required some type of neonatal support (Chaskel et al., 2018) and in the children of mothers with previous illnesses or complications throughout pregnancy (Aguilera et al., 2019; Dyck et al., 2020). Moreover, based on the premise that high income partly explains higher education, which would then supposedly increase protective healthy behaviours (such as strict prenatal care), we hypothesised that both income and education would be inversely associated with the DNE scores.

Methods

Participants, procedures, and design

This is a cross-sectional study involving PNB attending a high-risk outpatient clinic that serves as a reference for over 27 municipalities (Western Regional Health Association, Francisco Beltrão, PR, Brazil). From March to November 2020, 48 PNB had their first consultation at the clinic and were screened for the study. Six of them could not be included as they were aged more than six months (chronological age) or because they were diagnosed with a syndrome. Hence, 40 neonates aged up to six months of chronological age at the time of the evaluation and who were born in less than 37 gestational weeks were included.

The Brazilian-adapted version of the DNE was used (Massarollo, 2021a). The measure consists of 34 items divided into six dimensions: tone, type of tone, reflexes, movements, abnormal signs, and behaviour. Items are classified as abnormal (zero points), intermediate (.5) or normal (one point). The global score is obtained by totalling all items. The test is considered normal when scores range between 30.5 to 34. For PNB, however, the cut-off score is 26 (Dubowitz et al., 1998; Grinaboldi et al., 2015). Each dimension can also be evaluated individually, having distinct reference values (i.e., tone: between nine and 10; type of tone: five; reflexes: between five and six; movements: three; abnormal signs: three; behaviour: between six and seven). When the examination resulted in abnormal scores, parents were given further instructions in relation to developmental stimuli that can be performed at home and were told to adhere to the treatment prescribed by the clinic’s multidisciplinary team. In cases of infants’ fatigue, sleepiness, fever or fear, the procedure was interrupted until the situation was resolved. This was done in order to ensure reliable results (de Araújo, 2013).
A sociodemographic and clinical questionnaire was adopted to gather data on gender, birthweight, appearance, pulse, grimace, activity, respiration (Apgar) scores, occurrence of medical diagnosis, type of delivery, municipality of origin, and parental background characteristics (Massarollo, 2021b; please see extended data for a complete overview of this questionnaire). The researcher registered this information on paper when conducting the interviews. Finally, this study has been approved by the Research Ethics Committee at Western Paraná State University (n° 14099619.3.0000.0107), followed all the national and international guidelines for research with human beings and obtained written consent from parents before data collection.

Data analyses
Descriptive statistics (frequencies, percentages, means and standard deviations) were sought to obtain a sociodemographic and clinical profile of the sample. The Shapiro–Wilk test was used for assessing normal distribution. As maternal age, paternal education and income did not present a normal distribution, these were analysed with non-parametric techniques, while the other variables of interest had normal distribution. Thus, Pearson’s correlations and multiple regression analyses were deployed. Considering that the number of PNB with (n=10) and without (n=30) alteration on the DNE differed in size, Welch’s t-test was used for mean comparisons. All these techniques are clearly indicated in the appropriated tables. Cramer’s V (X² family tests) and Cohen’s d (Welch) were the effect size measures in the bivariate analyses according to the following interpretation: Cramer’s V (moderate: >.10; strong: >.15; very strong: >.25); Cohen’s d = ≥.20 (small), ≥.50 (moderate) and ≥.80 (strong) (Ferguson, 2009).

Multiple regression analyses (stepwise method) were run to explore the factors associated with the DNE global scores. Variables were included in the following order: new-born (weight, gestational age, Apgar scores, medical diagnosis, number of complications, and length of hospitalisation), maternal (number of prenatal visits, age, history of miscarriage, number of pregnancies, alcohol and tobacco use, maternal complications, and number of chronic diseases), and sociodemographic (income, parental education, and father’s age) variables. Analyses were run using the Statistical Package for the Social Sciences v. 23 and Jasp Statistics v. 0.13.1, with p values ≤ .05 set for significant results. Considering that all eligible PNB throughout March-November 2020 were included, except for cases already described (exclusion criteria), statistical power was computed on a post-hoc basis and G*Power v. 3.1.9 was deployed to achieve this goal. By entering data from our multiple regression analyses (i.e., number of predictors and effect size; F), the achieved power was 94% (two-tailed; α = .05) (Faul et al., 2014).

