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Child development evaluation in Latin-America: a vision through XXI century

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Content

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EDITORIAL

The first 1000 days: the great opportunity

Los primeros 1000 días de vida: la gran oportunidad

Marta M. Zapata-Tarrés

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"*Many of the things we need can wait; children cannot. Now is the time: their bones are forming, their blood is too, and their senses are developing. We cannot tell them 'tomorrow;' their name is today.*"

—Gabriela Mistral

The first 1000 days of life span from conception to the 2nd year of life have been demonstrated to be a decisive period in human development. During this period, human beings grow at an incredible speed, laying the foundations for physical, emotional, and cognitive health for life. The decisions made regarding this person, from the moment of pregnancy, not only affect their current health but also define their future health. This stage can unfold naturally, with processes taking place despite any deficiencies or hardships. However, it is through education and responsibility that it becomes possible to modify these determinants. The first 1000 days are one of the most vulnerable stages of life; therefore, adequate nutrition, basic healthcare, and a stable emotional environment can make a big difference[1-6].

From a biological perspective, the development of the organism, particularly the brain, is remarkable; neuronal connections grow at an unprecedented rate, and the way a child experiences the world during this stage is fundamental to their capacity to learn, think, and establish relationships with others[7,8].

This is the first great opportunity: early motivation. Children interact with their mother, play with their caregivers, and if this takes place in a safe and welcoming environment, they will have greater and better chances of developing cognitive, linguistic, and emotional skills that will last a lifetime. These interactions influence not only their quantity but, above all, their quality. Societies that invest in education, healthcare, and family support can ensure a substantial change in potential, transforming reality and guaranteeing equality of opportunities from the very beginning. The motivation of knowing they can change their environment is a lesson that will shape the way they attend school, navigate society, and understand that they are not destined to a future bound by the same conditions[9].

Parallel to this process, physical and emotional development play a fundamental role. To achieve this, breastfeeding must be exclusive during the first 6 months of life, ensuring that the newborn receives all necessary nutrients and immunoglobulins, as well as affection and attachment. In this regard, we must recognize that achieving this goal requires supporting mothers through maternity leave and breastfeeding facilities in their workplaces[1-4]. Failure to guarantee these rights increases the risk of malnutrition and preventable diseases.

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This supplement of the *Boletín Médico del Hospital Infantil de México* addresses the subject of child development, focusing on the evaluation and early detection of possible disorders. In addition, it offers an updated and highly relevant review for all countries in the region, describing the screening tests available in the Americas, the policy-making process in Peru regarding child development evaluation, and the experience of validating a Mexican screening test in Colombia. A series of studies highlight the Mexican effort to establish a diagnosis of developmental levels through a screening test developed by Mexicans for Mexican children and children worldwide. This tool, the Child Development Evaluation or CDE test[10], results in a color-coded system that prompts families and healthcare providers to request confirmation and take timely action. Validating, implementing, and disseminating the test across various settings and with different stakeholders, including through telemedicine, was necessary. Furthermore, this supplement includes the story of the unwavering commitment of the Developmental and Behavioral Pediatrics Service at the *Hospital Infantil de México Federico Gómez*, led by Antonio Rizzoli, to the development of Mexican boys and girls.

Public policy has far-reaching implications in this regard. Improving the quality of maternal and child health programs, nutrition, immunizations, and promoting safe spaces is an investment not only in the child but also in the future of society. The cost of not intervening rapidly is high, as affecting individual development impacts the collective potential of the country.

Opportunities should also focus on emotional health, as research has shown that this period represents a unique window to build strong relationships that form the foundation of long-term emotional well-being. Children who experience secure attachment, who are hugged and listened to, are more emotionally stable, better able to cope with stress, and more likely to develop positive relationships in the future. These actions, which align with the original definition of biopsychosocial health, are achieved through community programs and family support strategies that receive adequate resources to establish these connections and foster prosperity[9].

Today, poverty, violence, and lack of resources can hinder this process. However, early intervention can generate decisive changes. In the context of global inequality, opportunities to improve the lives of the most disadvantaged children are more urgent than ever. All children deserve to feel safe and cared for, regardless of their social or economic background.

Every child is a promise for the future. The first 1,000 days are undoubtedly a great opportunity because by changing the life of one child, we can change the destiny of society. The decisions we make now will shape the world of tomorrow.

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EDITORIAL

The future of children is always today

El futuro de los niños es siempre hoy

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"The future of children is always today. Tomorrow will be too late." The great poet Gabriela Mistral said this phrase almost a century ago, yet we still owe a great debt to childhood, despite the Convention on the Rights of the Child, signed by all countries on November 20, 1989[1]. Many issues have since been highlighted, among them the right of every boy and girl to achieve their optimal potential for physical, cognitive, psychological, social, behavioral, and affective development, regardless of their ethnicity, nationality, socioeconomic status, or their parents' level of education.

There is compelling evidence of the critical importance of the first thousand days of life in the integral development of the human being – a pivotal period for development and one of intense neuronal activity, during which the most complex neural circuits are formed compared to the rest of life. Whatever is done or left undone during this period will have far-reaching consequences at different stages of life[2-4].

The ecological model of child development by Bronfenbrenner[5] considers that development as a whole depends on the dynamic interaction between the boy or girl and their environment, represented from the macro to the micro level by the state, the community, and the family. Each of these holds norms, values, and responsibilities (public policies, institutional frameworks, organizational models, community participation, love, care, and the fulfillment of children's immediate needs).

Today, when everything tends to be evaluated from an economic perspective, Nobel laureate in Economics from the University of Chicago, James Heckman, demonstrated in 2005 that the return rate on investment in early childhood is very high – up to eight times the amount invested[6]. This return rate decreases during the school years and higher education, eventually flattening in adulthood. While there is a return on investment at every stage of life, nothing compares to early childhood. There is extensive evidence from neuroscience and social sciences regarding the determining and risk factors in development, such as poverty, lack of stimulation, emotional attachment, violence, and abuse. Prolonged and toxic stress caused by these risk factors leads to increased production of adrenaline, noradrenaline, and cortisol, which have lifelong consequences, including deficits in cognitive and psychosocial skills that translate into higher school dropout rates, delinquency, substance abuse, deterioration of self-esteem, self-efficacy, and empathy, as well as a greater prevalence of mental health issues and early onset of non-communicable chronic diseases[2-4].

If we know what must be done and the tremendous advantages of accompanying and strengthening development during these first thousand days of life, why don't we do it?

Could it be that we have only fought for survival? Could it be that children have no voice and are rendered invisible? Could it be that those of us with the

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knowledge and the related institutions have not been able to advocate enough or spread the knowledge to reach the necessary political levels?

The United Nations Children's Fund, the Pan American Health Organization, and other organizations have been publishing studies, successful experiences, and developing intervention models for decades. Despite this, we are still far from reducing the rates of developmental delay[7-9].

Today, more than 250,000,000 children under 5 years of age (43%) worldwide experience deficient biopsychosocial development, with the vast majority of cases concentrated in countries with the greatest socioeconomic and educational vulnerabilities, as well as those with the highest levels of inequity[8-10].

Public policies for child protection must be intersectoral, as many sectors and actors are involved (health, education, and social security, among others). This requires the capability to work in both multidisciplinary and transdisciplinary ways, blending biological and social sciences, an enormous challenge for developing countries[2,11].

To create good policies, plans, and programs, it is required to have accurate information and appropriate instruments and indicators. Only in this way can we determine whether our efforts are correctly aligned with our objectives[12,13].

Mexico has been a pioneer in this field, and it is noteworthy when major initiatives in the area of development emerge from a pediatric hospital. Such is the case of the Developmental and Behavioral Pediatrics Service at the Hospital Infantil de México Federico Gómez, led by Antonio Rizzoli and his team, who, in addition to sharing experiences between Chile and Mexico, are training Developmental Pediatricians who will undoubtedly have the leadership necessary to advance our region toward a childhood where the right to development is respected.

Building instruments to measure child development is a complex task because it requires evaluating multiple dimensions. Validating an instrument for use at the national level is an enormous effort. This is why the contribution of the Child Development Evaluation Test test[14], an instrument developed, validated, and implemented as part of public policy in Mexico, and the lessons, challenges, and opportunities derived from it represent an invaluable contribution to the region.

Many instruments have emerged over time; some are in use in certain countries, but others are either too complex or expensive to apply or have not yet been validated across different populations. It remains up to each country to decide which developmental assessment tool to use, highlighting the relevance of the umbrella review of various screening tests developed in Latin America.

Therefore, the content of this special supplement of the *Boletín Médico del Hospital Infantil de México* is of utmost importance, as it provides highly valuable information at an international level, specially for Latin American countries. The experiences presented here can be replicated and adapted in different contexts, but the most important aspect is how this wealth of knowledge and scientific experience is put into practice in countries and applied to childhood through national policies with a sense of urgency. The first thousand days pass quickly, and the future of children must always be today.

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RESEARCH ARTICLE

Early developmental screening tools constructed in Latin American countries: umbrella review

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Abstract

Background: *Multiple early childhood development (ECD) screening instruments have been developed in Latin America.* **Objective:** *The objective of this study was to describe ECD screening tests for children under 4 years of age constructed in Latin American countries in the context of healthcare, currently in use.* **Methods:** *A systematic review of literature published until April 2024 was conducted to identify screening tests constructed in Latin America. The search for each test was expanded, and individual records were completed. Authors of the instruments and/or their validations were identified and contacted to corroborate the information. An ECD screening test was defined as one that assesses at least three different domains. Only tests used in the healthcare system were included in the study. Those without publications and/or accessible information were excluded from the study.* **Results:** *Twenty-one tests constructed in nine countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Mexico, Peru, and Uruguay) were included, many used in different countries of the region. Seven were constructed and/or validated in the past 5 years. They predominantly consist of direct assessment or questions to primary caregivers. Four were validated for online use, and one for virtual use. In the validation, most combined different psychometric analyses, with heterogeneity in methodology and reference patterns. Median summary sensitivity was 0.67 (95% confidence interval [CI] 0.34-1.0), and specificity was 0.71 (95% CI 0.42-1.0).* **Conclusions:** *The ECD screening tests developed in Latin America show thorough validation and ongoing updates, though they exhibit some variability. Direct assessment using paper predominates. The consistency of the instruments, when used in different countries and populations, stands out.*

Keywords: *Child development. Neurodevelopmental disorders. Neuropsychological tests. Latin America.*

Pruebas de tamizaje del desarrollo infantil temprano construidas en Latinoamérica: revisión paraguas

Resumen

Introducción: *En Latinoamérica hay múltiples instrumentos de screening desarrollo infantil temprano (DIT).* **Objetivo:** *Describir los instrumentos de tamizaje de DIT para niños/as menores de 4 años construidos en países latinoamericanos en el contexto de la atención de salud, y están vigentes.* **Métodos:** *Revisión sistemática de literatura publicada hasta abril 2024 para identificar pruebas construidas en Latinoamérica. Se profundizó la búsqueda dirigida y se completó ficha individual.*

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Se contactaron a autores de los instrumentos y/o validaciones, para corroborar la información. Se definió como prueba de tamizaje de DIT aquella que evalúa al menos 3 dominios diferentes. Sólo se incluyeron instrumentos en uso en sistema de salud. Se excluyeron las que no tenían publicaciones y/o información accesible. **Resultados:** *Se seleccionaron 21 instrumentos construidos en 9 países (Argentina, Brasil, Chile, Colombia, Costa Rica, Cuba, México, Perú y Uruguay), muchos utilizados en distintos países de la región. Siete pruebas fueron construidas y/o validadas en los últimos 5 años. Predominaron instrumentos de evaluación directa exclusiva o asociada a preguntas a cuidadores principales. Cuatro fueron validados para aplicación online y uno virtual. En la validación, la mayoría combinó distintos análisis psicométricos, con gran heterogeneidad en metodología y patrones de referencia. La mediana resumen de sensibilidad 0,67 (intervalo de confianza 95% (IC95) 0,34-1,0) y especificidad 0,71 (IC95% 0,42-1,0).* **Conclusiones:** *Los instrumentos de tamizaje del DIT construidos en Latinoamérica muestran procesos exhaustivos de validación y actualización, con heterogeneidad entre ellos. Predomina la evaluación directa en papel. Destaca la consistencia de los instrumentos al utilizarse en países y poblaciones.*

Palabras clave: *Desarrollo infantil. Trastornos del neurodesarrollo. Pruebas Neuropsicológicas. Prueba de detección. América Latina.*

Introduction

Early childhood development (ECD) is how children acquire motor, cognitive, linguistic, and socioemotional skills from complex interactions among multiple biological, psychological, and social factors. It is estimated that globally, 1 in 5-6 children will not reach their developmental potential[1], with a gradient related to the socioeconomic and educational level of countries and populations[2]. Considering the evidence that early detection and timely intervention of developmental delays favorably impact the child's future, their family, and society[3], this has been established as a priority indicator among the global sustainable development goals for 2030[4].

This is why periodic developmental surveillance as part of health supervision is recommended to identify in a timely manner those children who deviate from typical development and who would benefit from targeted intervention[5]. When warning signs are present or at specific ages, culturally valid and reliable standardized tests that are simple to administer and easy to interpret should be applied[6].

Although multiple ECD screening instruments have been developed in Latin America, the most widely used ones come from the United States of North America without necessarily undergoing a prior cultural validation or adaptation process[7]. To achieve universal administration of screening instruments, especially in low- and middle-income countries, broader care coverage is required, along with recurring training of health professionals and/or promoters, accompanied by cultural and ecological validations or adaptations of the tests[8]. Understanding the validation processes enables decision-making, both at clinical and public policy levels[9].

