RESEARCH ARTICLE

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

Antonio Rizzoli-Córdobaa*, Fernando Ortega-Riosvelascoa, Miguel Ángel Villasis-Keeverb, Mariel Pizarro-Castellanosa, Guillermo Buenrostro-Márquezb, Daniel Aceves-Villagránb, Gabriel O'Shea-Cuevase, Onofre Muñoz-Hernándeza

Unidad de Investigación en Neurodesarrollo, Hospital Infantil de México Federico Gómez, Mexico City, Mexico
Unidad de Investigación en Epidemiología Clínica, Unidad Médica de Alta Especialidad, Hospital de Pediatría, Centro Médico Nacional Siglo XXI, Instituto Mexicano de Seguro Social, Mexico City, Mexico
Dirección General del Programa Oportunidades, Comisión Nacional de Protección Social en Salud, Mexico City, Mexico
Comisión Nacional de Protección Social en Salud, Mexico
Dirección de Investigación, Hospital Infantil de México Federico Gómez, Mexico City, Mexico

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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.
Introduction: The Child Development Evaluation (CDE) is a screening tool designed to detect problems in neurodevelopment. It was developed in Mexico and is aimed at children from 1 month old until 1 day before reaching 5 years of age. The CDE was developed by a group of experts in Pediatrics, Pediatric Neurology and Psychology in order to have a reliable and easily applicable instrument in primary care. This was determined after analyzing that, despite the existence of validated psychometric tests for the detection of children with neurodevelopmental disorders, there were not any that could be applied to the Mexican population and assist the health system for detection and appropriate treatment.

Currently, most tests to assess neurodevelopment are designed to be used by specialists, and their implementation requires a considerable time investment (and may include many hours), which makes them impractical for use by health care workers at the community level.

In order to make the CDE a reliable test, the design and development processes were carried out according to the psychometric aspects that determine its validity and reproducibility.

For this purpose, the panel of experts contributed to the CDE appearance, content and construct validity because it integrates the elements necessary for neurodevelopmental troubleshooting in children <5 years of age, including the following five areas:

1. Biological risk factors (e.g., mother's age, problems occurring during pregnancy or birth)
2. Warning signs (aspects that may suggest a developmental problem)

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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Confiablez de la detección de problemas de desarrollo mediante el semáforo de la prueba de Evaluación del Desarrollo Infantil: ¿es diferente un resultado amarillo de uno rojo?

Resumen

Introducción: La prueba Evaluación del Desarrollo Infantil (EDI) es un instrumento de tamizaje de problemas en el desarrollo diseñado y validado en México. La calificación obtenida se expresa como semáforo. Se consideran positivos tanto el resultado amarillo como el rojo, aunque se plantea una intervención diferente para cada uno. El objetivo de este trabajo fue evaluar la capacidad de la prueba EDI para discriminar entre los niños identificados con semáforo amarillo y los identificados con rojo al compararse con el Inventario de Desarrollo de Battelle 2.ª edición (IDB-2) en cuanto al cociente de desarrollo del dominio (CDD).

Métodos: El análisis se llevó a cabo utilizando la información obtenida para el estudio de validación. Se excluyeron los pacientes con resultado normal (verde) en EDI. Se utilizaron 2 puntos de CDD (IDB-2) por dominio: < 90 para incluir normal-bajo y < 80 para diagnóstico de retraso. Se analizó el resultado con base en la correlación del resultado del semáforo de EDI(amarillo o rojo) y el IDB-2, total y por subgrupos de edad.

Resultados: Al considerar un CDD < 90 en amarillo, el 86.8% tuvo al menos un dominio afectado, y el 50%, 3 o más dominios, en comparación con el 93.8% y el 78.8% para el resultado en rojo,respectivamente. Hubo diferencias en todos los dominios entre amarillos y rojos (p < 0.001) para el porcentaje de niños con un CDD < 80: cognitivo (36.1 vs. 61.9%); comunicación (27.8 vs. 50.4%); motor (18.1 vs. 39.9%); personal-social (20.1 vs. 28.9%); y adaptativo (6.9 vs. 20.4%).

Conclusiones: Los resultados de semáforo (amarillo o rojo) permiten identificar diferente magnitud de los problemas en el desarrollo y apoyan intervenciones diferenciadas.

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The Child Development Evaluation (CDE) is a screening tool used to assess whether a child is at risk for developmental delay or other impairments. It is a test that simulates a traffic light, with the colors indicating different levels of developmental status: green (normal development), yellow (mild delay), and red (high risk for developmental delay).

**Eligibility Criteria:**
- The CDE is administered to children aged 1 month to 1 year.
- To be eligible, children must be evaluated in the following areas:
  1. **Age:** Must be 16 months or younger.
  2. **Development:** Must be within the normal range for their age group, as determined by a standardized test.

