Reliability for detection of developmental problems using the semaphore from the Child Development Evaluation test: Is a yellow result different from a red result?

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Abstract

Background: The Child Development Evaluation (CDE) is a screening tool designed and validated in Mexico for detecting developmental problems. The result is expressed through a semaphore. In the CDE test, both yellow and red results are considered positive, although a different intervention is proposed for each. The aim of this work was to evaluate the reliability of the CDE test to discriminate between children with yellow/red result based on the developmental domain quotient (DDQ) obtained through the Battelle Development Inventory, 2nd edition (in Spanish) (BDI-2).

Methods: The information was obtained for the study from the validation. Children with a normal (green) result in the CDE were excluded. Two different cut-off points of the DDQ were used (BDI-2): < 90 to include low average, and developmental delay was considered with a cutoff < 80 per domain. Results were analyzed based on the correlation of the CDE test and each domain from the BDI-2 and by subgroups of age.

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Results: With a cut-off DDQ <90, 86.8% of tests with yellow result (CDE) indicated at least one domain affected and 50% 3 or more compared with 93.8% and 78.8% for red result, respectively. There were differences in every domain ($P < 0.001$) for the percent of children with DDQ < 80 between yellow and red result (CDE): cognitive 36.1% vs. 61.9%; communication: 27.8% vs. 50.4%; motor: 18.1% vs. 39.9%; personal-social: 20.1% vs. 28.9%; and adaptive: 6.9% vs. 20.4%.

Conclusions: The semaphore result yellow/red allows identifying different magnitudes of delay in developmental domains or subdomains, supporting the recommendation of different interventions for each one.

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evaluate whether the CDE met other psychometric properties, so it does not accurately scan each of the components of neurodevelopment.

Therefore, the panel stipulated the need to apply another test to establish with certainty whether or not a child has developmental disorders. To accomplish this, a trained psychologist must apply a test such as the Battelle Developmental Inventory 2ª (BDI-2) Spanish edition.

It should be noted that these three colors were chosen to confirm or rule out developmental delay using one of the cases classified as green do not require any intervention considering that their development is normal.

Finally, all children classified as green do not require intervention, whereas children classified with a red result, an immediate subsequent evaluation is needed to determine the possible cause of developmental delay or detection of any specific disease, which may be important for planning and enabling strategies or differentiated interventions in each case.

The assessment conducts interventions or actions to improve the child's health. Thus, the possible outcomes of the CDE are as follows:

a) Normal development (classified as “green”)—this group includes children who are within the normal range of development and do not exhibit signs of developmental delay or disorders.

b) Mild risk for developmental delay (classified as “yellow”)—when a child has not attained the developmental milestones corresponding to his/her age group and signs, and neurological examination is normal.

c) High risk for developmental delay (classified as “red”)—this group consists of children who are at high risk for developmental delays or disorders. These children require referral and rapid assessment to determine the possibility of developmental delay or disorders.

According to the CDE, children who live in urban and rural areas in three entities of Mexico: Chihuahua, Yucatán and Mexico City. The spectrum of capabilities of these children.

In the first analysis performed, it was found that the CDE had a sensitivity (capacity to detect developmental problems) of 61% (95% CI = 54-67%). Whereas the differences between children classified as yellow or red (DQ < 70) as compared to cases classified as yellow or red (DQ < 70) of 81% (95% CI = 90). In the study in which 438 children from 1 month old until 1 day were included and who before reaching 5 years of age were included and who lived in urban and rural areas in three entities of Mexico: Chihuahua, Yucatán and Mexico City. The spectrum of capabilities of these children.
Statistical significance was defined as two-tailed test or Fisher's exact test was used. 

Data are presented as absolute (n) and relative (%). To evaluate differences between groups, range (IQR) for numeric variables. 

Significant differences were found for all domains with the exception of cognition. Significant differences were observed between yellow and red groups: cognitive (68.8% vs. 58.4%); motor (38.9% vs. 64.6%); and adaptive (59.0% vs. 74.3%); personal-social (84.1% vs. 80.1%) communication (74.3% vs. 59.0%); and receptive communication (Fig. 3). 