While there are previous reviews[8,10-12], we did not find any that include all currently valid tests, probably because instrument development follows a dynamic process of construction and updating. Therefore, this research aims to describe the ECD screening instruments for children under 4 years of age that were developed in Latin American countries in the context of health care and are currently in use.

Methods

This is a systematic review of all literature published until April 2024.

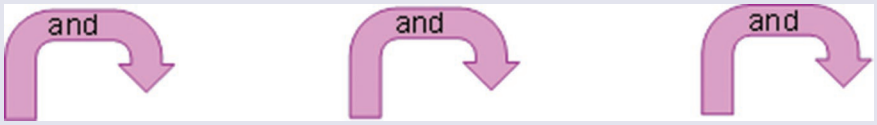
Literature search

The review was conducted in three stages. In the first stage, developmental screening tests used in Latin America were identified through a literature search in PubMed, Scielo, Lilacs, Dialnet, and PsycNET databases. The focus was on manuscripts that describe instruments used and developed in Latin American countries. A series of Medical Subject Headings terms was used for this purpose (Table 1).

Through the bibliographic search, instruments were identified in the selected studies. After their selection, an exhaustive search was conducted for each instrument, individual data sheets were completed, and the authors of the instruments and/or validation publications were identified.

The authors were contacted and asked to complete or correct the information in the test data sheets and complement the bibliographic review. The information gathered was cross-checked and discussed among the present study's authors. When the results tables were

Table 1. MeSH terms used in bibliographic search



Children	Child development	Screening instruments Child development	Latin American countries
"Child" [MeSH Terms] OR "children" [All Fields] OR "Infant" [MeSH Terms]	"Child Development" [MeSH Terms] OR "Child Development" [All Fields] OR "neurodevelopmental" [All Fields] OR "neurodevelopmentally" [All Fields] OR "Psychomotor Disorders" [Mesh]	("Predictive Value of Tests" [MeSH Terms] OR "developmental screening" [All Fields] OR "developmental screening instruments" [All Fields] OR "Developmental Screening Test" [All Fields] OR "Surveys and Questionnaires" [MeSH Terms] OR "Mass Screening" [Mesh])	"latin america" [MeSH Terms] OR "latin america" [All Fields] OR "Mexico" [MeSH Terms] OR "Mexico" [All Fields] OR "Nicaragua" [MeSH Terms] OR "Nicaragua" [All Fields] OR "Panama" [MeSH Terms] OR "Panama" [All Fields] OR "Paraguay" [MeSH Terms] OR "Paraguay" [All Fields] OR "Peru" [MeSH Terms] OR "Peru" [All Fields] OR "Republica Dominicana" [All Fields] OR "Argentina" [MeSH Terms] OR "Argentina" [All Fields] OR "Bolivia" [MeSH Terms] OR "Bolivia" [All Fields] OR "Brazil" [MeSH Terms] OR "Brazil" [All Fields] OR "Colombia" [MeSH Terms] OR "Colombia" [All Fields] OR "Costa Rica" [MeSH Terms] OR "Costa Rica" [All Fields] OR "Cuba" [MeSH Terms] OR "Cuba" [All Fields] OR "Chile" [MeSH Terms] OR "Chile" [All Fields] OR "Ecuador" [MeSH Terms] OR "Ecuador" [All Fields] OR "El Salvador" [MeSH Terms] OR "El Salvador" [All Fields] OR "Guatemala" [MeSH Terms] OR "Guatemala" [All Fields]

MeSH: Medical Subject Headings.

ready, they were returned to the authors for final validation.

Study selection criteria

Studies published in English or Spanish were included. Scientific articles and conference abstracts were considered. Published conference proceedings and posters, scale publications, and technical reports were also included in the analysis.

Two reviewers (LS and IO) independently and transparently evaluated article selection and ECD instruments. Any discrepancies between them were resolved through consensus. A template was used to collect data based on information from the selected articles, with emphasis on identifying developmental screening instruments that met the inclusion criteria.

Selection criteria for included tests

ECD screening tests were defined as those that evaluate multiple domains, including at least three areas of development. Only scales constructed in Latin American countries and currently used in the health field were included in the study.

Initially excluded were instruments not originally constructed in Latin American countries, instruments designed to evaluate preschoolers from age 4 onwards, those that did not include at least three different developmental domains, scales used for diagnostic evaluation rather than screening, academic assessments, and national surveys. Finally, tests for which no available publications were found that would allow analysis of their construction process were excluded from the study.

Data systematization

For each instrument, the following information was collected: (1) test details: name, abbreviation, versions, year of validation/revalidation/new versions, domains evaluated, target age group, administration time, and administration method. (2) Psychometric methodologies used in validation, including reliability measures

and concurrent validity studies: number of children in which it was validated, reference standard, and sensitivity/specificity. (3) Countries in the region and/or special groups in which the test has been validated and/or used as a measure of consistency and measurement invariance across different geographical and clinical contexts.

Results synthesis

Only tests that analyzed concurrent criterion validity considering a reference standard were included for the analysis of results synthesis. From the results extracted from publications and/or requested from the authors, 2 × 2 tables were constructed that included the variables: true positives, false positives, true negatives, and false negatives. Forest plot figures and summary receiver operating characteristic (SROC) curves were constructed using version 2 of "Graphical enhancements to SROC plots to facilitate the analysis and reporting of meta-analysis of diagnostic test accuracy data"[13,14].

Results

Through the bibliographic search, 628 unique manuscripts were obtained, of which 66 were selected for abstract review and 33 for full reading. One hundred and forty-three instruments were identified and analyzed in-depth; 25 instruments met the selection criteria, with 4 being discarded due to lack of current use or information, resulting in a final sample of 21 instruments (Fig. 1)[15].

The directed search combined with authors' contributions yielded 93 manuscripts, including manuals and technical sheets, which were reviewed to construct the data sheets for each test. One of the test authors or validation authors corroborated these data sheets.

The included instruments come from Argentina (3)[16-26], Brazil (3)[27-34], Chile (3)[35-39], Colombia (1)[40,41], Costa Rica (1)[42-45], Cuba (2)[46-51], Mexico (6)[52-70], Peru (1)[71,72], and Uruguay (1)[73,74]. Of these 21 instruments, two corresponded to shortened or pre-screening versions, such as PRUNAPE and PRUNAPE pre-screening (CPPP) in Argentina and IDADI and IDADI-B (short) in Brazil (Table 2).

For 12 instruments (57%), published evidence was found of their application and/or validation in population samples different from the original sample, and 5 (34%) in special populations, such as children with Down syndrome (TADI-2), with Autism Spectrum Disorder (IDADI and REBA-PED), with sequelae of Perinatal Encephalopathy (VANEDELA), and in indigenous, marginalized, and migrant populations (TADI-2, PTNI) (Table 3).

General analysis of questionnaires

Table 2 presents the general analysis of the questionnaires, which were constructed from the 1970s to the present. Eleven (52%) have been constructed and/or validated in the past 10 years (2014 or later) and 7 (33%) within the past 5 years. Two peaks in instrument publication stand out in 2013 and 2021.

According to the instrument selection criteria, which considered children under 4 years of age, 8 (38%) are validated to begin being applied from the neonatal period, 19 (90%) can continue to be applied after 4 years, and only one extends into adolescence (INDIPCD-R2).

Administration time has a wide range, from a few minutes to 1 h. Fourteen (67%) report administration times of 20 min or less, including the shortened versions of the PRUNAPE/CPPP and IDADI/IDADI-B instruments.

Among the reviewed tests that met the criteria of evaluating at least 3 developmental areas, the comprehensiveness of domains in ECD evaluation stands out. Some instruments, like INDIPCD-R, focus on functional areas, while VANEDELA evaluates development, somatometry, and developmental reactions. Some instruments also include warning/alert signs (VANEDELA and EDI). Another particularity was found in the EDI test, which includes neurological exploration and biological risk factors.

Outstanding diversity is noted in test application methods. Nine use direct evaluation (43%), 7 (33%) combine direct evaluation/observation and questions to parents/primary caregivers, and 5 (24%) are parent/primary caregiver reports or interviews. Four (19%) of the instruments have been validated for online use, and one can be applied virtually, while the rest continue with the traditional "pencil and paper" modality.

Instrument validation methodology

Regarding validation processes, there is significant variability among instruments, noting that those constructed from 2013 onwards better describe the combination of different strategies to measure validity and reliability (Table 3)[16-86].

Thirteen instruments (62%) describe content selection and validation processes, 15 (71%) describe criterion

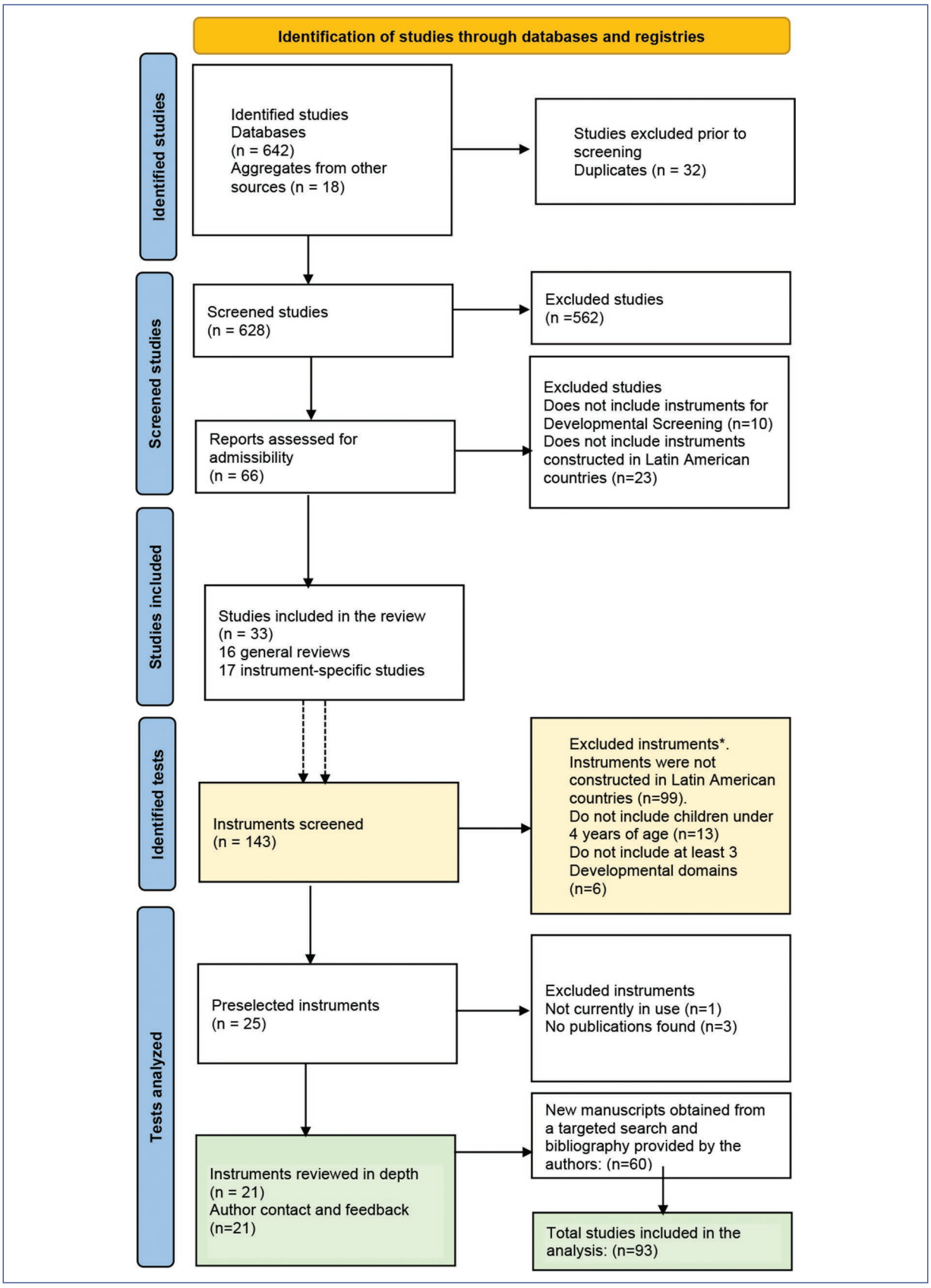


Figure 1. PRISMA flow chart with the instruments included in the bibliographic search[15].

