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RESEARCH ARTICLE

Validity of administering the child development evaluation test through telemedicine to children aged 18-72 months

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Abstract

Background: *Early childhood development is a complex process that requires reliable tools for the timely detection of alterations that may affect a child's progress. The Child Development Evaluation test (EDI, in its Spanish acronym) is a screening test developed and validated in Mexico to be administered in person by a professional. The objective is to evaluate the validity of administering the EDI test through telemedicine in terms of its diagnostic concordance with the face-to-face modality.* **Methods:** *This analytical, prospective, and cross-sectional study included patients aged 18-72 months and was conducted at a tertiary care hospital in Mexico City. The test was administered through telemedicine and subsequently in person. In addition, sensitivity and specificity data were reported with confidence interval of 95% (95% CI). The face-to-face evaluator was blinded to the telemedicine results.* **Results:** *Fifty children with a median age of 47 months participated in the study. A sensitivity of 100% (95% CI, 91-100) and specificity of 100% (95% CI, 70-100) overall were obtained. Language was the higher area with a sensitivity of 100 (95% CI: 91-100) and specificity of 90 (59-98); the results for the other areas are shown. The lowest sensitivity was neurological examination (67; CI 95%: 30-90) but has the highest specificity (98; CI 95%: 88-99).* **Conclusion:** *The EDI test implemented through telemedicine shows high correlation with the face-to-face modality, maintaining high sensitivity and specificity. These results make it an appropriate method for screening children of this age, although further larger studies are needed to corroborate it.*

Keywords: *Child development. Telemedicine. Diagnostic agreement. Developmental assessment.*

Validez de la aplicación de la prueba evaluación del desarrollo infantil a través de telemedicina en niños de 18 meses a 72 meses de edad

Resumen

Introducción: *El desarrollo infantil tempano es un proceso complejo que requiere de herramientas confiables para la detección oportuna de alteraciones que puedan afectar el progreso del niño/a. La prueba Evaluación del Desarrollo Infantil (EDI), es un tamiz desarrollado y validado en México, para ser aplicada por un profesional de manera presencial. El objetivo es evaluar la validez de la prueba EDI aplicada por telemedicina en tanto a su concordancia diagnóstica con la modalidad presencial.*

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Métodos: *Estudio transversal analítico prospectivo con pacientes de 18-72 meses de edad, en un hospital de tercer nivel en la Ciudad de México. Se aplicó la prueba EDI por medio de telemedicina y posteriormente en forma presencial. Se reportó la sensibilidad y especificidad con intervalo de confianza de 95% (IC95%). El evaluador presencial fue cegado al resultado de telemedicina.* **Resultados**: *Participaron 50 niños con mediana de edad de 47 meses. Se encontró una sensibilidad 100% (IC95% 91-100) y especificidad del 100% (IC95% 70-100). El área de lenguaje tuvo la mayor sensibilidad 100 (IC95%: 91-100) con una especificidad de 90 (59-98); el resto de rsultados por área se describen. El examen neurológico tuvo la menor sensibilidad (67; CI 95%: 30-90) pero la mayor especificidad (98; CI 95%: 88-99).* **Conclusiones**: *La prueba EDI aplicada por telemedicina demuestra alta concordancia con la modalidad presencial, manteniendo alta sensibilidad y especificidad por lo que es adecuada para tamizaje en niños de esta edad, aunque se requieren estudios más grandes y en diferentes contextos para corroborarlo.*

Palabras clave: *Desarrollo Infantil. Telemedicina. Concordancia Diagnóstica. Evaluación del Desarrollo.*

Introduction

Early child development (ECD) is a transformative process in which children progressively acquire increasingly complex skills in areas such as movement, thought, emotion, and interpersonal relationships[1]. This human development forms the basis of the social capital and economic progress of nations, depending on a maturation process encompassing sensory capacities, motor, cognitive, linguistic and socioemotional skills, in addition to the self-regulation of behaviors and emotions. For these competencies to flourish, children must grow up in a nurturing environment characterized by sensitivity and affection – an environment that supports the full development of their potential[2,3].

According to data from the National Population Council (CONAPO), the estimated population of children under 6 years of age in Mexico was 13.1 million in 2019. It is projected that nearly 12.8 million children were born between 2019 and 2024. Of these, about 157,000 currently experience or will experience a disability[4,5].

Among children aged 3-5 years, 18% exhibit developmental delays for their age in at least three areas: Literacy or numeracy, physical and socioemotional development, and learning skills. More than 75% exhibit delays in literacy and numeracy, and only six out of ten children in this age range participate in early childhood education programs, whereas 65% lack access to children's books. Preschool education coverage reaches 48% of 3 year olds, while for 4-year-old children, this figure rises to 91.5%[4]. According to a National Survey (Ensanut) in 2022, national wide only 27.1% of children < 5 years has an ECD evaluation[6].