Results
Descriptive results
Among the 40 PNB, 60% were female (Massarollo, 2021b). Birthweight varied from 775 g to 3960 g, with a mean of 2194 g. Gestational age at birth ranged from 25 weeks and three days to 36 weeks and five days, with a mean of 34 weeks. Regarding prematurity classification, one (2.5%) was extremely premature, four (10%) were very premature, seven (17.5%) were moderate premature, and 28 (70%) were late premature. The Apgar 1 min score ranged from one to nine (M = 7.3) and the Apgar 5 min score ranged from five to 10 (M = 8.7). In terms of parental variables, it was found that the mother’s age ranged from 16 to 46 years, with a mean of 29.5, while the father’s age ranged from 20 to 63, with a mean of 33.1. Self-reported ethnicity was mostly white (65% and 72.5% for mothers and fathers, respectively). Overall, 42.5% of parents were married and 57.5% reported living together. As for prenatal data, the number of prenatal consultations varied between three and 15 visits (M = 8.6) and eight (20%) participants did not know the precise number of medical visits during pregnancy. Moreover, 95% of mothers reported a least one gestational complication, the most common being preeclampsia (30%) and urinary tract infection (17.5%); 35% had at least one chronic disease before pregnancy, with hypertension being the most common (17.5%). In total, 77.5% were on regularly prescribed medication.

In terms of PNB data, caesarean delivery was prevalent (n=27; 67.5%) and the length of hospitalisation was 23.1 days on average (mean), ranging from zero to 86 days. Four (10%) PNB had to stay in ICU, 11 (27.5%) needed intermediate care, 21 (52.5%) needed both ICU and intermediary care and only four (10%) did not require hospitalisation in special wards. In addition, 31 PNB (77.5%) needed some type of oxygen support and nine (22.5%) were intubated. Eight in 10 had some peri/neonatal intercourse or diagnosis, with sepsis (40%), respiratory distress (40%) and jaundice (15%) among the most frequent. The DNE global scores ranged from 20 to 31, with 10 (25%) PNB scoring below the cut-off mark. When analysing the subdomains, 97.5% were below reference values for tone, 77.5% for tone type, 62.5% for behaviour, 40% for movements, 27.5% for abnormal signs, while only 5% scored lower in the reflexes.

Associations between neonatal, maternal, and sociodemographic variables with the DNE
Correlation analyses were carried out between neonatal, maternal, and sociodemographic variables with the global scores and each domain of the DNE (Table 1). The positive, moderate correlations found between birthweight and tone (Pearson’s r = .36; p = .02), type of tone (Pearson’s r = .32; p = .04), reflexes (Pearson’s r = .38; p = .01), abnormal signs (Pearson’s r = .45; p = .003) and the DNE global score (Pearson’s r = .42; p = .006) are noteworthy. Table 2 presents comparisons between new-born, maternal and sociodemographic variables according to the DNE classification. There was a significant difference in the gestational age (p = .02), which was notably smaller in the group which presented abnormal scores in the DNE. Hospitalisation levels were significantly lower in the group with normal DNE scores (p = .04) as well the number of orotracheal intubations required (p = .02).