Table 2. General characteristics of screening scales constructed in Latin American countries

Country	Name	Abbreviation	Year of publication	Age group	T' administration	Test administration method	Domains	References
Argentina	National Screening Test *Prueba Nacional de Pesquisa*	PRUNAPE	2002	0-72 months (0-5,99 years)	20-30 min	Direct assessment + questions to parents	Fine motor, gross motor, personal-social, language, and cognitive function are explored within the language and personal-social domains.	16-21,24
Argentina	Pre-survey PRUNAPE Questionnaire *Cuestionario PRUNAPE pre-pesquisa*	CPPP	2013	6-72 months (0.5-5.99 years)	5-13 min (7 min on average)	Direct assessment + questions to parents	Fine motor, gross motor, personal-social, language, and cognitive function.	22-24
Argentina	Child Development Observation Instrument for Children Under 4 Years of Age *Instrumento de Observación del Desarrollo Infantil para Niñas y Niños Menores de 4 Años*	IODI	2017	0-48 months	15-20 min	Direct observation + parental questions during pediatric health supervision consultation	Bonding, social-emotional, motor development, visual-motor coordination, cognitive, communication, and bonding patterns.	25,26
Brazil	Child Development Assessment Questionnaire *Questionário para Avaliação do Desenvolvimento Infantil*	QAD-PIPAS	2016	0-59 months	20 min	Parent/caregiver interview	Motor, cognitive, language, and social-emotional.	27,28
Brazil	Dimensional Inventory of Child Development Assessment *Inventário Dimensional da Avaliação do Desenvolvimento Infantil*	IDADI	2020	4-72 months	40-60 min	Parent/caregiver or professional report. Available in online version.	Cognitive, socioemotional, and communication: receptive and expressive language, gross and fine motor skills, and adaptive behavior.	29-31,34
Brazil	Dimensional Inventory of Child Development Assessment - short version *Inventário Dimensional da Avaliação do Desenvolvimento Infantil- short version*	IDADI-B (Short)	2021	4-72 months	15 min	Parent/caregiver or professional report. Available in online version.	Cognitive, socioemotional, and communication: receptive and expressive language, gross and fine motor skills, and adaptive behavior.	32,33

(Continues)

Table 2. General characteristics of screening scales constructed in Latin American countries *(continued)*

Country	Name	Abbreviation	Year of publication	Age group	T' administration	Test administration method	Domains	References
Chile	Psychomotor Development Assessment Scale *Escala de Evaluación del Desarrollo Psicomotor*	EEDP	1978	0-2 years	20 min	Direct assessment	Motor, coordination, social, and language.	35
Chile	Psychomotor Development Test *Test de Desarrollo Psicomotor*	TEPSI	1980	2-5 years	30-45 min	Direct assessment	Motor, coordination, and language.	36
Chile	Test of Child Learning and Development *Test de Aprendizaje y Desarrollo Infantil*	TADI/TADI-2	2012/2023	6-72 months	20 and 40 min	Direct assessment + questions to parents	Cognition, motor, language, and socioemotional.	37-39
Colombia	Abbreviated Developmental Scale *Escala Abreviada del Desarrollo*	EAD/EAD-3	1987-1990/2016	0-84 months	NR	Direct assessment	Fine-adaptive motor, gross motor, hearing and language, and personal social.	40,41
Costa Rica	Simplified Scale for the Evaluation of the Integral Development of the Child from 0 to 6 years of age *Escala simplificada de Evaluación del Desarrollo Integral de la niña y el niño de 0 a 6 años*	EDIN/EDIN II	1987/2013	0-72 months	NR	Direct assessment	Fine motor, gross motor, language, social-emotional, and cognitive.	42-45
Cuba	Tool for the early detection of developmental delays. *Herramienta para la detección precoz de retrasos en el desarrollo*	NPED/NPedDesk	2007	3-72 months	10-15 min	Direct assessment using an automated, computerized and portable online tool (on different digital platforms).	Language/communication, psychomotor, and sensory maturation (vision/ hearing). Social-emotional development is assessed transversally, that is, it is observed in conjunction with other areas of development.	46-48

(Continues)

Table 2. General characteristics of screening scales constructed in Latin American countries *(continued)*

Country	Name	Abbreviation	Year of publication	Age group	T' administration	Test administration method	Domains	References
Cuba	Neurodevelopmental Disorders Screening Instrument *Instrumento de Pesquisa de Trastornos del Neurodesarrollo*	EDPSIM	2019	0-72 months	15-20 min	Direct assessment + questions to parents	Personal/social, language, fine motor, gross motor; and the cognitive area is assessed by understanding and solving problems that are posed to evaluate patterns of the above-mentioned areas.	49-51
Mexico	Child Development Assessment Test *Prueba de Evaluación del Desarrollo Infantil*	EDI/EDI Modified version/2nd ed.ition	2010/2013/2021	1-60 months From 1 months to 5 years 11 months 29 days	5-15 min	Direct assessment and directed questions	Gross motor, fine motor, social, language, cognition, cognition, neurological screening, biological risk factors, and alarm/warning signs.	52-60
Mexico	Screening Test to Assess Child Neurodevelopment *Prueba de tamiz para evaluar el Neurodesarrollo Infantil*	PTNI	2013	11-49 months	15-20 min	Direct assessment	Fine and gross motor, language, cognition, cognitive, social-affective, and independence.	61
Mexico	Developmental Behavior Profile/revised *Perfil de Conductas de Desarrollo/revisado*	PDC/PCD-R	1997/2006	0-48 months	20-40 min	Direct assessment	Gross motor, expressive language, receptive language, emotional/ social, manual dexterity, cognition, and praxis.	62,64
Mexico	Developmental Behavioral Profile Risk Behavior Indicators *Indicadores de conductas de riesgo del Perfil de Conductas del Desarrollo*	INDIPCD-R/INDIPCD-R2	2012/2021	6 months-12 years	5-15 min	Assessment answered by parents. Available for online application	It is defined by risk indicators in different areas of development, including neurological signs, difficulties in social interaction, sensory processing, cognition, and motor organization. It does not subdivide areas of development.	63-65,69

(Continues)

Table 2. General characteristics of screening scales constructed in Latin American countries *(continued)*

Country	Name	Abbreviation	Year of publication	Age group	T' administration	Test administration method	Domains	References
Mexico	Neurobehavioral Assessment of Infant Development *Valoración Neuroconductual del Desarrollo del Lactante*	VANEDELA	1985/1999/2007/2013	1-24 months	10-15 min	Direct assessment	Somatometry, developmental behaviors, developmental reactions, and warning signs.	66,67
Mexico	Surveillance Templates for Identifying Disturbances in Infant Development *Cartillas de Vigilancia para identificar alteraciones en el Desarrollo del Lactante*	SIVIPRODIN	2014	1-24 months	10 min	Questions to primary caregivers	Neurobehavioral screening: developmental behaviors (not divided by domains, but includes five basic areas of development: motor, language, personal social, socioemotional, cognition), mother/child binomial indicators, and psychosocial risk.	68,70
Peru	Rebagliati Hospital Infant Developmental Assessment Profile *Perfil de Evaluación del Desarrollo Infantil del Hospital Rebagliati*	REBA-PED	2021	1-60 months	5-10 min	Direct assessment or questions to parents or primary caregiver (face-to-face or virtual)	Gross motor skills, fine motor skills, hearing and language, intelligence, and personal-social learning.	71,72
Uruguay	National Guidelines for the Surveillance of Child Development under 5 years of age *Guía Nacional para la Vigilancia del desarrollo del Niño y la Niña menores de 5 años*	GNVD/GNVD V2	2010/2018	0-5 years	20 min (range 15-30 min according to age)	Direct assessment	Motor, coordination, social, and language.	73,74

Table 3. Psychometric characteristics of child development screening instruments constructed in Latin American countries

Country	Abbreviation	Validation Process	Number of children used for validation	Reference Standard**	Sensitivity/specificity and predictive values**	Reliability	Other validation studies in the region	References
Argentina	PRUNAPE	Content validity Concurrent criterion validity through different specific objective and internationally validated tests	106	Evaluation with objective tests administered by specialists in seven areas: ophthalmology, neurology, otolaryngology, higher brain functions, language, social relationship, growth, and development.	S: 0.80 E: 0.93 PPV: 0.95 NPV: 0.77	Cohen κ 0.72	Psychometric studies have been replicated in different parts of Argentina and Ecuador. In Cuba it has been used as a reference standard for the validation of developmental scales.	16-18, 20,24,75
Argentina	CPPP	Concurrent criterion validity	533	PRUNAPE	S: 0.42-0.43 E: 0.8-0.85 PPV: 0.71-0.76 NPV: 0.57-0.79 (depending on whether it is self-administered or administered by health personnel)	NR	NR	22,24
Argentina	IODI	Content validation by expert consensus Inter-observer agreement Implementation Feasibility Analysis (qualitative)	110 observations for feasibility analysis	NR	No psychometric studies	No psychometric studies	Psychometric analysis of the IODI taking PRUNAPE as a reference in 91 Argentinean children S: 0.88 E: 0.79 VPP: 0.60 NPV: 0.95	26,77
Brazil	QAD-PIPAS	Content validation by expert consensus Discriminant construct validity Concurrent criterion validity Internal consistency Test-retest stability	2005	CREDI (in children from 0 to 36 months)	Significant positive correlation in six of the eight age groups analyzed.	Cronbach's alpha 0.61-0.80 Test-retest: κ 0.81	In Brazil, it has been used in the evaluation of large population samples.	27,28,78

(Continues)

Table 3. Psychometric characteristics of child development screening instruments constructed in Latin American countries *(continued)*

Country	Abbreviation	Validation Process	Number of children used for validation	Reference Standard**	Sensitivity/specificity and predictive values**	Reliability	Other validation studies in the region	References
Brazil	IDADI	Content validation by expert consensus Internal consistency Concurrent criterion validity Structural validity (Rash analysis) Construct validity Stability	85	Regulatory and clinical sample	For ASD screening S: 0.90-1.00 E: 0.41-0.65 AUC: 0.85-0.98	Correlation between domains 0.87-0.95	NR	29-31
Brazil	IDADI-B (Short)	Internal consistency Concurrent criterion validity Construct validity	1865	IDADI	S: 0.90-0.97 E: 0.87-0.93 AUC: 0.95-0.97	Cronbach's Alpha 0.75-0.93 Omega McDonald's 0.85-0.97 Correlation between IDADI-B and IDADI domains 0.75-0.90	NR	33
Chile	EEDP	Content validity	600	NR	NR	NR	New studies in Chile, included in the ELPI. It is part of the health program in Peru. It has been used as a reference for validation of scales in Argentina.	78,79
Chile	TEPSI	NR	540	Stanford-Binet Intelligence Scale and DDST	Correlations r 0.73-0.92	NR	New studies in Chile, included in the ELPI. Used in Peruvian child health surveillance controls. Preliminary norms were published for Argentine children aged 3 and 4 years.	35,78,80-82

(Continues)

Table 3. Psychometric characteristics of child development screening instruments constructed in Latin American countries *(continued)*

Country	Abbreviation	Validation Process	Number of children used for validation	Reference Standard**	Sensitivity/specificity and predictive values**	Reliability	Other validation studies in the region	References
Chile	TADI/TADI-2	Content validation through expert consensus Cultural validity Construct validity Concurrent criterion validity Internal consistency Inter-rater agreement Test-retest stability Factor analysis Feasibility analysis	TADI = 2862 TADI-2 = 882	i) BSID-III (93 children < 36 months) ii) BDI-2 (100 80 children aged 4-6 years)	According to domain i) S: 0.42-0.82 E: 0.48-0.61 ii) S: 0.92 E: 0.53	Test-retest: r 0.97-0.99 Cronbach's alpha 0.88-0.96 Concordance between evaluators: κ 0.99-	New studies in Chile, included in the ELPI. Validation in special groups, such as children with Down Syndrome.	37-39,78, 83,90
Colombia	EAD-1/EAD-3	Content validity through expert consensus Concurrent criterion validity	NR	Criterion validity of the EAD-1 language and hearing domains in 300 children.	S: 0.54 E: 0.42 PPV: 0.87 NPV: 0.11	NR	NR	41,84
Costa Rica	EDIN II	Content validity by means of expert judgment and consensus Concurrent criterion validity	380 children	BDI-2 in 69 children	S: 0.69 E: 0.64 AUC: 0.73 [IC 95% 0.60-0.86	NR	NR	42-45
Cuba	NPED/ NPed-Desk	NR	NR	NR	S: 0.95 E: 0.86	NR	Validated in Mexico, Honduras and Venezuela	46-47,85
Cuba	EDPSIM	Content validation through expert consensus Concurrent criterion validity through diagnostic studies and internationally validated tests.	113	Diagnostic studies were carried out by six specialties: Neurology BSID-II Terman Merrill Test Speech audiometry (Speech Language Development Screening Test) Peabody, Articulation test. Otorhinolaryngology Ophthalmology psychiatry	S: 0.83 E: 0.98 PPV: 0.97 NPV: 0.89	κ index 0.83 Coincidence percentage 0.92 Youden index 0.81	NR	49-50

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Table 3. Psychometric characteristics of child development screening instruments constructed in Latin American countries *(continued)*

Country	Abbreviation	Validation Process	Number of children used for validation	Reference Standard**	Sensitivity/specificity and predictive values**	Reliability	Other validation studies in the region	References
Mexico	EDI	Concurrent criterion validity Inter-rater correlation	438	BDI -2 and BSID –III	With BDI -2 S: 0.81 E; 0.61 PPV: 0.65 NPV: 0.78 AUC: 0.84 [IC 95%: 0.80-0.88. Domain analysis: S: 0.80-0.92 E: 0.79-0.89 Partial correlation by domain adjusted for age 0.21-0.51	Correlation between evaluators: r: 0.88 (n = 302).	Validation in Ecuador/ Colombia and Peru. In process of validation in Panama.	52-57,60
Mexico	PTNI	Content validity Criterion and construct validity Reliability Inter-rater agreement	Pilot sample 9,130 children Application in 27,059 children	Proxy variables (indicators of malnutrition and anemia) Indicators (malnutrition, anemia, and timely stimulation)	S: 0.88 E: 0.77 PPV: 0.85 NPV: 0.83	20-Kunder-Richardson coefficient 0.70-0.82	Study in a large sample and in an indigenous population in Mexico.	61,79,81, 91,93
Mexico	PDC/PCD-R	Content validity Construct validity Concurrent criterion validity Correlation validity Internal consistency Inter-rater agreement Standard error	374	BSID-II in 40 children	Positive and statistically significant correlation between PCD-R and BSID-II. Analysis by domains: S: 0.89-0.94 E: 0.91-0.94 PPV: 0.36-0.49 NPV: 0.92-0.99	NR	It has been used to assess development in large samples of children.	62,64,86
Mexico	INDIPCD-R/ INDIPCD-R2	Multiple validation processes for the different versions of the test. Content validity Concurrent criterion validity Predictive validity Discriminant construct validity Internal consistency Inter-rater agreement Test-retest stability Factorial analysis	345/1225	145 children evaluated with PCD-R 66 children evaluated for sensory profile 2	S: 0.94-1.0 E: 0.69-0.84 PPV: 0.9 NPV 0.9-1.0 (Evaluated in different samples of children)	Cronbach's alpha 0.93 Pearson's correlation coefficient 0.83	It has been used to identify children with sensory integration difficulties.	63,65