Early detection of alterations in child development is essential to guarantee the well-being of children and their families, as accurate diagnoses allow for timely intervention and ensure ongoing supervision of early childhood development. Before 2010, there were no systematic screening tests in Mexico that assessed child development[7]. Although section 9.6.1 of NOM-031-SSA1-1999, focusing on child health care, states that psychomotor development should be evaluated at each growth and development visit, it does not specify the instruments to be used for this assessment, instead it only refers to the limits of normal behavior described in Appendix F[8]. Since 2013, the Child Development Evaluation Test (EDI in its Spanish acronym), a developmental screening developed and validated in Mexico for the early detection of child development issues[9], is the recommended screening tool for Mexican children as a part of the national policy[5,10] and has shown better properties compared with other tests available in Mexico[11]. As 2020, EDI test is applicable from the 1st month of life until the day before the child's sixth birthday[12].

At present, the EDI test is part of Operating Guidelines of the National Center for Child Health (CeNSIA for its acronym in Spanish) Childhood Development component[5]. These guidelines indicate that every child should undergo at least one child development assessment per year, following the mandatory ages at 1 month and subsequently at ages 6, 18, 30, 42, and 60 months.

Ensuring the continuity of child development assessments became challenging during the SARS-CoV-2 pandemic, thus transforming traditional medical systems while encouraging the use of alternatives like telemedicine. This tool used as administering strategy offers the advantages of cost reduction, improved accessibility, and reduced waiting times[13,14] and also could help to increase the ECD evaluation coverage that is found nationwide[6].

The purpose of this study was to evaluate the diagnostic concordance of the EDI test between telemedicine and face-to-face modalities in patients aged 18-72 months.

Methods

An analytical, prospective, and cross-sectional design was adopted, aimed at evaluating the diagnostic agreement between the EDI test in person and through telemedicine. The protocol was submitted to and approved by the Research Ethics and Biosafety Committee under registration number HIM-2021-017 at Hospital Infantil de México Federico Gómez (HIMFG). The study was conducted between October and December of 2021. Convenience, non-probabilistic sampling was used, including patients aged 18-72 months who had been transferred to the Developmental and Behavioral Pediatrics Service (BDPS) of the HIMGF. Those participants whose native language was Spanish and who had access to the internet and necessary materials were included in the study after having signed the informed consent form. Exclusion criteria included those participants who could not be evaluated under both modalities, whose information was incomplete according to the variables of interest, and who withdrew their informed consent.

Instrument

The EDI test evaluates five major areas of development: gross motor (GM), fine motor (FM), language, social, and cognitive skills. In addition, it identifies biological risk factors, warning signs, and red flags, with the results classified using a traffic light system: green (normal development), yellow (developmental delay), and red (risk of developmental delay)[12].

Information regarding the general characteristics of the population and the risk factors associated with child development were collected and described from an environmental and biological perspective. Confounding variables that could influence the results were also identified, such as previous use of communication platforms (video-call technology) and whether the patient was a 1st-time user of the service. The target variable of the study was the EDI test result in two forms: Ordinal (green, yellow, and red) and dichotomous (normal: Green; abnormal: Yellow or red).

Procedure

To ensure consistency in test administration, three personnel underwent an 8-h training course on EDI, including theoretical and practical evaluations, with a minimum requirement of 90% correct answers. In addition, a group of experts carried out a practical verification to ensure that the personnel administering the instrument met the required standards.

The evaluation process was carried in five stages. First, participants were invited to participate through the pediatrics department, verifying their eligibility according to their corrected age and medical history.

The test was administered through telemedicine in a controlled environment (quiet room), where only the primary caregiver and the child were present. The primary caregiver used a portable computer device to interact through a virtual platform and specific materials, including a measuring tape for head circumference, which had been previously delivered to participants. In another room, the evaluator used a portable device and connected to the virtual platform. Both had their cameras on. After the evaluator's presentation and the section corresponding to the child's age, the EDI test was administered by the professional, who asked questions or gave detailed instructions to the primary caregiver or the child to assess each item. For the neurological examination, activities were modeled specifically related to head circumference measurement and other items. Subsequently, without knowledge of the telemedicine assessment results, the in-person test was administered during the physician's office visit, supplemented by the patient's physical examination and medical history. The time difference between the telemedicine and in-person assessments was a maximum of 1 week.

Both tests were scored based on the EDI manual,[12] and the results were recorded in a confidential, anonymized database. Finally, customized recommendations were provided based on the results obtained, and, if necessary, medical referrals were made.