Linear regression models yielded six models. The model with Durbin Watson’s value closer to 2, which was statistically significant (p = .02) and with higher explained variance (R² Adjusted = 26%) is summarised in Table 3. The strongest predictor
Table 1. Correlations between the Dubowitz neurological examination, new-born variables, parent’s age and education, and income.

| Variables           | Tests and p values | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 |
|---------------------|--------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1. Tone             | Pearson’s r        |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 2. Tone patterns    | Pearson’s r        | .17|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 3. Reflexes         | Pearson’s r        | .46|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 4. Movements        | Pearson’s r        | .22|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 5. Abnormal signs   | Pearson’s r        | .13|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 6. Behaviour        | Pearson’s r        | .03|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 7. Global score     | Pearson’s r        | .76|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 8. Birthweight      | Pearson’s r        | .36|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 9. Apgar 1 min      | Pearson’s r        | .19|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 10. Apgar 5 min     | Pearson’s r        | -.04|   |    |    |    |    |    |    |    |    |    |    |    |    |
| 11. Mother’s age²   | Spearman’s rho     | -.19|   |    |    |    |    |    |    |    |    |    |    |    |    |
| 12. Father’s age    | Pearson’s r        | -.10|   |    |    |    |    |    |    |    |    |    |    |    |    |
| 13. Mother’s education | Pearson’s r       | .06|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 14. Father’s education³ | Spearman’s rho    | .03|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 15. Income³         | Spearman’s rho     | .04|    |    |    |    |    |    |    |    |    |    |    |    |    |

Note. In bold, significant predictors; ² non-normal distribution.

Table 2. Comparisons of new-born, maternal, and sociodemographic variables between those with normal and abnormal scores in the Dubowitz Neurological Examination (n = 40).

| Variables              | Abnormal scores (n = 10) | Normal scores (n = 30) | Effect (p value) |
|------------------------|--------------------------|------------------------|-----------------|
| Infants variables      |                          |                        |                 |
| Birthweight            | 1802.00±685.73           | 2325.00±629.51         | -.79 (.051)²    |
| Gestational age        | 32.12±2.55               | 34.49±2.39             | -95 (.002)³     |
| Apgar 1 min            | 7±1.24                   | 7.4±1.75               | -.26 (.44)³     |
| Variables                      | Abnormal scores (n = 10) | Normal scores (n = 30) | Effect (p value) |
|-------------------------------|--------------------------|------------------------|-----------------|
|                               | Mean±SD n (%)            | Mean±SD n (%)          |                 |
| Apgar 5 min                   | 8.60±.51                 | 8.76±1.22              | -.24 (.21)¹     |
| Complications (number)*       | 22.60±.96                | 22.70±.18              | -.04 (.84)¹     |
| Hospitalisation (days)        | 38.50±26.10              | 17.96±21.55            | .85 (.04)¹      |
| Required ICU                  |                          |                        |                 |
| Yes                           | 7 (28%)                  | 18 (72%)               | .04 (.84)²      |
| No                            | 3 (20%)                  | 12 (80%)               |                 |
| Required special ward         |                          |                        |                 |
| Yes                           | 9 (28.1%)                | 23 (72%)               | .14 (.65)³      |
| No                            | 1 (12.5%)                | 7 (87.5%)              |                 |
| Required O2                   |                          |                        |                 |
| Yes                           | 8 (25.8%)                | 23 (74.2%)             | .03 (1.0)²      |
| No                            | 2 (22.2%)                | 7 (77.8%)              |                 |
| Required intubation           |                          |                        |                 |
| Yes                           | 5 (55.6%)                | 4 (44.4%)              | .38 (.02)³      |
| No                            | 5 (16.1%)                | 26 (83.9%)             |                 |
| **Maternal variables**        |                          |                        |                 |
| Mother's age                  | 31.00±7.61               | 29.06±6.36             | .27 (.48)¹      |
| Number of prenatal visits     | 8.77±2.72                | 8.68±3.62              | .03 (.91)¹      |
| Number of pregnancies         |                          |                        |                 |
| 1                             | 5 (31.3%)                | 11 (68.8%)             | .36 (.15)²      |
| 2                             | 4 (36.4%)                | 7 (63.6%)              |                 |
| 3                             | 0 (0%)                   | 10 (100%)              |                 |
| 4                             | 0 (0%)                   | 1 (100%)               |                 |
| 5 or more                     | 1 (50%)                  | 1 (50%)                |                 |
| Previous abortion             |                          |                        |                 |
| Yes                           | 2 (18.2%)                | 9 (81.8%)              | .09 (.70)²      |
| No                            | 8 (27.6%)                | 21 (72.4%)             |                 |
| Alcohol and tobacco use       |                          |                        |                 |
| Never                         |                          |                        |                 |
| Quit in the pregnancy         |                          |                        |                 |
| Yes                           | 3 (21.4%)                | 11 (78.6%)             | .05 (.88)²      |
| 6 (28.6%)                    | 1 (20%)                  | 15 (71.4%)             |                 |
| 4 (8%)                       |                          | 4 (8%)                 |                 |
| Gestational complications     |                          |                        |                 |
| Yes                           | 8 (23.5%)                | 26 (76.5%)             | .08 (.63)²      |
| No                            | 2 (33.2%)                | 4 (66.7%)              |                 |
| Has chronic diseases          |                          |                        |                 |
| Yes                           | 4 (28.6%)                | 10 (71.4%)             | .05 (1.0)²      |
| No                            | 6 (24%)                  | 19 (76%)               |                 |
| **Sociodemographic variables**|                          |                        |                 |
| Income                        |                          |                        |                 |
| Up to 1 minimum wage         | 1 (25%)                  | 3 (75%)                | .23 (.57)²      |
| 1-3 minimum wages            | 7 (37.8%)                | 15 (68.2%)             |                 |
| 3-6 minimum wages            | 2 (22.2%)                | 7 (77.8%)              |                 |
| 6 or more minimum wages      | 0 (0%)                   | 5 (100%)               |                 |
| Variables | Abnormal scores (n = 10) | Normal scores (n = 30) | Effect (p value) |
|-----------|------------------------|-----------------------|----------------|
| Mother’s education | 1-4 grade (elementary) | 1 (50%) | 1 (50%) | .23 (.57) |
| | 5-9 grade (elementary) | 0 (0%) | 7 (100%) | |
| | Secondary education, incomplete | 0 (0%) | 4 (100%) | |
| | Secondary education, complete | 7 (43.8%) | 9 (56.3%) | |
| | Higher education | 1 (16.7%) | 5 (83.3%) | |
| | Postgraduate | 1 (25%) | 3 (75%) | |
| Father’s education | None | 0 (0%) | 1 (100%) | .39 (.42) |
| | 1-4 grade (elementary) | 1 (33.3%) | 2 (66.7%) | |
| | 5-9 grade (elementary) | 1 (14.3%) | 6 (85.7%) | |
| | Secondary education, incomplete | 1 (10%) | 9 (90%) | |
| | Secondary education, complete | 5 (41.7%) | 7 (58.3%) | |
| | Higher education | 2 (50%) | 2 (50%) | |
| | Postgraduate | 0 (0%) | 3 (100%) | |