(Continues)

Table 3. Psychometric characteristics of child development screening instruments constructed in Latin American countries *(continued)*

Country	Abbreviation	Validation Process	Number of children used for validation	Reference Standard**	Sensitivity/specificity and predictive values**	Reliability	Other validation studies in the region	References
Mexico	VANEDELA	Concurrent criterion validity Test-retest stability	379	GDST	Analysis by age group: S: 0.79%-0.89%. E: 0.83-0.95 PPV: 0.73-0.97 NPV: 0.72-0.96	Test-retest: 0.62-1.0	It has been used in large samples of Mexican children.	66,67,92
Mexico	SIVIPRODIN	Concurrent criterion validity overall and for each age month	2,702 children from 1 to 24 months old	BSID -II y GDST	S: 0.84 E: 0.76 PPV: 0.84 NPV: 0.77 Analysis by age group: S and E were adequate in all months, except for months 1 and 20-23 months.	NR	Predictive validity study of the interaction of binomial and psychosocial risk on neurodevelopment in a Mexican population.	68,70
Peru	REBA-PED	Concordance between evaluators Correlation between domains	100 evaluations	NR	NR	κ: 0,82-0.84	Study in children with ASD	71,72,77,89
Uruguay	GNVD V2	Content validation by expert consensus Internal consistency Inter-rater reliability Concurrent criterion validity	341	BDI-4	S: 0.77 E: 0.65 PPV: 0.42 NPV: 0.89	κ: 0.60-0.83	NR	73,74

**When there were several validation studies, the last one published by the authors was considered.
ASD: autism spectrum disorder; AUC: area under the curve; BDI: battelle developmental inventory; BDI-2: 2nd ed.ition; BDI-4: 4th ed.ition; BSID: bayley scale of infant development; BSID-II: 2nd ed.ition. BSID-III: 3rd ed.ition; CI: confidence interval. CREDI: caregiver reported early development index; DDST: denver developmental screening test: E: specificity; ELPI: early childhood longitudinal survey (*Encuesta Longitudinal Primera Infancia*), Chile. GDST: gesell developmental schedule Test; IDADI: *inventário dimensional da avaliação do desenvolvimento infantil*; NPV: negative predictive value; NR: not reported; PCD-R: profile of developmental behaviors-revised; PPV: positive predictive value; PRUNAPE: national screening test (*Prueba Nacional de Pesquisa*); S: sensitivity.

validity. Reliability is studied through different analyses, with internal consistency measurement predominating in 8 (38%), inter-rater agreement in 7 (33%), and construct validity in 7 (33%).

There is significant variation in sample sizes in which the instruments were validated, from dozens of children to large population samples. Notably, 14 (67%) of the reviewed instruments have samples of more than 300 children. Different reference standards were used for test validation, among which the most repeated were the Bayley Scales of Infant Development and the Battelle Developmental Inventory in their different versions. One test considered proxy variables, such as indicators of malnutrition, anemia, and stimulation, for discriminant validity (PTNI in Mexico). Two tests used the extended version related to the same instrument as reference (CPPP and IDADI-B). Notably, PRUNAPE and EEDP have been used as reference standards for validating instruments in Latin American countries.

Thirteen (71%) instruments report concurrent criterion validity indices for detecting developmental difficulties using a reference test. However, it was possible to construct SROC and forest plot analysis with data from 11 instruments (Figs. 2 and 3). The sensitivity of screening tests for identifying children with developmental delays, verified through reference tests, ranged from 0.42 (CPPP) to 1.00 (EDIN-II), median 0.67 (95% confidence interval (CI95%) 0.34-1.0), while specificity varied between 0.53 (TADI-2) and 1.00 (INDIPCD-R), median 0.71 (CI95% 0.42-1.0).

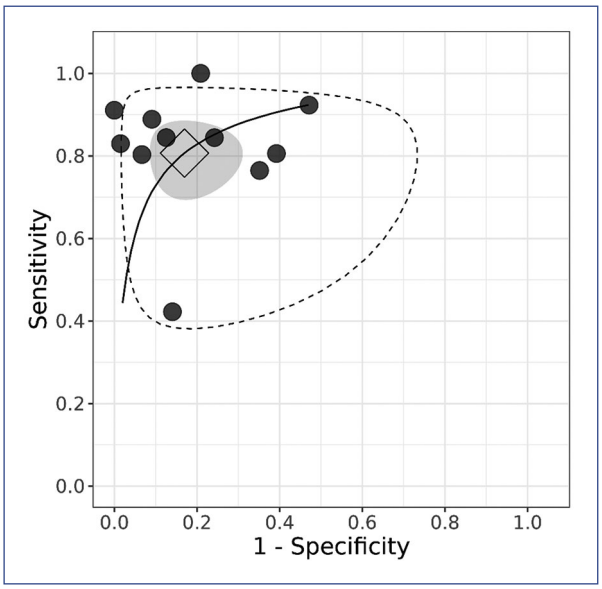

Figure 2. SROC curve for overall sensitivity and specificity of screening tests. Note: The dotted line represents the 95% prediction region of the bivariate model; the shaded area represents the 95% credible region of the bivariate model. Large heterogeneity among tests is observed[13,14].

Discussion

After an exhaustive literature review, 21 instruments constructed in nine different Latin American countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Mexico, Peru, and Uruguay) were identified for ECD evaluation of children under 4 years in the health field. This geographic diversity reflects the shared interest and commitment to addressing ECD evaluation[4]. In this regard, it is worth noting that, driven by UNICEF, a universal instrument for child development evaluation was constructed, which, given its multicentric nature, was not incorporated in the present analysis[87].

The chronology of test validation spans several decades, from the 1970s to the present. Half of the instruments included are 10 years old or less since their last validation; however, according to this study's inclusion criteria, all continue to be used, either in the country where they were constructed and, in some cases, also in other countries of the region[7]. The importance of successive validations is to update validity, considering a society in constant transformation, generating secular changes, manifested through the Flynn effect, referring to changes in norms over time, according to which global scale scores progressively increase[88]. In addition, over time, views on development are renewed, which are instrumentalized in new comprehensive tests that serve as standards in concurrent validations or expert considerations in content validations. Validations can also incorporate new psychometric parameters for bias control, confidence interval estimation, or differential probability criteria.

It is noteworthy that 57% of the analyzed instruments have been applied and/or revalidated in population samples different from the original sample, and five have been used in populations with special characteristics[30,38,89-93]. Cultural relevance is a crucial aspect to consider in ECD evaluation as it specifies the reliability of instrument measurements when applied to children from different populations, avoiding biases that could affect the results[94,95]. Although this aspect was not analyzed in the present study, it is noteworthy that Latin American countries have many equivalences in basic vocabulary, grammar, and syntax, making them understood without difficulty by most Spanish speakers, which is why instrument adaptation should focus on aspects of cultural overlap between the original version

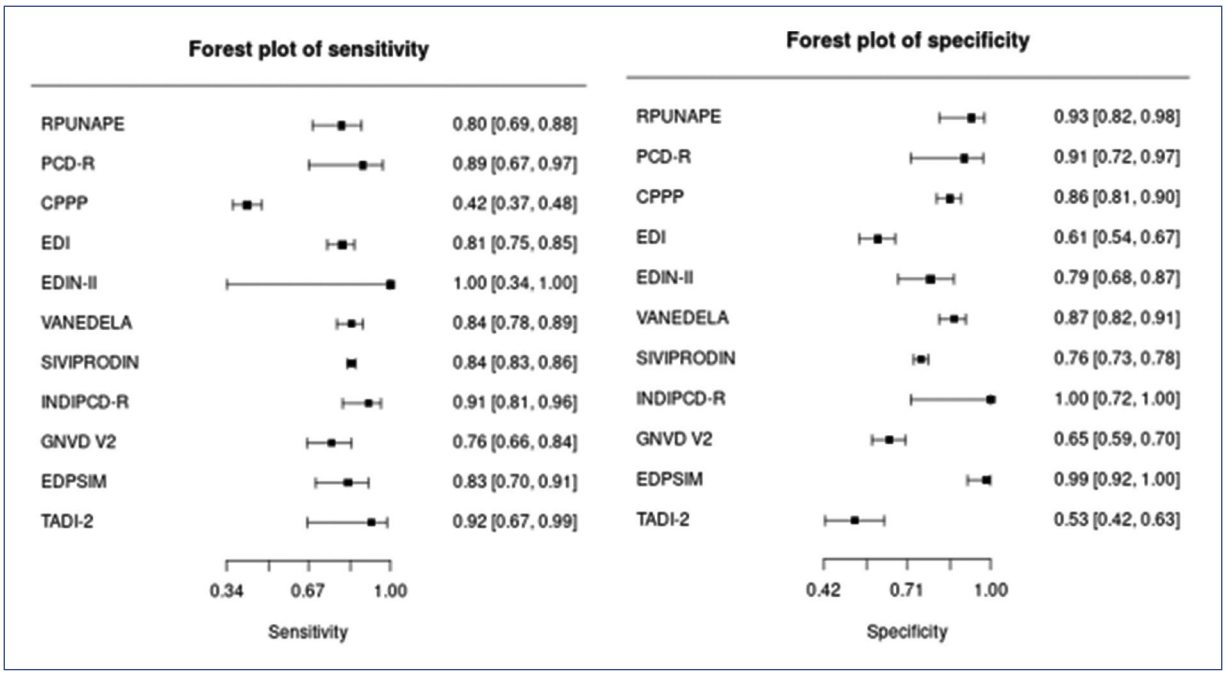

Figure 3. Forest plots of the estimated sensitivity and specificity of the developmental screening scales. Recalculated values in some tests with the data provided by the authors to construct the 2 × 2 table, explaining the difference between the published values of sensitivity and specificity and those reported in the figure[13,14].

from the country where it was constructed and the country where it will be applied[96].

Notable is that the predominant method for ECD evaluation was direct assessment, often combined with questions to parents/primary caregivers. Only five use direct report methods or caregiver interviews. In Argentina and Mexico, versions of the IODI and EDI instruments are available for application as reports in health booklets or cards. This experience has been validated in other countries of the region[97,98]. The reporting modality will likely be included in future versions of the instruments, as the reliability of parents/caregivers in contexts of lower literacy or changing parenting styles still needs to be demonstrated, which has been resolved in populations of middle- and low-resource countries with assistance from health promoters[99,100]. On the other hand, depending on trained professional time availability could restrict the possibility of mass screening. Undoubtedly, combining methods improves the precision and comprehensiveness of ECD evaluation[101].

In turn, there is increasing evidence supporting the online application of instruments, which allows immediate feedback and, additionally, adequate recording of results[102,103]. Notably, four of the reviewed instruments have been validated for online use and one for virtual use[47,65,71], while the others continue in pencil and paper format.

The great variability among the analyzed instruments stands out regarding the validation processes that guarantee reliability and validity, including content, construct, criterion validation, and reliability. The heterogeneity among instruments is especially related to the different reference tests and cutoff points. To date, there is no consensus on the perfect standard, and most reference tests have limitations, both in their diagnostic precision and in the definition of their thresholds, and they generally lack an adaptation and validation process before their application[104-106].

The balance between adequate sensitivity and specificity is important, as greater sensitivity can be associated with an increase in both true- and false-positive cases, which tends to worry families and consume the scarce resources available in public health in the region's countries. In contrast, increased specificity may lead to more false negatives, which can harm the negative predictive value of the test. This issue can be addressed through a system of serial monitoring of child development[107]. This aspect has been resolved in some ECD screening tests through the traffic light

criterion and/or differentiating different levels of alert, risk, and delay[38,45,56,83]. Furthermore, noteworthy is the growing tendency to observe not only developmental behaviors but also warning signs, perinatal risks, and psychosocial conditions that have proven to constitute a risk for ECD alterations, even when the child's behaviors still appear age-appropriate[57,66].

One of the limitations of the present study has been the difficulty in differentiating between ECD surveillance and screening instruments, often separated by a thin line. In this sense, several screening instruments have created abbreviated scales for pre-screening, as occurs with PRUNAPE and IDADI, which, strictly speaking, could be considered developmental surveillance scales[22,32,65,68]. In addition, specific validity parameters by age range were not analyzed, considering that the structure is a succession of cross-sectional behavioral cuts in some cases, with each age cut operating as an independent test[66].

The study's strength is that key information about validation processes and psychometric indicators was completed and validated through email exchanges or direct conversations with the instrument authors. This allowed obtaining a deeper and more accurate view. Quality and bias analysis was beyond the objectives of the present study, but it is undoubtedly an aspect that can be explored in future research.

Conclusion

ECD screening instruments constructed in Latin America show thorough validation and updating processes, with great heterogeneity among them. Their consistency stands out when used in countries other than where they were validated, and the preference for direct evaluation using pencil and paper.

The evidence gathered regarding significant and dynamic evolution in terms of validation and applicability of developmental screening instruments demonstrates a continuous commitment to improving equity in access to resources, with the aim of better meeting the needs of diverse Latin American populations.