In children 16-59 months of age, significant differences were found in the percentage of participants with affected domains (cutoff DDQ < 80) for those who obtained a yellow result (93.8%) and red result (90), respectively. Significant differences were also found in the percentage of children who obtained a red result in the CDE test (yellow vs. red), the percentage of "false positives" (TDQ < 90) was 46.5% for those who obtained a yellow result and 75.2% for a red result. 

When considering only those domains with delay or significant delay (DDQ < 67.8-109.3), which was significantly higher (p < 0.0001) than those with a yellow result, 86.8% had at least one affected domain compared with 50% in children with a red result. 

Two cutoff points for DDQ were used in the analysis of the test: 

- For DQ > 90 with a score lower than 10 (SD delay because the score for subdomain has an average of 1.33 SD, which is equivalent to a 1 SD and 2.2% less than 80, classifying it within the range of developmental delay (DDQ < 80). 

- Classification of abnormal development of the TDQ for the categories of normal-low was defined with a cutoff value of 10 (SD). The score for subdomain has an average of 10 (SD) and 14.6% three or more domains, compared with 67.8-109.3, which was significantly higher (p < 0.001) among participants (Table 1). The difference of the two proportions was statistically significant (p < 0.05). 

Significant differences observed between yellow and red groups: cognitive (36.1 vs. 61.9%); communication (74.3% vs. 59.0%); personal-social (84.1% vs. 80.1%) and motor domains (26.7 vs. 43.9%) may be explained by the percentages of involvement and were presented for all subdomains except receptive communication, attention and memory, adult interaction, fine motor skills, and receptive communication. 

The study was approved by the Research, Ethics, and Biosafety Committees of the Hospital Infantil de México Federico Gómez. 

DQ with a score lower than 10 (SD) or 1.33 SD, which is equivalent to a 1 SD and 2.2% less than 80, classifying it within the range of developmental delay (DDQ < 80). 

Significant differences were found in the percentage of children who obtained yellow and red results: cognitive (68.8% vs. 58.4%); motor (38.9% vs. 64.6%); and adaptive (59.0% vs. 74.3%); personal-social (84.1% vs. 80.1%) communication (74.3% vs. 59.0%); and receptive communication (Fig. 3).
As shown in Table 1, 86.8% of children with yellow results and 93.8% of children with red results have at least one domain with a DDQ < 90 and may benefit from an intervention to promote healthy development. Depending on the results, possible interventions require a different magnitude because 78.8% of the children were identified with a red result in three or more domains with DDQ < 90 (low-normal to severe delay) and 81.4% in at least one domain within significant delay (DDQ < 80) compared with 50% and 56.3% for children with a yellow result, respectively.

Furthermore, it would be convenient to consider that the possible explanations for the CDE cannot discriminate between yellow and red in the attention and memory subdomains. According to the BDI-2, 7 children < 18 months of age are focused on evaluating visual tracking, anticipatory behavior (perceive that someone is approaching), audio tracking and paying attention to sounds. Test items of self-concept and social role (SR) subdomain in this same group evaluate the response to interaction with adults and expression of emotions. In order to do this, as was the case for the attention and memory subdomain, it is...
necessary that the child be able to see and hear properly; therefore, a delay in these subdomains can be directly associated with visual or hearing impairments. Therefore, when a child is classified with a yellow result, initially it may be sufficient to provide counseling in order to encourage visual and auditory monitoring behaviors and promote anticipatory behaviors, whereas identification of children with a red result should help in making a timely referral for assessment by a specialist. Because children classified with a red result have a higher frequency of delay in attention and memory subdomains (Table 3), it would be easier to recommend a pediatric evaluation to rule out visual or hearing impairments. As stated in NOM-015-SSA3-2012, diagnosis of congenital abnormalities that lead to hearing impairment must be conducted within 3 months of age and preferably by an audiologist, but also early detection of visual impairment and early stimulation in case of congenital visual impairment.

Assessment of gross motor subdomain during this period includes head control, limb movement, sitting, crawling, standing and walking. In case of delay, it is essential to establish a specialized neurological diagnosis (e.g., quadriplegia or hemiplegia). Because one of the evaluations of the neurological examination is asymmetry in body movements and questions related to this domain are included in the warning signs, children classified as yellow and with a delay in this domain could improve with maternal recommendations for performing massage and exercise to improve muscle tone and encourage motor skills. However, if the child persists with a yellow result in both assessments (6 months), then he/she should be considered as having a red result and be referred to a specialist for evaluation.