Statistical analysis

The interobserver agreement analysis was assessed using Cohen's κ coefficient among the three health professionals who conducted the in-person evaluation before the start of the study. A descriptive analysis of the population was performed, calculating measures of central tendency and dispersion for quantitative variables while absolute and relative frequencies were shown for qualitative variables. Sensitivity, specificity, and confidence intervals were estimated using contingency tables with one degree of freedom for the EDI test applied through telemedicine, relative to the face-to-face assessment. The data were analyzed using SPSS software version 26.0.

Table 1. Description of universal demographic variables

Sex	
Female	40% (n = 20)
Male	60% (n = 30)
EDI test groups	
Group 9 (ages 16 months-18 months and 29 days)	6% (n = 3)
Group 10 (ages 19 months-24 months and 29 days)	0% (n = 0)
Group 11 (ages 25 months-30 months and 29 days)	12% (n = 6)
Group 12 (ages 31 months-36 months and 29 days)	10% (n = 5)
Group 13 (ages 37 months-48 months and 29 days)	22% (n = 11)
Group 14 (ages 49 months-59 months and 29 days)	34% (n = 17)
Group 15 (ages 60 months-71 months and 29 days)	16% (n = 8)
Place of origin	
Mexico City	34% (n = 17)
State of Mexico	42% (n = 21)
Interiors of the Republic	24% (n = 12)
Current place of residence	
Mexico City	36% (n = 18)
State of Mexico	50% (n = 25)
Interiors of the Republic	14% (n = 7)
Platform use by caregivers	
Yes	80% (n = 40)
No	20% (n = 10)
First-time patients in the pdyc service*	
Yes	64% (n = 32)
No	36% (n = 18)
Use of ICTs** in patients	
Yes	90% (n = 45)
No	10% (n = 5)
Preschool or kindergarten attendance	
Yes	42% (n = 21)
No	58% (n = 29)
Type of education	
On-site school	32% (n = 16)
Virtual school	10% (n = 5)
None	58% (n = 29)
Risk type	
Environmental risk of developmental delay	22% (n = 11)
Biological risk of developmental delay	48% (n = 24)
No risk to development	50% (n = 25)

Results

Before initiating the study, the overall agreement obtained between the three health professionals was higher than 0.9, indicating a very high level of agreement.

The study sample comprised 50 children, 60% male (n = 30) and 40% (n = 20) female, with a median age of 47 months (range, 18-70 months). The primary caregivers had a median age of 29 years (range, 20-53 years old). Of the total, 42% of participants (n = 21) attended preschool or early childhood education. Among them, 32% attended face-to-face school, and 10% took online lessons. In all, 64% (n = 32) were 1st-time patients in the Developmental and Behavioral Pediatrics Department (Table 1).

The place of origin of the population varied; 24% (n = 12) belonged to the interiors of the Mexican Republic, 34% (n = 17) were from Mexico City, and 42% (n = 21) were from the State of Mexico. The survey explored the use of digital platforms by the primary caregivers who attended the evaluation, finding that 80% (n = 40) were familiar with them, while 20% (n = 10) had never used them. In all, 90% (n = 40) had used information and communication technologies through different devices with internet connection (television, cell phone, or tablets).

Within the study population, an assessment was conducted to determine any potential risks for developmental delays. Of the participants, 22% (n = 11) exhibited environmental risk, 48% (n = 24) exhibited biological risk, and 50% (n = 25) exhibited no risk for developmental delay (Table 1).

Tables 2A and 2B present the categorical agreement between ordinal and dichotomous results, respectively. The overall sensitivity of the EDI test applied through telemedicine was of 100% (95% CI, 91-100%), and its overall specificity also reached 100% (95% CI, 70-100%) (Table 3).

The results showed greater variability by areas of development (Table 3). In the GM area, sensitivity was 86% (95% CI, 65-95%) and specificity was 83% (95% CI, 65-92%). In the FM area, sensitivity was 96% (95% CI, 81-99%) and specificity was 88% (95% CI, 69-96%). In the area of language (LE), sensitivity was 100% (95% CI, 91-100%) and specificity was 90% (95% CI, 59-98%). Regarding the social development area, sensitivity was 80% (95% CI, 58-92%) and specificity was 77% (95% CI, 59-88%).

In the area of knowledge, sensitivity reached 96% (95% CI, 79-99%), with a specificity of 67% (95% CI, 39-86%). Finally, in the neurological examination, sensitivity was 67% (95% CI, 30-90%) and specificity 98% (95% CI, 88-99%).

Discussion

This study examined the validity of the EDI test applied through telemedicine, based on its diagnostic concordance with the face-to-face version of the test.

The results indicated a sensitivity and specificity of 100% as the overall score, with confidence intervals ranging between 91% and 100% and 70% and 100.

However, when the developmental domains were analyzed individually, it was found that the social domain exhibited the lowest sensitivity and specificity. This was unexpected as the responses in both modalities were provided by the same primary caregiver (direct questions instead of observed behaviors during the administration). This discrepancy may be attributed to differences in reporting, as described by Barnett et al.[15] in 2018, as well as in observations that are guided by the clinician in the face-to-face modality.