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Conflicts of interest

Luisa Schonhaut and Antonia Valdés participated as advisors in different validation processes of the TADI-2 and in publications of the instrument.

Rolando Rivera G. has participated in the design and validation of VANEDELA, SIVIPRODIN and validation of PCD-R.

Antonio Rizzoli-Córdoba participated in the development of the modified version, validation of the EDI Test and development of the 2nd edition of the manual in Mexico and validation of the EDI test in Colombia.

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 study does not involve patient personal data nor requires ethical approval. The SAGER guidelines do not apply.

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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Initial steps in the selection of a child development screening instrument in the peruvian context

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Abstract

Background: *The foundational elements for optimal well-being and health are established during the early stages of life. When progress does not meet expectations, it is necessary to explore possible disorders, health conditions, or other probable factors affecting it. Health professionals in our country must have access to developmental screening instruments that facilitate early detection of these potential risks and delays, thus enabling timely intervention.* **Methods:** *After a pre-selection of the evidence and adequate training of a multi-sectoral panel, a virtual deliberative dialog was held with key stakeholders and decision-makers to determine the most appropriate development screening instrument for the Peruvian context. The evidence was analyzed and discussed in light of the established criteria. In addition, factors pertaining to implementation on a national level were discussed.* **Results:** *A set of instruments were obtained and prioritized in the following order: Evaluation of Child Development (EDI, Spanish acronym) ranked first, followed by the Abbreviated Developmental Scale Third Edition (EAD-3, Spanish acronym) and the Ages and Stages Questionnaire (ASQ-3, Spanish acronym), based on the established criteria. The primary components implicated in the execution of this evaluation on a national scale were subsequently identified.* **Conclusions:** *This deliberative dialog has enabled a first approach to the selection of a development screening instrument on the national level, providing valuable information to guide the implementation process.*

Keywords: *Child development. Developmental disabilities. Mass screening. Screening tool. Public policy.*

Pasos iniciales en la selección de un instrumento de tamizaje del desarrollo infantil en el contexto peruano

Resumen

Introducción: *El desarrollo de los primeros años de vida sienta las bases para la salud y el bienestar de las personas. Cuando éste no progresa según lo esperado, es preciso explorar en posibles trastornos, condiciones de salud u otros factores que puedan estar afectando el proceso. Los profesionales de salud de nuestro país necesitan contar con instrumentos de tamizaje del desarrollo que faciliten la detección temprana de estos posibles riesgos y retrasos para intervenir oportunamente.* **Métodos:** *Luego de una preselección de la evidencia y una adecuada preparación por parte de un panel multisectorial, se realizó un diálogo deliberativo virtual con participación de actores claves y tomadores de decisiones, buscando determinar cuál es el instrumento de tamizaje de desarrollo más apropiado para el contexto del Perú. La evidencia fue analizada y discutida con base en criterios establecidos; asimismo, se discutieron factores relacionados con la implementación a nivel nacional.*

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Resultados: *Se pudo obtener un conjunto de instrumentos priorizados en el orden siguiente: Evaluación del Desarrollo Infantil (EDI) ocupó el primer lugar seguido de Ages and Stages Questionnaire (ASQ-3) y la Escala Abreviada del Desarrollo Tercera Edición (EAD-3) con base a los criterios establecidos. Se señalaron los principales aspectos implicados en la implementación de esta prueba a escala nacional.* **Conclusiones:** *El presente dialogo deliberativo ha permitido una primera aproximación para la selección de un instrumento de tamizaje del desarrollo a nivel nacional proveyendo valiosa información para conducir el proceso de implementación.*

Palabras clave: *Desarrollo infantil. Tamizaje masivo. Discapacidad del desarrollo. Prueba de tamizaje. Política pública.*

Introduction

An individual's initial years of life are of paramount importance, as they establish the foundational elements that underpin their health and well-being in those years. During this period, the physical, sensory, communicative, cognitive, and socioemotional skills are nurtured, paving the way for autonomy and the gradual acquisition of complex skills[1]. Therefore, children must receive loving and sensitive care from their caregivers, health professionals, teachers, and other frontline workers[2]. Considering the widely acknowledged crucial nature of the initial three years of life for early childhood development (ECD), it is imperative to capitalize on this period for the timely identification of children facing developmental challenges. Deviations from the anticipated parameters or timelines during developmental processes may cause potential disorders, health conditions, or other factors that may adversely impact the subject's development[3]. Thus, early detection must be conducted through existing large-scale services and programs, such as the Control of Growth and Development (CRED), which is a pivotal starting point and the most accessible one to families[4]. Consequently, health professionals require instruments to facilitate the detection of these potential risks and developmental delays.

In Peru, the extent to which these instruments facilitate the timely identification of these issues remains ascertained; therefore, further data on their actual scope is necessary. The employed instruments were developed over twenty years ago and may possess some technical limitations inherent to a long-standing standardization[5-7]. Children with sustained developmental delays are at increased risk of learning difficulties, behavioral problems, and functional disorders later in life[8]. It has been demonstrated that, when detected early, interventions are significantly more effective; therefore, this circumstance requires prompt attention. Furthermore, periods of greater neuroplasticity allow greater receptivity to treatment[9,10]. Lack of early detection and timely intervention may cause greater developmental difficulties and hinder children's ability to reach their full potential.

Developmental assessment instruments can be classified into two types based on their purpose: screening or evaluation. Screening instruments offer a preliminary assessment of the child's health and developmental status and indicate whether further evaluation is necessary to identify potential difficulties that require specialized interventions or services. They are usually brief and accurate; however, they usually fail to detect the degree or extent of the problem. Conversely, assessment instruments facilitate a more comprehensive understanding of the individual needs of children at risk. These needs are identified through observation, collection, recording, and interpretation of pertinent information, enabling informed decision-making[11]. This important difference has been recognized in the process of updating the developmental assessment instruments in the Technical Health Standard for Growth and Development Monitoring of Children under Five Years Old, which is being conducted within the framework of the ECD Results-Based Budget.

In response, a multi-sectoral panel of specialists met weekly during the first half of 2020 to compile and analyze the evidences related to the developmental screening instruments currently in use, nationally and internationally, and to propose a shortlist for inclusion in the development of the "General Child Development Screening in the National Context" Deliberative Dialogue (DD). The objective of this dialog was to contribute to the formulation of a policy for the selection of a developmental screening instrument for use in Growth and Development Monitoring services, based on scientific evidence. In addition, this study investigated the factors influencing its implementation and strategies to approach it.

This paper reports the experience of a DD conducted at the height of the pandemic, an evaluative exercise to select the most appropriate screening instrument for monitoring the growth and development of children in health facilities in Peru.

Methods

Pre-selection of evidence

A comprehensive search of national and international evidence on developmental screening instruments was conducted from January to March 2020, including gray literature and taking major international databases as reference: Medline through Pubmed, Scielo, Cochrane Library, Epistemonikos, and TripDatabase. Words or phrases related to the subject, combined terms, free search terms, and specific terms related to the topics "psychomotor development," "developmental assessment tools," "developmental screening," "screening," "child development," and "screening tools" were considered for this search. Moreover, the web pages of organizations and repositories of guidelines related to child development were reviewed. The search was conducted for information on the following criteria: (a) evidence of use in the Peruvian and Latin American context; (b) availability of the instrument in Spanish; (c) experience of use or knowledge by sectors; and (d) evidence of characterization of the psychometric properties. From this study, a preliminary list of 11 general child development screening instruments was obtained: (1) Peruvian Developmental Test (TPED, Spanish acronym)[12]; (2) Evaluation of Psychomotor Development Scale (EEDP, Spanish acronym)[13]; (3) Test of Psychomotor Development (TEPSI, Spanish acronym)[7]; (4) Evaluation of Child Development (EDI, Spanish acronym)[14]; (5) Global Monitoring of Child Development (GMCD)[15]; (6) Ages and Stages Questionnaire—Third Edition (ASQ-3-3)[16]; (7) Abbreviated Developmental Scale—Third Edition (EAD-3-3, Spanish acronym)[17]; (8) Test of Infant Development and Learning (TADI, Spanish acronym)[18]; (9) Pikler-Lòczy Institute Developmental Scale[19]; (10) Denver-II Developmental Screening Test (DENVER-II)[20]; and (11) National Screening Test (PRUNAPE, Spanish acronym)[21].

A summary of the evidence for each of these instruments was developed in the form of a matrix and included information on multiple aspects (Table 1).

The matrix with information from the 11 selected instruments was delivered to the multi-sectoral panel of specialists from three sectors (Ministry of Health, Ministry of Education, and Ministry of Development and Social Inclusion) for review and analysis, both independently and by teams (grouped according to their belonging to a particular sector), and always with the option of consulting other relevant sources of information.

The review criteria were: (A) importance and priority of the instrument for assessing the development in children under 5 years; (B) certainty of the available evidence about the instrument; (C) acceptability; and (D) feasibility. The teams also considered other relevant aspects for the selection or rejection of instruments. Each criterion was evaluated by questions with closed-ended and categorized answers, namely: (a) No; (b) Probably not; (c) Probably; (d) Yes; (e) Depends; (f) I don't know. This is how teams were able to establish a priority ranking of three instruments. Third place was taken by the EAD-3-3, whereas the ASQ-3-3 ranked second, and the EDI test was at the top position, as all three teams were unanimous.

Table 1. Information collected for each of the 11 instruments

Author	Cost of tools and materials
Year	Cost of scoring materials
Language	License/permit requirements
Countries of use	Validation study/sample size
Type of instrument	Test-retest reliability
Domains evaluated	Inter-rater reliability
Definition of domains	Concurrent validity
Age range	Specificity
Periodicity of evaluation	Sensitivity
Evaluator/scorer	Administrators
Type of appraisal	Training duration
Administration time	Educational requirements
Scoring time	Cost of training
Number of items	Availability of online training
Type of response	Remarks
Score	Key references
Score interpretation	
Description of items	
Example item	
Required reading level	

Deliberative dialog methodology

Deliberation is a collaborative process supporting the construction of common agreements, allowing re-evaluation of assumptions, highlighting strengths and broadening perspectives on particular issues to lead consensual decision-making processes, and assuming a set of recommendations based on evidence[22].

DD is a group process of transformative discussion based on scientific evidence with the potential to address the challenges faced by policymakers and stakeholders while using information derived from research. These challenges primarily center on the observation that the information available to decision-makers is not always pertinent to the issues they encounter. In addition, it is often difficult to access, utilize, or translate this information into tangible action. DDs overcome these barriers and facilitate

evidence-based decision-making by creating opportunities for policymakers and stakeholders to discuss, contextualize, and determine the meaning of evidence related to knowledge and experience, and provide policymakers with relevant knowledge for timely and actionable decisions[23]. The attainment of these objectives is contingent upon three factors: establishment of an appropriate environment, convocation of an adequate and representative group, and use of evidence.

This brings us to the central question of deliberation: *What is the most appropriate screening instrument for the monitoring of growth and development in public health facilities nationwide?*

Preparation of deliberative dialog

A document was developed containing a synthesis of the evidence on the instruments obtained in the pre-selection priority ranking. This document was to be read and reviewed before the DD sessions. Thus, the participants had a common basis from which to begin deliberation and consider the relevant[24] evidence. Considering the need to hold virtual sessions due to the pandemic restrictions, a convenient date and time were decided, a technical support team was formed for the sessions, and an agenda was scheduled.

Methodologically speaking, adaptations were made to the method proposed by Acosta et al. (2018)[25] and Boyko et al. (2012)[23]. The preparation of the DD was carried out with logistical support from UNICEF between March and June 2020. This support was part of the process of updating the Developmental Assessment Instruments in the Technical Health Standard for the Control of Growth and Development of Children under 5 Years of Age. This work was conducted within the framework of the Budget for Results with a focus on this topic[26]. During planning, potential participants were selected based on four criteria (Table 2) that could guarantee representativeness, the ability to articulate different points of view, experiences, and the interests of the represented groups, and a strong motivation to engage with the topic.

The potential participants were invited to participate through a letter including information regarding the objectives of the activity and logistical details. Participants who confirmed their involvement completed a conflict of interest declaration form and were contacted through phone to provide information about the event's agenda. Reminders were also sent through e-mail and text messages one week and one day before the agreed date. A communication channel was used to answer questions or doubts and increase participants' commitment to the process. The composition of the sample is presented in table 3.

Table 2. Selection criteria for participants

Health professionals with specialized knowledge and experience in child development, especially in developmental assessment.
Policymakers and authorities (public officials and administrators) of institutions related to child development.
Researchers or academics from research institutions and national and international universities with a primary focus of child development and related topics.
Organizations and societies related to early childhood work.

Table 3. Sample composition

Sex	
Male	4
Female	21
Group	
Health professionals with specialized knowledge and experience in child development, especially in child development assessment.	6
Policymakers and authorities (public officials and administrators) at institutions related to child development.	6
Researchers from national and international research institutions and universities	6
Representatives of early childhood organizations	7
Type of institution	
Public	14
Private	11

The design was entirely virtual and the moderators and reporters were designated in advance from among the members of the technical support team. They were instructed to create an atmosphere of meaningful communication among participants, confidence in expressing themselves, and fairness in the interventions. Furthermore, they were instructed to maintain neutrality and not influence the discussion[23]. As the virtual format was new at the time, the organizing team tested the technical issues in advance.