Note. *Comparisons between specific complications did not differ between groups; 1 Welch’s t test; 2 Fisher’s exact test. In bold, statistically significant differences.

Table 3. Predictors of the total scores of the Dubowitz neurological examination.

| Variables            | B¹        | SE²       | β³        | t⁴       | p⁵        | 95% Confidence Interval |
|----------------------|-----------|-----------|-----------|----------|-----------|-------------------------|
| Intercept            | 22.89     | 2.95      | -         | -        | -         | -                       |
| Birthweight          | .002      | 6.569e-4  | .45       | 2.73     | .01       | 4.457e-4               |
| Income               | 1.56      | .63       | .52       | 2.46     | .02       | .262                   |
| Father’s age         | -.16      | .07       | -.55      | -2.12    | .04       | -.318                  |
| Mother’s education   | -.50      | .37       | -.27      | -1.33    | .19       | -1.273                 |
| Mother’s age         | .12       | .09       | .34       | 1.31     | .20       | -.067                  |

Note. The following variables were considered, but not kept in the final stepwise model: gestational age, Apgar 1 and 5 min, number of complications presented by the newborn, length of hospitalisation, number of prenatal visits/consultations (mother), history of miscarriage or abortion (mother), alcohol and tobacco use in the pregnancy, number of pregnancies, gestational complications, chronic diseases (mother), and fathers’ education.