In the analysis by subdomains in the age group of 16-59 months, the highest prevalence of delay was observed (>50%) in children with a red result in the CDE in attention and memory, reasoning and academic skills, perceptions and concepts, interaction with peers, interaction with adults as well as self-perception, social role and expressive communication. This finding underscores the need for the application of a test to evaluate more accurately each of the neurodevelopmental aspects, such as the BDI-2. Thus, we would have the ability to identify the problem or problems in some of these subdomains and establish an individual counseling for each case where parenting practices or actions needed could be strengthened so that children receive an enriched environment, thereby improving their development.

Table 2. Domain with DQ < 90 for the different results of the CDE. 

<table>
<thead>
<tr>
<th>Domain</th>
<th>1-15 months</th>
<th>16-59 months</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 75</td>
<td>n = 56</td>
<td>n = 113</td>
</tr>
<tr>
<td>Yellow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td>35 (46.7%)</td>
<td>21 (30.4%)</td>
<td>56 (38.9%)</td>
</tr>
<tr>
<td>Communication</td>
<td>42 (56.0%)</td>
<td>43 (62.3%)</td>
<td>85 (59.0%)</td>
</tr>
<tr>
<td>Adaptive</td>
<td>24 (32.0%)</td>
<td>21 (30.4%)</td>
<td>45 (31.2%)</td>
</tr>
<tr>
<td>Personal/Social</td>
<td>31 (41.3%)</td>
<td>36 (52.2%)</td>
<td>67 (46.5%)</td>
</tr>
<tr>
<td>Cognitive</td>
<td>45 (60.0%)</td>
<td>54 (78.3%)</td>
<td>99 (68.8%)</td>
</tr>
</tbody>
</table>

* x² test between yellow and red results for evaluating differences according to domain and subdomain.

m, months; BDI-2, Battelle Developmental Inventory-2; CDE, Child Development Evaluation; DQ, development quotient.

Figure 2. Percentage of children according to domain affected (domain quotient, DQ < 80) and age group comparing the result with the CDE.
In addition to considering the potential impact of the individual clinical outcome of the implementation of CDE, it is necessary to note that detection of neurodevelopmental problems at the population level may result in implications for the health system or for the family. For example, due to what has been reported in the present study, the fact that the classification in yellow and red identifies children with minor and major developmental delays, respectively, is favorable in some situations because patients will be referred to different specialists (to the pediatrician, in the case of a yellow result and to the psychologist for applying neurodevelopmental confirmatory tests in the case of a red result) avoiding overload of services and subsequent evaluations. However, implementation of the CDE nationwide involves having available at the community, state and jurisdictional level a reference and counter-reference system effective for children identified with disorders so they can receive appropriate and timely medical care, both to establish the diagnosis and to provide, where appropriate, the corresponding treatment. This implies, among other things, the need for health services to have sufficient and qualified staff in each of the levels of health care. Finally, it is worth mentioning that the results of this study should be taken with caution and under limitations. Data presented do not come from a nationally representative population.

Table 3. Domains and subdomains with delay according to the different results of the CDE test.

<table>
<thead>
<tr>
<th>Domain</th>
<th>Yellow</th>
<th>Red</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yellow</td>
<td>Red</td>
<td>p</td>
</tr>
<tr>
<td>Total n</td>
<td>144</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>1-15 m n</td>
<td>75</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>16-59 m n</td>
<td>69</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