Development of deliberative dialog sessions

In August 2020, two remote sessions were held one week apart. The first session provided an overview of the purpose of the dialog and its importance by focusing on selecting a developmental screening instrument

Table 4. Important guidelines for deliberative dialog

All participants are invited to intervene, none will be excluded.
It is not acceptable for one or two participants to dominate the discussion.
Participants are requested to listen to each other.
The deliberation will focus on the three developmental screening instruments.
Facilitators ensure to maintain a conducive environment for deliberation, respecting and tolerating discrepancies.

to be included in the update of the respective regulations. In addition to the assessment tool, the agenda, methodology, and practical and confidentiality provisions were provided (Supplementary Material). The five groups comprised five members each (25 participants), accompanied by a moderator and reporter (both from the technical support team not involved in the deliberation). They were designated a group secretary to complete the responses in the assessment format in the four domains and each of the three instruments (EDI, EAD-3, and ASQ-3) and to present the group's final decisions. The criteria evaluated were: (A) importance and priority of the instrument in the assessment of development in children under 5 years; (B) certainty of the available evidence about the instrument; (C) acceptability; and (D) feasibility and implementation aspects.

Some guidelines were provided to adequately manage dialog, maintain the structure of the discussion, and create an environment where participants could freely express themselves (Table 4). At the end of the deliberation, the participants summarized the comments, opinions, and suggestions, and a plenary session was held.

During the deliberation, the participants analyzed and responded, guided by the moderator, focusing on the advantages and limitations of each instrument, as well as the potential barriers to their implementation. The sessions were recorded with prior consent. Observations, comments, and feedbacks were collected from each group. At the end of the first session, all notes and transcripts of the reporters were compiled, and the recordings were reviewed. The organizing team convened a debriefing meeting to analyze and synthesize the information collected. A report of the analysis was subsequently prepared and presented in a second session and participants were invited to ask queries (Table 5). They were also asked to provide observations, suggestions, or recommendations, emphasizing the most significant aspects for implementation in the national context.

Table 5. Questions for participants

What are the positive aspects/advantages of the instrument or its use?
What are the negative aspects/disadvantages of the instrument or its use?
Do you think that the instrument could be implemented in some health facilities of the second and third levels of care to support the diagnosis of developmental delay? Why?
What would be the potential barriers to implementation?
Which professional (s) could make use of the instrument? Please specify.
Based on your knowledge about the instrument and your experience using it, do you consider it important/necessary to implement it at the level of public health facilities?
How would a developmental assessment be conducted in the context of public health facilities in the event of the unavailability of these instructions? Would the clinical assessment of the child be sufficient?
How long does it take for you to apply the instrument?
Do you have any suggestions or practical indications for the application of the instrument?

Results

The two aforementioned sessions ran smoothly in each group. The multi-sectoral organizing team worked diligently to achieve the objectives of the activity. The findings for each of the objectives are described below:

About the instrument

The importance and priority criterion was assessed by the question "Is the application of the test for screening during the control of child growth and development at the first level of national care a multi-sectoral priority?" For this criterion, the EDI instrument obtained the highest score on a Likert scale (range of answers from "Not a priority at all" to "Very high priority") followed by the ASQ-3-3 and EAD-3. In the question "Is the application of the test useful for screening risks in child development at the national level?" the EDI instrument obtained the highest score, followed by the ASQ-3 and EAD-3 (responses ranged from "Not useful at all" to "Very useful").

In the certainty of evidence criterion, in the question "Does the test demonstrate reliability and validity of evidence (sensitivity, specificity, test-retest reliability, inter-rater reliability, concurrent validity)?" the ASQ-3 instrument obtained the highest scores, followed by EDI and EAD-3 (Likert scale, with options from "Not

Table 6. Summary of scores based on the criteria and overall score

Main criterion	Subcriterion	Test		
		EDI	EAD-3	ASQ-3
Importance and priority of the instrument	Multi-sectoral priority	27	21	25
	Usefulness to screen for risks in child development on a national level.	27	18	26
Certainty of evidence	Reliability and validity	24	12	27
	Overall test results	24	13	24
Acceptability	Acceptability for the health professional	25	13	21
	Acceptability for decision-makers	26	13	11
Feasibility and implementation	Sustainability	24	13	15
	Likelihood of barriers or constraints on implementation	21	7	6
	Feasibility of implementation under the Early Childhood Development Result-Based Budget Program Framework	25	11	17
Total score		196	103	146

reliable at all" to "Very reliable"). In the question asking about the balance between the positive and negative effects of the instrument, participants mentioned the EDI and ASQ-3 as the instrument with the most positive balance, followed by EAD-3 (responses ranged from "Not favorable at all" to "Very favorable").

In the acceptability criterion, assessed through the question "How acceptable would the test be to key stakeholders (health personnel who will apply the test) in relation to benefits and costs?," EDI obtained the highest score, followed by ASQ-3 and EAD-3 (Likert scale responses from "Not acceptable at all" to "Very acceptable"). Regarding the question, "Do you consider that decision-makers would accept the use of the test at the national level for reasons related to the resources required for its implementation (cost of the test, materials, or training)?" EDI scored the highest, followed by EAD-3 and ASQ-3 (response range from "Unlikely" to "Very likely"). In the question "Overall, how likely do you think it is that the parties involved (parents/caregivers/health personnel who will administer the test) would agree to apply the test?," EDI scored the highest, followed by ASQ-3 and EAD-3 (responses ranged from "Unlikely" to "Very likely").

In the feasibility and implementation criterion, in the question "How likely is it that the application of the test will be sustainable?," the highest score was obtained by the EDI instrument, followed by ASQ-3 and EAD-3 (Likert scale with options from "Unlikely" to "Very likely"). The question "How likely is it that the significant barriers may limit the feasibility of implementing the test or require reconsideration when implementing it?," the highest score was obtained by EDI, followed by EAD-3 and ASQ-3 (Likert scale with options from "Unlikely" to "Very likely"). In the question "In general, how feasible do you consider the implementation of the test on a national level considering the target group of the ECD Outcome-Based Budget Program?," the highest score was obtained by the EDI instrument, followed by ASQ-3 and EAD-3 (responses ranged from "Not feasible" to "Very feasible").

The overall score obtained for the EDI instrument was 196 points, the ASQ-3 was 146 points, and EAD-3 was 103 points. The summary of the scores based on the criteria is described in table 6. The vital arguments for this selection focused on the psychometric evidence of validity ("good sensitivity, acceptable specificity"), applicability in the Peruvian context, minimum cost, accessibility of the materials, and free use. There was a possibility that its administration may take a little longer than usual; however, "it would not imply a change in methodology in the way health personnel applies it." Another argument put forth is that the test is administered through staff observation, enabling the identification of developmental risks and incorporating a neurological evaluation. Regarding its implementation, training, supervision, and monitoring, as well as the establishment of a care pathway for cases of developmental delay were considered important.

The following main advantages of the EDI instrument were reported by the groups:

- It has psychometric evidence of validity and an acceptable level of reliability
- It is comprehensive, because it evaluates motor, social, cognitive, and language areas, in addition to risk factors and warning signs
- It uses a traffic light rating system to better inform parents
- Materials to be used are accessible and easy to implement
- The application time is appropriate
- The application is simple
- It covers the target period established in the guidelines of the Results-Based Budget Program for ECD
- It involves direct and indirect evaluation
- It is in Spanish
- Support documents are available, such as the Complementary Manual for the Application of the Child Development Evaluation Test, the Neurological Examination Manual for children under 5 years old at the first and second levels of care, and the Manual for the training of facilitators in the EDI
- The test "would not imply a methodological change in the way health personnel apply it."

About implementation

The second objective was to identify the probable factors influencing the implementation of the selected instrument and the strategies to address them. The following aspects were considered when developing an appropriate implementation process:

Transfer process

Administrative processes and formalities must be considered before application to ensure free and sustained use of the test, which involves:

- Permissions for use must be requested from the developers who hold the copyright to the test
- Requests must be made, in addition to all arrangements for technical support from the development team in different phases of the implementation process
- The potential costs involved in the initial training process for developers must be assessed
- Requests and arrangements for initial training in the use of the test must be made.

Training/coaching

Training and coaching in the use of EDI were identified as key components to ensure effective implementation within the national context. According to the participants, adequate training is essential to standardize the conditions of administration, ensuring homogeneity in the formulation of the questions to the caregivers and the correct instrument application.

According to the findings, participants argued that training processes must meet certain characteristics:

- Since the test covers multiple axes, including neurological examination, it needs to be complemented with training in psychomotor development and neurological assessment, aimed at professionals in charge of CRED control at the first level of care.
- Training sessions should focus on practical workshops and include activities of application, correction, and interpretation of the instrument, promoting experiential learning.
- Training should incorporate parent and caregiver training, thereby strengthening their knowledge of child development and providing them with the tools to actively support their children and understand how to provide that support.
- The virtual modality is pivotal in facilitating access to "different levels, with intensive training in health facilities located in remote areas, where there is often only one health professional or even technical staff." These trainings can be implemented through platforms like the National School of Public Health. To ensure the validity of dichotomous answers, it is essential to train professionals in the correct formulation of questions. Consequently, a standardization process must be established to favor optimal conditions for the application of the instrument.

Two main modalities are proposed to perform the training processes:

- Staggered, with the training led by master trainers or facilitators, such as those assigned by the Integrated Health Network Directorates and Regional Health Directorates and Management.
- Generalized, massive implementation through the National School of Public Health platform.

Implementation in the growth and development monitoring services

Participants noted that, once the required permits are in place, the following aspects should be considered before implementation:

- Contextual adaptation through cultural and linguistic adaptation by reviewing possible barriers or other anthropological considerations.
- Revision of administrative aspects (effective application time within the CRED consultation, coding in records, development of indicators, etc.).
- Revision of logistical aspects (having the manuals in physical form, adaptation/acquisition of materials).

Incorporation in the update of the technical health standard for growth and development control

Regarding the integration of the EDI test within regulatory frameworks, its application should not be confined to its use as a screening instrument; instead, it should be incorporated into a comprehensive system for the identification of developmental delays, with a particular emphasis on the early detection and intervention of such issues. Within this system, other components complementary to the use of the instrument were proposed, which must be differentiated and correctly applied by CRED professionals):

- Developmental monitoring: use of an instrument specifically designed for continuous observation.
- Assessment: application of a *gold standard* instrument to enable a comprehensive evaluation of the level of developmental delay and the detection of an underlying diagnosis or condition.
- Intervention and care: implementation of a care pathway for detected cases of developmental delay, as well as decentralization of specialized care on a regional level.
- Furthermore, a review and selection of the ages of mandatory application was deemed necessary in the context of the update to the Technical Health Standard for Growth and Development Control.

In-office use of CRED controls

The participants expressed the need to implement a comprehensive application with greater involvement of health professionals. The use of the instrument must be supported by specific training in communication and intercultural skills, thus ensuring the provision of effective and respectful care for families. Furthermore, the significance of incorporating physicians—as opposed to solely nursing professionals—was underscored, thereby promoting their active involvement in the detection and intervention processes for children exhibiting developmental delays.

Staff turnover and working conditions

The high turnover of healthcare providers in health facilities was a significant challenge as it can lead to interruptions in the application of the instrument. Many participants suggested taking necessary steps to maintain the permanence of the staff, provide greater job stability, and take charge of a sufficient number of nursing professionals so that care can be provided with greater peace of mind and diligence.

Supervision and monitoring of use

This aspect arose recurrently during deliberation. It was considered essential to establish a system of supervision, monitoring, and follow-up, including the suggestion of re-evaluating the operation annually. Furthermore, pilot testing was recommended to determine the learning curve and adjust the implementation aspects. Other points to be considered include:

- Carrying out a validation study within a national context to confirm the psychometric properties described in the original study. Accompanying and monitoring the operational implementation as part of the support to the health professional until the implementation process itself becomes sustainable.

Other considerations reported by participants

- Its use may procure some level of complexity for people outside the field of health care or unfamiliar with pediatric care. In addition, it is recommended to provide a manual of guidelines for parents and caregivers, which provides them with access to practical tools to support the comprehensive development of children. This manual should also facilitate constant follow-up and training on child development. Although most of the participants consider EDI a simple and quick test to administer, some people regard it as “laborious” because it takes approximately 15 min, which may be excessive in the context of CRED Controls, considering the length of the consultation and the number of procedures to be performed during the consultation.
- An attitudinal barrier was identified, related to the acceptance in the change of instrument due to their greater familiarity with the tests in current use (TPED, EEDP, and TEPSI).
- The environment in which the application is to take place must be sufficiently spacious to allow for a comprehensive evaluation of the children involved.

- It is essential to implement "cascade sensitization," starting with health professionals, parents, and health authorities.
- It was recommended that the topic of ECD be incorporated into the training of health professionals, beginning with the undergraduate level, to strengthen the competencies in this area. Moreover, comprehensive care-related aspects should be considered, such as the mother's mental health, the family environment, the quality of the mother–child relationship, care time, and psychosocial risk. In addition, it is important to consider factors such as weight, height, and breastfeeding, and emphasize social development to rule out the suspicion of autism.
- Adequate advocacy is necessary to prioritize the above issue and promote a political decision translated into plans, strategies, and budget allocations to enable implementation and facilitate scaling up at the national level.
- The new instrument selected should be widely disseminated by appropriate means, ensuring technical training for health professionals, including attitudes, practices, and knowledge.

Discussion

The priority of having a screening instrument for the detection of developmental delays in children has been widely recognized as a fundamental approach in the national ECD policy for achieving the health outcomes proposed for children under 3 years. Instead of being an isolated intervention, the application of screening instruments should be a universal measure in primary health care that promotes the timely and effective identification of developmental delays and disabilities, ensuring prompt referral to specialized services within a system of care responsive to each child's individual needs[27].