Note. Variance Inflation Factors ranged from 1.17 to 2.90 (collinearity absent). Durbin-Watson value of 2.18 ruled out autocorrelation between predictors.

Note. In bold, significant predictors.

Note. 1 - Unstandardised coefficients; 2 – Standard errors; 3 - Standardised coefficients; t – value of the t test; p – p values.
was father’s age ($\beta = -0.55$) followed by income ($\beta = 0.52$). Birthweight was also linked with higher DNE global scores ($\beta = 0.45$).

**Discussion**

This study investigated factors associated with the DNE in premature infants, hypothesising that abnormalities in the neurological assessment would be correlated with neonatal, maternal, and sociodemographic factors. Specifically, we predicted low scores in the DNE in infants which required some type of neonatal support (Chaskel et al., 2018) and in the children of mothers with diagnosed illnesses or among those with pregnancy complications (Aguilera et al., 2019; Dyck et al., 2020). Furthermore, based on the premise that elevated income might explain higher educational levels, which, in turn, could increase the adoption of healthy behaviours - including strict prenatal care - we hypothesised that these sociodemographic factors would be inversely associated with the DNE.

Even though premature birth has been associated with various medical, sociodemographic, and environmental factors, nearly 66% of these births occur without a clearly defined risk factor. Indeed, the strongest predictors associated with the DNE in this study were father’s age and family income. While specific comparisons with past reports are not fully possible due to the adoption of diverse measures, our findings build upon, and are coherent with the specialised literature. For instance, a strong correlation has been reported between children’s motor development and father’s age (Borba et al., 2017); moreover, there is evidence that younger fathers have increased chances of having underweight and premature children (Goisis et al., 2018). We observed a positive correlation between both paternal and maternal education and family income. In this direction, Delgado et al. (2020) recently reported lower motor development among those receiving governmental benefits, supporting the claim linking low income with neurological deficits in Brazilian children. Another investigation in Brazil showed that economic hardship can have an impact on premature births, particularly among uneducated mothers (Sadovsky et al., 2018). Indeed, maternal instruction has been negatively associated with full-term pregnancies and birthweight (Mattei & Carreno, 2017).

We also noticed that mothers with higher age had babies with greater vitality (i.e., Apgar 5 min score). Past studies noted that adolescent mothers are more likely to have premature children with a low Apgar score in the fifth minute (Souza et al., 2017), while those aged between 20 and 29 years are more likely to have children with Apgar 5 min scores of greater than eight (Maniz et al., 2016). Moreover, both otracheal intubation and length of hospitalisation were significantly lower in the group with normal DNE scores. In fact, the literature reports that longer hospitalisations are inversely related to motor development assessments in PNB (Formiga et al., 2017) and that gross motor performance is significantly lower when invasive mechanical ventilation is needed (Nazi & Aliabadi, 2015).

Prematurity and low birthweight are established risk factors for delays in motor and cognitive development (Upadhyay et al., 2019) and these alterations usually occur simultaneously (Oudgenoog-Paz et al., 2017). Indeed, birthweight was independently associated with the DNE global score in our study; furthermore, it correlated with the tone, type of tone, reflexes, and abnormal signs subdomains. These results resemble data reported by Formiga et al. (2017) who found a positive and moderate correlation at two and four months of life between birthweight and motor development (assessed through the Test of Infant Motor Performance; TIMP).

No studies were located which associated the DNE with maternal, neonatal, and sociodemographic factors, which impedes specific comparisons. However, past investigations have adopted the Hammersmith Infant Neurological Examination (HINE) (Haataja et al., 1999), which is similar to the DNE. In this respect, Romeo et al. (2016) observed associations between gestational age and the HINE’s overall score, whereas Chatziioannidis et al. (2018) reported only one factor associated with a low HINE score, namely being small-for-gestational-age.