- **Motor**: 26 (18.1%) 20 (26.7%) 6 (8.7%) 44 (39.9%) 25 (43.9%) 19 (33.9% ) < 0.001 0.039 < 0.001
- **Gross motor (GM)**: 21 (14.6%) 14 (18.7%) 7 (10.1%) 36 (31.9%) 21 (36.8%) 15 (26.8%) 0.001 0.019 0.015
- **Fine motor (FM)**: 35 (24.3%) 20 (26.7%) 17 (29.8%) 34 (30.1%) 15 (21.7%) 17 (3 0.4%) 0.299 0.689 0.272
- **Perceptual motor (PM)**: 7 (15.6%) — 7 (15.6%) 15 (34.1%) — 15 (34.1%) 0.043 — 0.043
- **Communication**: 40 (27.8%) 20 (26.7%) 20 (29.0%) 57 (50.4%) 21 (36.8%) 36 (64.3% ) < 0.001 0.211 < 0.001
- **Receptive communication (RC)**: 54 (37.8%) 27 (36.5%) 27 (39.1%) 54 (48.2%) 24 (42.1%) 30 (54.5%) 0.094 0.513 0.087
- **Expressive communication (EC)**: 27 (18.9%) 8 (10.8%) 19 (27.5%) 42 (37.5%) 8 (14.0%) 34 (61.8%) 0.001 0.576 < 0.001
- **Adaptive**: 10 (6.9%) 5 (6.7%) 5 (7.2%) 23 (20.4%) 7 (12.3%) 16 (28.6%) 0.001 0.266 0.002
- **Self-care (SC)**: 12 (8.4%) 5 (6.8%) 7 (10.1%) 27 (24.1%) 7 (12.3%) 20 (36.4% ) 0.001 0.277 < 0.001
- **Personal/Social**: 29 (20.1%) 9 (12.0%) 20 (29.0%) 44 (28.9%) 18 (31.6%) 26 (46.4%) 0.001 0.006 0.044
- **Interaction with adults (IA)**: 37 (25.9%) 9 (12.2%) 28 (40.6%) 42 (37.8%) 10 (17.9%) 32 (58.2%) 0.041 0.363 0.051
- **Interaction with peers (IP)**: 6 (13.3%) — 6 (13.3%) 23 (52.3%) — 23 (52.3% ) < 0.001 — < 0.001
- **Self-concept and social role (SR)**: 39 (27.3%) 14 (18.9%) 25 (36.2%) 50 (45%) 20 (35.7%) 30 (54.5%) 0.003 0.031 0.041
- **Cognitive**: 52 (36.1%) 19 (25.3%) 33 (47.8%) 70 (61.9%) 28 (49.1%) 42 (75.0%) < 0.001 0.005 0.002
- **Attention and memory (A/M)**: 43 (30.1%) 16 (21.6%) 30 (52.6%) 61 (54.5%) 27 (39.1%) 31 (56.4%) < 0.001 < 0.001 0.056
- **Perception and concepts (P/C)**: 25 (17.5%) 3 (4.1%) 22 (31.9%) 35 (31.2%) 3 (5.3%) 32 (58.2%) 0.01 0.743 0.003
- **Reasoning and academic abilities (R/A)**: 10 (22.2%) — 10 (22.2%) 25 (56.8%) — 25 (56.8%) 0.001 — 0.001

For each domain, we used < 80 as a cutoff point for the Development Quotient (DQ). For each subdomain, we used as a cutoff point the Point Scale (PS) < −1.33 standard deviations (SD).

a These categories are evaluated only in patients 24 months and older. As a result, the total participants for these subdomains were n = 45 (yellow) and n = 44 (red).

* x2 test between yellow and red results for evaluating differences according to each domain and subdomain.

BDI-2, Battelle Developmental Inventory-2; CDE, Child Development Evaluation.
yellow and red) detected of neurodevelopmental disorders (58.6%) in the 458 cases analyzed. This ratio will certainly be lower when the CDE is applied at the population level, and it can also be established with greater certainty the reliability of CDE results with different subdomains of BDI-2.

Another limitation is the cross-sectional design of this study; therefore, it is still unknown what will happen when evaluations are conducted in accordance with the CDE as children grow or when interventions occur in cases classified with a yellow result. It is also required to know the causes or diagnoses of cases classified with a red result.

In conclusion, results obtained in the present study using a “traffic light” ranking for children <5 years of age with developmental disorders and classified as a yellow or red result when applying the CDE allow us to identify children with different magnitudes of developmental delay. This may contribute to the provision of different interventions applied immediately after the test. However, to determine with strength the ability of the CDE to identify children with neurodevelopmental disorders, it is necessary to increase the number of children in whom this test was applied and to compare the results with the reference standard.
Reliability for detection of developmental problems using the semaphore from the Child Development Evaluation test.