In recent years, questions have arisen about the real usefulness and efficiency of the instruments used in our country because the past literature has not been able to establish their validity. The COVID-19 pandemic exacerbated this problem by significantly impacting growth and development monitoring services and the application of such instruments. This decreased the opportunities for timely detection of developmental delays. This scenario has prompted an immediate undertaking of efforts to establish an updated and adequate instrument. In the field of public health, DDs are useful for inspiring discussions, improving complex understanding, and fostering consensus on health priorities with the potential to address the challenges that policymakers and stakeholders face when using evidence[23]. The aforementioned process, under the leadership of the health sector and with the involvement of representatives from the education and social development sectors, has identified the necessity for support in making contextualized decisions on a national level. Other experiences of deliberative dialog have been developed in our country in the field of health, such as those promoted by the National Institute of Health to formulate recommendations for clinical practice guidelines[28] and establish policies and interventions to reduce injuries caused by traffic accidents[29]. However, this is the first study that focused on child development in Latin America providing greater visibility to the urgency of detecting developmental risks and determining the need to implement a standardized screening instrument.

This exercise helped determine the selection of the EDI test as a developmental screening instrument for use in health services through the DD. It also helped recognize that this instrument is a viable option for rethinking the psychomotor development assessment strategy. As with our findings, previous reviews have highlighted the validity of the instrument, its accessibility, and its low administration time as positive aspects[30].

Figure 1 shows the summary of the selection process. Overall, the EDI test scored the highest on the appraisal criteria, compared to ASQ-3 and EAD-3. Regarding the importance and priority of the instrument, the EDI test achieved scores similar to those of ASQ-3, a widely recognized international test, although the latter obtained a higher score in the certainty of evidence criterion. The EDI test also outperformed in the acceptability criterion, especially among decision-makers, which could be related to the fact that ASQ-3 has a high and restrictive cost for the Peruvian context, where there are fewer economic resources. A significant finding is that, although the EAD-3 has been recognized as a useful and priority test, it presents difficulties in terms of its sustainability, despite being an open-access instrument. Another relevant aspect is that the EDI test scored higher in the feasibility of implementation within the ECD Budget Program Framework, which is a priority for Peru.

However, there are some limitations considered when interpreting the results. Although efforts were made to achieve the greatest possible representativeness in the sample and have a variety of participant profiles, the small sample size could limit the generalization of the results to a wider population. In addition, although participants were provided with a matrix with all the test information to facilitate evaluation, complete knowledge of the instruments cannot be guaranteed and previous

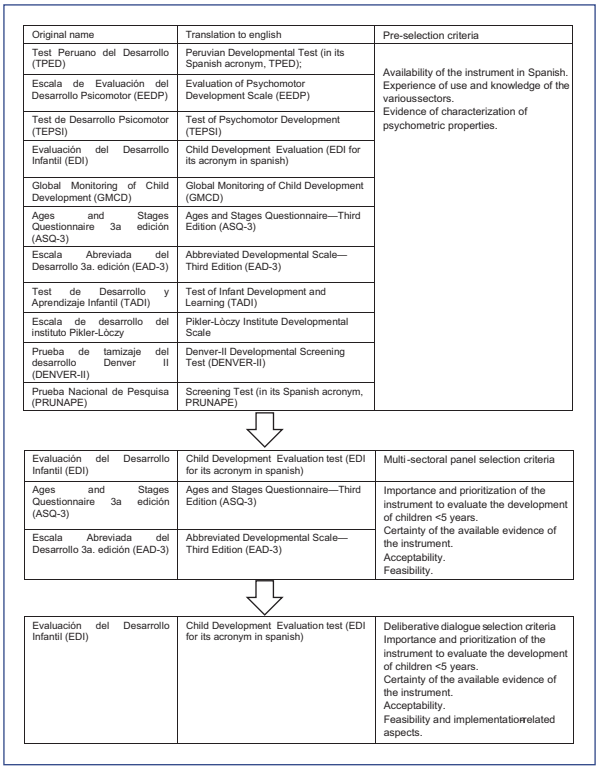

Figure 1. Summary of the selective process. The original name (acronym) in the native language of the screening test analyzed is shown together with its translation to English.

experience in their use may be necessary for a more accurate assessment. The present study was conducted in August 2020, so there may be more recent evidence not included in this paper at the time of publication.

To guarantee the effectiveness of its implementation at the national level, it is essential to incorporate these characteristics in the normative documents, as well as in the processes of training, sociocultural adaptation, preparation of services, supervision, monitoring, and validation. All these aspects should be discussed and accounted for by the test developers to assess the suitability of the implementation and training processes before scaling up in the current context and considering the logistical and operational needs.

All these measures will ensure the reliability of the results obtained during implementation. It is imperative that screening be complemented by continuous developmental monitoring activities, performed by health professionals during regular contact with families and in congruence with them. This will assist in identifying children who require screening, even in the absence of specific psychomotor developmental concerns reported by caregivers.

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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 study does not involve patient personal data nor requires ethical approval. The SAGER guidelines do not apply.

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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RESEARCH ARTICLE

Cross-cultural adaptation, validation, and reliability of the child development evaluation test (EDI) in Colombia

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Abstract

Background: *Monitoring child development requires not only the determination of developmental milestones but also surveillance and continuous monitoring, hence the importance of having valid and reliable evaluation instruments. This research aimed to cross-culturally adapt the Child Development Evaluation (CDE) test for Colombia and determine its validity and reliability.* **Methods:** *The cross-cultural adaptation process was conducted in four phases: I. Adaptation to Colombian Spanish: adjustments of the test to Colombian Spanish and analysis of equivalences; II. Content and face validity: evaluation by five expert judges who performed quantitative and qualitative assessments of the test; III. Review by the original author; IV. Pilot test. Reliability analyses for internal consistency and intra-rater reliability were performed.* **Results:** *For the adaptation to Colombian Spanish, most test items were equivalent to Mexican Spanish, with some requiring minimal conceptual and contextual changes to maintain their meaning; culturally relevant formulations and expressions were adjusted. In the content and face validity assessment, adequate results were found regarding the importance, influence, and observability of the items. Internal consistency reliability was moderate, with Cronbach's α values between 0.41 and 0.57, and intra-rater reliability was very good, with Kappa index values > 0.76.* **Conclusion:** *The CDE test demonstrates cross-cultural adaptation, content and face validity, and reliability for its application and use in Colombia.*

Keywords: *Child development. Surveys and questionnaires. Cross-cultural comparison. Reproducibility of results. Validation study.*

Adaptación transcultural, validación y confiabilidad de la Prueba de Evaluación de Desarrollo Infantil (EDI) en Colombia

Resumen

Introducción: *El proceso de seguimiento al desarrollo infantil requiere no solo la determinación de los hitos del desarrollo, sino también un proceso de vigilancia y monitoreo continuo, de ahí la importancia de contar con instrumentos válidos y confiables para evaluación. La investigación tuvo como objetivo adaptar transculturalmente la prueba de Evaluación de Desarrollo Infantil para Colombia y determinar su validez y confiabilidad.* **Métodos:** *Proceso de adaptación transcultural se realizó con cuatro fases: I. Adecuación al español colombiano: ajustes de la prueba al español colombiano y análisis de*

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equivalencias; II. Validez de contenido y apariencia: participación de 5 jueces expertos que realizaron evaluación cuantitativa y cualitativa de la prueba; III. Revisión por autor original; IV. Prueba piloto. Se realizó análisis de confiabilidad por consistencia interna e intraevaluador. **Resultados:** *Para la adaptación al español colombiano la mayoría de ítems de la prueba fueron equivalentes al español mexicano, algunos requirieron mínimos cambios desde lo conceptual y contextual para mantener su significado, se ajustaron formulaciones y expresiones culturalmente relevantes; en la validez de contenido y apariencia se hallaron adecuados resultados de evaluación de importancia, influencia y observancia de los ítems. La confiabilidad por consistencia interna fue moderada, con valores Alfa de Cronbach entre 0.41 y 0.57, y la confiabilidad intraevaluador muy buena con valores de índice de Kappa superiores a 0.76.* **Conclusión:** *La prueba EDI cuenta con adaptación transcultural, validez de contenido y apariencia, y confiabilidad para su aplicación y uso en Colombia.*

Palabras clave: *Desarrollo Infantil. Encuestas y cuestionarios. Comparación transcultural. Reproducibilidad de los resultados. Estudio de validación.*

Introduction

Child development is a fundamental human process that crucially influences potential performance and functioning in later ages[1], so building a solid foundation in early childhood is relevant for individual and social well-being. Actions taken during the 1st years of life should focus on improving outcomes in the areas of nutrition, health, cognitive development, and psychosocial development to achieve the best quality of life and well-being[2].

The state policy for comprehensive early childhood development ("From Zero to Forever" Law [*Ley de cero a siempre*], 1804 of 2016) in Colombia, in its commitment to the country's economic, social, political, and cultural development, aims to contribute to the comprehensive development of girls, boys, and adolescents to generate conditions of well-being and access to opportunities with equity[3]. This policy would be aligned with the Global Sustainable Development Goals adopted by the United Nations, which intend for everyone to enjoy peace and prosperity[4]; therefore, it is essential to consider child development variables for such purposes. In this sense, it is important to recognize that early childhood care represents the opportunity to enhance children's capabilities and acquire the necessary competencies for their development. Hence, evaluation processes must be a priority and have sufficient characteristics to perform early screenings and differentiated interventions.

At present, literature reports on child development in Hispanic America are limited, mainly due to the need for regular measurement systems that are generalized across different types of consultation[5]. A systematic review study aimed to identify the metric properties of validated evaluation scales in Hispanic America for measuring psychomotor development in children up to 18 years of age and found that while the scales mostly showed positive indices, it is necessary to continue with validation studies that allow for decision-making and their clinical and research use[5].

Given this context, it is necessary to have evaluation instruments that are sufficiently valid and reliable, allowing professionals to have adequate tools to detect early situations that may affect children's normal development. In recent years, the development of screening systems based on responses from children's primary caregivers has gained strength[6], consistent and concordant with clinical evaluations. Hence, child development evaluation (CDE) instruments should ideally contain both aspects: questioning parents and caregivers to provide specific information about risk factors, warning signs, developmental milestones, and child abilities.

Different neurodevelopmental screening tests exist for children under 5 years of age[7]. In the United States, these include the Ages and Stages Questionnaires, Battelle Developmental Inventory, Bayley Scales of Infant and Toddler Development, Brigance Early Childhood Screen, clinical adaptive test/clinical linguistic and auditory milestone scale, Child Development Inventory, Denver Development Screening Test, and Parents Evaluation of Developmental Status. For Latin America, there are the EEDP Psychomotor Development Evaluation Scale, EDIN Child Integral Development Scale, NPED Pediatric Neurodevelopment, PRUNAPE, and TEPSI Psychomotor Development Test.

In Colombia, there are standardized and validated instruments, particularly the Abbreviated Development Scale (EAD)[8-10], which emerged to assess child development and enable monitoring and timely detection of children at risk for alterations. The EAD currently has its third version, EAD-3, which focuses on children up to 7 years old. Its final result generates a development level in children; however, it does not objectively consider other variables that contextualize their condition regarding risk factors, warning signs, and alerts, among others.

The scarcity of Colombian instruments to evaluate child development presents an opportunity to identify new tools that can be applied to its population. Hence, the CDE Test (EDI)[11] of Mexican origin is recognized as an appropriate instrument for cross-cultural adaptation and studying psychometric properties of validity and reliability. This would provide an instrument with health and research utility for characterizing developmental and epidemiological profiles in the Colombian child population.

The EDI test is a screening instrument for early detection of neurodevelopmental problems[11-14], applied to children under 5 years of age. It generates a qualitative development result and identifies risk factors, warning signs, and alert signs. This test has a sensitivity of 74% (95% confidence interval [CI] 0.65-0.82) and a specificity of 60% (95% CI 0.51-0.68) for children under 16 months, and a sensitivity of 89% (95% CI 0.82-0.95) with a specificity of 62% (95% CI 0.53-0.71) for the group over 16 months, reaching more than 80% when analyzing each development domain or subdomain separately[13].

The cross-cultural adaptation of instruments is the first step in obtaining adequate tools that must subsequently be validated to verify their psychometric properties. It is also necessary for use in linguistic and cultural contexts different from those in which they were originally constructed[15-17]. The objective of the research was to cross-culturally adapt the EDI test for Colombia and determine content and face validity, internal consistency reliability, and intra-rater reliability.

Methods

The study design consisted of two phases: I. Cross-cultural adaptation and face and content validation; II. Determination of internal consistency and intra-rater reliability. For phase I, cross-cultural adaptation and face and content validation of the EDI test, a process based on international guidelines was conducted[15,16]. The researchers contacted the original authors in Mexico, who authorized the process and use of the test. Four stages were carried out: adaptation to Colombian Spanish, content and face validity, review by original author, and pilot testing.

The instrument used was the EDI test, a tool for early detection of developmental problems[11], which was applied to children under 5 years of age and consisted of items distributed across 14 specific age groups. Its application methods are conducted through directed questions and direct observation of the child, comprising the evaluation of various axes: gross motor, fine motor, language, social, and knowledge areas, as well as biological risk factors, alert signs, warning signs, and neurological examination. Each item is qualitatively assessed according to whether it meets the corresponding performance and generates a development result through a traffic light system, in which red represents the risk of developmental delay, yellow represents developmental lag, and green represents normal development.