With respect to the traffic light classification system (green, yellow, and red), significant differences were observed between the yellow and red categories. Telemedicine evaluations yielded more cases with a yellow rating, whereas in the face-to-face modality, the same patients were classified as being part of the red group (Tables 2A, 2B, and 3). It is recommended to prioritize the yellow results obtained through telemedicine in the same manner as the red ones, as both indicate a risk of developmental delay and should be evaluated personally, at the primary care facilities doing the evaluation in person.

Regarding the neurological exploration area, in this study, there were discrepancies in the measurement of head circumference, with differences of up to 3 cm between the online measurements and those taken in person. Thus, more precise measurement techniques should be implemented, such as taking three consecutive measurements (similar to a height assessment) or performing the measurement at a primary health center. In the case of a red result in this area, as it is crucial to refer the patient to the second level of care for a comprehensive neurological evaluation and timely treatment,[16,17] the corroboration of the result must be done in person at primary care facilities before to stablish a presumptive diagnosis and stressing the family.

Finally for the online EDI administration, it is essential to provide detailed feedback to the primary caregivers, emphasizing EDI test results, especially in the cases of yellow or red results. This guidance will facilitate timely interventions to support the patient's development. Larger studies and with different population and in different settings are needed to stablish the adequations needed for online administration.

The challenges of physical examination through telemedicine were shown by Barney et al.[14] found that 97% of adolescent and young adult consultations were successfully completed through telemedicine. However, certain barriers existed with regard to physical examinations and safety, particularly in terms of mental health, eating disorders, and addictions.

Table 2A. Concordance of EDI in face-to-face versus telemedicine modalities with ordinal outcomes

Modality	On-site		
	Red	Yellow	Green
Telemedicine			
Red	34	2	0
Yellow	2	3	0
Green	0	0	9

Table 2B. Concordance in face-to-face versus telemedicine modality with dichotomous results

Modality	On-site	
	Abnormal	Normal
Telemedicine		
Abnormal	41	0
Normal	0	9

Taylor and Portnoy[18] highlighted the effectiveness of telemedicine in rural communities and emergency departments, emphasizing its potential for integration into daily practice. Given the results of this study, it could be suggested that only the developmental areas axis could be administered as telemedicine, and the neurological examination realized in person to avoid confusions, and to consider a dichotomic result for the patients, normal or further evaluation in person in the primary care facilities are needed (to avoid incorrect labeling and stress for the family).

In the pediatric setting, Ray et al.[19] analyzed families' perceptions of telemedicine and found that caregivers value it as complementary to, rather than a replacement for, face-to-face visits. In the context of neurodevelopmental disorders, Valentine et al.[20] reviewed 42 studies conducted between 2018 and 2019 and concluded that telemedicine is effective for diagnosis and follow-up. Furthermore, it has been shown to offer economic benefits while improving access to services. In this context, this form of administration of EDI test through telemedicine could help to increase the coverage of ECD evaluated children, under optimal conditions of connectivity and access to information and communication technologies and could set a precedent and benefit children in remote communities or in situations of economic vulnerability where access to in-person evaluations is limited.

Table 3. Calculation of sensitivity and specificity of the EDI test conducted through telemedicine, compared with the face-to-face assessment

Result	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	Positive predictive value (%)	Negative predictive value (%)
Global EDI result	100 (91-100)	100 (70-100)	100	100
Gross motor	86 (65-95)	83 (65-92)	78	88
Fine motor	96 (81-99)	87 (69-96)	89	95
Language	100 (91-100)	90 (59-98)	97	100
Social	80 (58-92)	77 (59-88)	69	85
Knowledge	96 (79-99)	67 (39-86)	84	88
Neurological examination	67 (30-90)	98 (88-99)	80	95

This preliminary study has several limitations, such as the small sample, the convenience sampling, that only patients as one site were enrolled, the range of age for the screening, and the results are shown for all the age range and not for specific age groups of the EDI test and that all the telemedicine evaluations were carried before the in-person evaluation.

Conclusion

The results showed that the infant developmental screening (EDI) test carried out through telemedicine exhibits adequate sensitivity and specificity for children aged 18-72 months old. However, in the case of an abnormal EDI test result (yellow/red) in any developmental area or neurological examination, a complete on-site clinical evaluation is advisable. Moreover, further research in different settings is required to corroborate these findings.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical considerations

Protection of humans and animals. The authors declare that no experiments involving humans or animals were conducted for this research.

Confidentiality, informed consent, and ethical approval. The authors have followed their institution's confidentiality protocols, obtained informed consent from patients, and received approval from the Ethics Committee. The SAGER guidelines were followed according to the nature of the study.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

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