**Screening Process:**
- The CDE includes several components that are evaluated to determine the child's developmental status:
  1. **Developmental Milestones:** These include fine and gross motor skills, language development, and social and knowledge domains.
  2. **Alarm Signs:** These are signs that indicate potential developmental problems or delays.
  3. **Neurological Examination:** This includes assessments of movements of the face, eyes, and body, and head circumference.

**Classification:**
- Based on the evaluation, children are classified into one of the following groups:
  - **Green (Normal Development):** This classification indicates that the child has reached developmental milestones appropriate for their age and does not exhibit any warning signs or changes in the axis of development.
  - **Yellow (Mild Delay):** Children in this category require referral and rapid assessment, as they may have developmental delays but are not at high risk for significant impairment.
  - **Red (High Risk for Developmental Delay):** Children classified as red should be referred to a pediatrician for further evaluation and potential strategies or differentiated interventions.

**Validity and Reliability:**
- The CDE's effectiveness in identifying children at risk for developmental delay was evaluated using a comparison to a gold standard, such as the Battelle Developmental Inventory 2ª (BDI-2) Spanish edition.
- The study found that the CDE had a sensitivity of 61% (95% CI 90-75%) and a specificity of 90% (95% CI 75-91%) for detecting developmental problems.
- The CDE's performance was found to be similar across different regions of Mexico, with areas such as Chihuahua, Yucatán, and Mexico City.

**Conclusion:**
- The CDE is an appropriate screening tool for identifying children at risk for developmental delay, as it can effectively discriminate between children with and without developmental problems. The test is recommended for use in early childhood development programs to facilitate timely intervention and support for children with potential delays.

**Additional Resources:**
- The Battelle Developmental Inventory 2ª (BDI-2) Spanish edition is a widely used tool for assessing developmental milestones in children.
- The Bayley-III scale is another standardized test used as a cutoff for identifying children with developmental delays.
On the other hand, for the subdomains, Z score was used.

Statistical significance was defined as two-tailed.

When considering a DDQ greater than or equal to the established cutoff (DQ 90) was 46.5% for those who obtained a yellow result and 93.8% and 78.8%, respectively, of those with a red result.

Within these values, 23% have at least one area with a score lower than 80 (delay and significant delay).

In the subgroup of 1-15 months of age, statistically significant differences were found for all domains with the exception of the CDE (yellow vs. red) in all areas except in the domain of communication.

In the subgroup of children 16-59 months of age, significant differences were found in the percentage of children who obtained abnormal results in the CDE (yellow vs. red) in all areas except in the domain of receptive communication.

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In children 5 years and over, there were significant differences in all domains and subdomains except receptive communication, fine motor skills, attention and memory. In children 3-5 years, significant differences were found (31.2% vs. 58.4%) (Table 2). With the same cutoff in the CDE (green, yellow, and red) after the percentages of involvement and were presented for all domains: cognitive (68.8% vs. 74.3%); communication (59.0% vs. 74.3%); personal-social (59.0% vs. 74.3%); motor skills (59.0% vs. 74.3%); fine motor skills (18.9 vs. 35.7%) for the personal-social domain; and gross motor skills (18.7 vs. 36.8%) for the motor domain. In children 2-3 years, significant differences were observed; meanwhile, in the subgroup of 16-59 months of age, significant differences were found (18.9 vs. 35.7%) for the personal-social domain; and gross motor skills (18.7 vs. 36.8%) for the motor domain. In children 16-59 months of age, significant differences were found in the percentage of children who obtained abnormal results in the CDE (yellow vs. red) in all areas except in the domain of receptive communication. Significant differences were found in the percentage of children who obtained abnormal results in the CDE (yellow vs. red) in all areas except in the domain of receptive communication, fine motor skills, attention and memory. In children 3-5 years, significant differences were found (31.2% vs. 58.4%) (Table 2). With the same cutoff in the CDE (green, yellow, and red) after the percentages of involvement and were presented for all domains: cognitive (68.8% vs. 74.3%); communication (59.0% vs. 74.3%); personal-social (59.0% vs. 74.3%); motor skills (59.0% vs. 74.3%); fine motor skills (18.9 vs. 35.7%) for the personal-social domain; and gross motor skills (18.7 vs. 36.8%) for the motor domain. In children 2-3 years, significant differences were observed; meanwhile, in the subgroup of 16-59 months of age, significant differences were found (18.9 vs. 35.7%) for the personal-social domain; and gross motor skills (18.7 vs. 36.8%) for the motor domain.
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.
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 <5 years of age. Once further details of the implementation of the CDE are available, we will be able to verify whether what is described in this analysis is reproducible. One of these limitations is related to the result of the high prevalence (total number of children classified as

| Domain       | Yellow      | Red         | p       | Total       | Red         | p       |
|--------------|-------------|-------------|---------|-------------|-------------|---------|
|              | n=144       | n=113       |         | n=257       | n=226       |         |
| 1-15 m       | n=75        | n=57        |         | n=132       | n=114       |         |
| 16-59 m      | n=69        | n=56        |         | n=125       | n=110       |         |

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 (<−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.
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