In addition to our main findings, the current investigation might have useful data for those involved in maternal and child health. Firstly, 25% of the PNB scored below the ideal cut-off limit of the DNE, albeit these rates range from 57% to 70% when the evaluation is performed at term age (Golin et al., 2009; Grinaboldi et al., 2015). Secondly, readers must consider that the sample of this research was assessed with ages up to six months (chronological age), thus already achieving the term age. In this sense Mercuri et al. (2003) stressed that, although PNB had lower DNE scores when compared to non-pre-terms, all infants evaluated in the study achieved normal scores at 18 months of life. This can be explained by the fact that many components of neurological assessment are age-dependent (Dubowitz et al., 1998), so an increase in maturity is expected to result in better scores in the DNE evaluation (Dubowitz et al., 2005; Romeo et al., 2013). This can also be observed in the first hours of life. Indeed, Romeo et al. (2017) noted significant differences when infants were assessed within 3, 6 and 48 hours. In our research, the domains with least altered scores were movements and reflexes, with 27.5% and 5% of infants scoring below reference values, respectively. These were the only domains that did not show significant differences between the very-, late- and full-term groups in the Romeo et al. study (2016). Additionally, Golin et al. (2009) found that 80% of the PBN scored below cut-off points for tone and 97% had insufficient scores regarding type of tone. These studies validate our findings, as 97.5% of the sample scored below the reference value for tone and 77.5% for type of tone.

Despite the attempts to reduce the incidence of spontaneous premature births, this still stands out as the main cause of perinatal morbidity and mortality, being a complex and multifactorial public health problem (Glover & Manuck, 2018). Over the years, the number of premature infants increased in southern Brazil, with higher proportions of late preterm...
infants (Sadovsky et al., 2018), accounting for about 74% of the premature population (Chatzioannidis et al., 2018). This is compatible with our research as 70% were late preterm too. Finally, a remarkable percentage (95%) of women from our study reported some sort of complication during pregnancy, with caesarean section accounting for 67.5% of deliveries. This comes with no surprise as it has been noted before that mothers of premature babies have higher rates of complications during pregnancy, especially preeclampsia and haemorrhage, as well as higher rates of caesarean delivery (Cheong et al., 2017). What surprises us is that, even with all the advancements in the field of prenatal care, those rates are still so elevated.

In summary, although our study presents some limitations, especially in the analysis of categorical variables with reduced number of cases per cell - which may have hindered the detection of some risk factors associated with the DNE - this investigation also has some strengths. These include the analyses of factors much less explored in the literature, since we could not locate other studies exploring the relationship between neonatal, maternal, and sociodemographic factors with the DNE in PNB. The measure, created decades ago, has been mostly used in recent studies involving Zika virus (Coutinho et al., 2021), which could explain the scarcity of updated studies utilising this neurological assessment tool among low-risk PNB (Grinaboldi et al., 2015).

An additional limitation concerns the fact that one must not generalise these findings to other realities due to numerous factors already mentioned. Consequently, more research is needed to support early strategies focusing on ameliorating the care dedicated to the child-mother dyad, particularly involving longitudinal and/or interventional designs to translate science into practice and to explore the external validity of the measure. In other words, effectively transforming the taxpayers’ money behind research into better quality of life.

**Data availability**

**Underlying data**

Zenodo: Individual responses from the Dubowitz neurological examination and demographic questionnaire. https://doi.org/10.5281/zenodo.5379603 (Massarollo, 2021b)

This project contains the following underlying data:
- DNE SCORE.xlsx (Spreadsheet with individual responses to the Dubowitz neurological examination)

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

**Extended data**

Zenodo: Individual responses from the Dubowitz neurological examination and demographic questionnaire. https://doi.org/10.5281/zenodo.5379603 (Massarollo, 2021b)

This project contains the following extended data:
- Questionnaire.docx (Sociodemographic and clinical questionnaire)

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DNE in PNB. The measure, created decades ago, this investigation also has some strengths. These include the analyses of factors much less explored in the literature, since we could not locate other studies exploring the relationship between neonatal, maternal, and sociodemographic factors with the DNE in PNB. The measure, created decades ago, which could explain the scarcity of updated studies utilising this neurological assessment tool among low-risk PNB (Grinaboldi et al., 2015).

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