Regarding the study procedure, in the first phase, adaptation to Colombian Spanish, researchers expert in child development made two adaptations of the EDI test from Mexican Spanish to Colombian Spanish blindly and independently for each of the items in the 14 test groups to obtain a version with the respective linguistic and contextual adaptations.

Analysis and classification of equivalences were performed: semantic, idiomatic, experiential, and conceptual[18-20]. Semantic equivalence refers to writing, grammar, and use of words that, when modified, preserve the meaning of the original version; idiomatic equivalence corresponds to colloquial expressions specific to the original culture that must be replaced by those more appropriate and natural to the new context; experiential equivalence represents expressions that mainly designate daily life situations and specific cultural experiences that must be adapted for better understanding, and conceptual equivalence corresponds to expressions and words whose meaning is different in each culture. The adaptations were then harmonized into a consensus version by the entire research team, and the first version of the EDI test for Colombia was obtained.

In the second phase, content and face validity, the test was sent to a committee of five expert judges with postgraduate training, teaching and research positions, experience in child development, and some with training and experience in translation and applied linguistics. The expert judges performed an independent quantitative and qualitative evaluation of the test. The quantitative evaluation was done through rating criteria of importance, influence, and observance for each item in the 14 test groups. Each item was rated on a 4-point Likert scale as follows: 1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree. The expert judges' ratings' results underwent quantitative and qualitative analysis.

In the quantitative analysis, means (M), standard deviations (SD), and coefficients of variation (CV) were considered for each item and each evaluation criterion – importance, influence, and observance. From this, decisions regarding required changes and adjustments to items were made according to the following criteria:

– Items showing high scores in importance and influence (M ≥ 3.0) and low variability (SD < 1.0) were either kept or underwent minor modifications
– Items showing reasonable scores in observance (M > 2.5) and low variability (SD < 1.5) were either kept or underwent minor modifications
– Scores lower than the above required the item to be adapted again
– Using the CV, the relationship between SD and mean was analyzed for each item; items obtaining a CV ≥ 0.4 required modification.

The qualitative evaluation corresponded to additional observations and comments made regarding each item. From this, the second version of the EDI test for Colombia was obtained. Once this version was obtained, the third phase proceeded, in which the test was sent to and approved by its original authors from the *Hospital Infantil de México Federico Gómez* (Federico Gómez Children's Hospital).

Finally, in the fourth phase, the EDI test for Colombia underwent pilot testing with a sample of 45 evaluators, of whom 15 were children's caregivers who evaluated the directed questions, and 30 were expert evaluators in child development who had previously received training and calibration from the original authors. The test was applied by an expert evaluator to 14 children, one per age group, applying all test blocks: block 1 of personal data, block 2 of the five axes in both directed questions and child observation, and block 3 of global scoring. This application was video-recorded, and the 30 evaluators blindly and independently applied the test for an average of 40 min. Both expert evaluators and caregivers completed a questionnaire about the clarity, comprehension, and precision of the items.

Once the adapted EDI test for Colombia was obtained, phase II proceeded to determine the psychometric properties of reliability through internal consistency and intra-rater reliability. For this, a sample of 195 children aged 0-5 years participating in programs of the Foundation for Child Care (*Fundación de Atención a la Niñez*, FAN) in Medellín, Colombia, was used, considering five children per test item, the minimum sample required for this type of study. The evaluators were experts in child development, with health and early childhood education training, and trained in test applications. Internal consistency was determined through Cronbach's α coefficient, and intra-rater reliability was conducted with test application by the same evaluator at two different times, with a time difference of < 1 week; its analysis was performed with the Kappa index considering a $p \leq 0.05$.

Regarding ethical considerations, the study was approved by the bioethics committee of the *Universidad Autónoma de Manizales*, Colombia, in act No. 086, and the parents and caregivers of the minors previously signed an informed consent.

Results

Phase I resulted in the adapted and validated EDI test for Colombia. Regarding this result, it should be detailed that for the adaptation to Colombian Spanish, the researchers conducted a systematic review of each test item blindly and independently. Subsequently, through team consensus, the final adaptation was obtained, resulting in changes and adjustments to some items to achieve a test with linguistic and contextual adaptation and adequacy without reporting doubts or ambivalence. Items were analyzed and classified as equivalent, non-equivalent, and with problems in some words. Equivalent items had no issues in their translation and adaptation from Mexican Spanish to Colombian Spanish and required minimal changes, especially from the conceptual and cultural component due to terminology differentiation associated with culture; almost all items in each group were classified as equivalent items.

Non-equivalent items corresponded to those where translation to Colombian Spanish was not possible, and significant translation and writing changes were necessary to preserve their meaning; in this case, no items were found for this classification. Items with problems, in some words, corresponded to those where changes and adjustments were necessary to maintain their meaning, but different culturally relevant formulations and expressions were used for the Colombian population. Most items requiring adjustments were due to experiential equivalence, followed by idiomatic equivalence and conceptual equivalence. Group 9 required the most adjustments, followed by group 13. It should be noted that in a single item, adjustments for one or several equivalences were necessary (Tables 1 and 2).

In the results of content and face validity, it was found that the alert signs axis in groups 1, 2, 3, 4, 5, 6, 7, and 8 required the most changes in some of its items, as they obtained SD ≥ 1.0 and CV ≥ 0.4 in the importance and influence criteria; in the observance criterion, only one item in group 1 obtained a CV = 0.4. Groups 9, 10, 11, 12, 13, and 14 did not require changes or adjustments since the quantitative results met the permitted values.

The qualitative evaluation was conducted for each item through observations or comments by each judge, who simultaneously suggested the recommended change.

Table 1. Item equivalence analysis

EDI test axes	EDI test groups (number of items)	Number of equivalent items	Number of non-equivalent items	Number of items adjusted for semantic equivalence	Number of items adjusted for idiomatic equivalence	Number of items adjusted for conceptual equivalence	Number of items adjusted for experiential equivalence
ALE MG MF LE SO CO ALA	1 (12)	11	0	0	1	0	1
	2 (15)	14	0	0	1	0	1
	3 (14)	12	0	0	1	1	1
	4 (14)	12	0	0	1	1	1
	5 (16)	13	0	0	0	0	3
	6 (15)	14	0	1	1	0	1
	7 (14)	12	0	0	1	0	2
	8 (17)	14	0	0	1	1	2
	9 (19)	15	0	0	3	11	2
	10 (17)	17	0	0	0	0	0
	11 (16)	14	0	1	1	0	0
	12 (21)	17	0	2	2	1	2
	13 (24)	19	0	0	4	0	5
	14 (25)	19	0	0	3	0	2
FRB (7)		4	0	0	1	1	2
EN (3)		3	0	0	0	0	0
Total (249)		224	0	4	21	16	25

ALE: warning signs. Developmental areas; MG: gross motor; MF: fine motor; LE: language; SO: social; CO: knowledge; ALA: alarm signals. FRB: biological risk factors. EN: neurological examination.

Table 2. Examples of items adapted and adjusted to Colombian Spanish according to equivalences (the items are expressed in Mexican and Colombian Spanish to preserve the linguistic and idiomatic differences, given the fact that in English translation it could be lost)

EDI test groups	EDI test axes	Original item in Mexican Spanish	Item adapted to Colombian Spanish	Type of equivalence
6	Social	Cuando le da de beber líquidos, ¿le ayuda a detener el biberón o la taza?	Cuando le da de beber líquidos, ¿le ayuda a sostener el tetero o la taza?	Semantic, experiential, idiomatic
13	Gross motor	Cuando le avientan a su niño (a) una pelota grande ¿puede cacharla?	Cuando le lanzan a su niño (a) una pelota grande ¿puede atraparla?	Experiential, idiomatic
	Fine motor	¿Puede meter una agujeta o cordón por los agujeros de una cuenta o de un zapato?	¿Puede meter un cordón por los agujeros de un zapato o de un juguete de ensartar?	Experiential, idiomatic
	Language	¿Puede platicarle algo de lo que hizo ayer?	¿Puede hablarle sobre algo de lo que hizo ayer?	Experiential, idiomatic

The researchers, by consensus, analyzed and identified differences in the content of phrases due to the use of synonyms, prepositions, verb tenses, and pronouns, among others, and determined the final wording of items where adjustment was recommended. Changes were made to most items, such as changes from singular to

Table 3. Examples of items adapted and adjusted to Colombian Spanish according to qualitative evaluation by expert judges. (the items are expressed in Mexican and Colombian Spanish to preserve the linguistic and idiomatic differences, given the fact that in English translation it could be lost)

EDI test group	EDI test axis	Original item in Mexican Spanish	Item adapted for Colombian Spanish
1	Warning signs	¿Considera que el desarrollo de su niño (a) es inadecuado?	Considera que el desarrollo de su niño (a) *es inferior al de otros niños de su misma edad?*
2	Gross motor	Cuando acuesta su bebé boca abajo, ¿levanta su cabeza durante al menos 3 segundos?	Cuando *el (la) niño (a) está acostado (a) boca abajo* ¿Levanta su cabeza durante al menos 3 segundos?
3	Fine motor	¿Tiene su niño (a) las manos abiertas la mayor parte del tiempo?	¿Tiene *el (la) niño* (a) las manos abiertas la mayor parte del tiempo?
4	Language	¿Balbucea o grita para llamar su atención?	¿*Su niño (a) balbucea o grita* para llamar su atención?
7	Warning signs	¿Hace esfuerzos por desplazarse o gatea?	¿ *El (la) niño (a) hace esfuerzos* por desplazarse o gatear?**
9	Warning signs	¿Se enoja mucho y tiene dificultad para calmarse, comparado con otros niños (as) de su edad?	¿Comparado (a) con otros niños (as) de su edad, se enoja mucho y tiene dificultad para calmarse?
11	Warning signs	¿Muestra indiferencia excesiva al entorno?	¿*Su niño (a) muestra* indiferencia excesiva con el entorno? *Por ejemplo: parece como si estuviera en su propio mundo, sin interesarse en nada de lo que pasa, parece no escuchar cuando se le habla.*
12	Language	Cuando está con personas que no conoce, ¿éstas entienden la mayoría de las palabras que dice?	*Cuando su niño (a) está con personas* que no conoce ¿*Estas personas entienden* la mayoría de las palabras que dice?
Biological risk factor		Madre menor a 16 años al momento del parto.	Madre *menor* de 16 años *en el* momento del parto.
Neurological examination		¿Presenta alteración en la movilidad de alguna parte del cuerpo?	*El (la) niño (a) presenta alteración* en la movilidad de alguna parte del cuerpo, *por ejemplo: ¿Sus movimientos son anormales o no realiza ningún movimiento?*

plural terms; wording changes, for example, in some items, more precise words were adjusted, and representative examples were included for better understanding; changes in punctuation marks; adjustments to statements regarding the explicit use of articles, subject, and possessive determiners. In this way, the items were transformed to improve the language, grammatical structure, and precision of what is being evaluated.

Regarding the biological risk factor axis, a significant change in its content was necessary, given that in Colombia, gestational weeks and birth weight that represent a risk in newborns are standardized. Hence, risk factors 3 and 4 were modified. In the Mexican version, the statements were “Gestation < 34 weeks” and “Child’s birth weight 1500 g or less,” and were changed to “Gestation < 36 weeks” and “Child’s birth weight of 2500 g or less.” Only 10 items from the entire EDI test did not require changes and remained the same as their original Mexican version (Table 3).

The original authors reviewed the Colombian version of the test, and no comments, changes, or adjustments arose; therefore, the EDI test for Colombia was approved to continue with pilot testing.

The pilot test results showed that the EDI test met the criteria for comprehension, clarity, and precision, and it was not necessary to make adjustments or modifications to the test structure or any of its items. For the methodological process of test reliability, it was necessary to develop an instruction manual and protocol to achieve rigorous test application.

After obtaining the cross-culturally adapted and valid EDI test for Colombia, phase II proceeded, in which data collection was carried out to obtain the psychometric properties of reliability. For this, a sample of 195 children was used, distributed across the 14 test groups. They ranged

in age from 1 to 59 months, with a mean of 18 months. 43.1% were female and 56.9% male; the majority (95%) belonged to socioeconomic strata 1, 2, and 3.

The results of internal consistency reliability were calculated for two dimensions together, the developmental areas and biological risk factors, and were found to be acceptable with Cronbach's α values of 0.41 and 0.57, respectively.

The intra-rater reliability was found to be very good, with Kappa index values > 0.76, except for the neurological examination area (Table 4).

Table 4. Intra-rater reliability

EDI test dimension	Variable	Kappa index
Biological risk factors	Attendance to two or more prenatal consultations	1*
	Pregnancy complications	0.99*
	Gestation < 36 weeks	1*
	Birthweight < 2500 g	1*
	Risk of cerebral hypoxia	0.98*
	Hospitalization in ICU before 1 month for 4 days or more	1*
	Mother < 16 years	1*
Biological risk factors		0.99*
Warning signs		0.78*
Neurological examination area		0.3*
Alarm signals		0.9*
Gross motor development area		0.78*
Fine motor development area		0.69*
Language development area		0.81*
Social development area		0.94*
Knowledge development area		0.96*
EDI global development level		0.76*

*p ≤ 0.001. ICU: intensive care unit.

Discussion

Assessment and screening processes for child development are priorities for timely and quality early childhood care. Children must live and enjoy the highest possible level of health and nurturing environments, which makes it imperative to conduct adequate, complete, and pertinent evaluations of their developmental process. In addition, advances in neuroscience have determined that the 1st years of life are fundamental for establishing developmental foundations, where new skills sequentially lead to other competencies. Therefore, investment in improving early childhood development is necessary to achieve cost-effectiveness for equitable and sustainable development in countries[21].

Using validated screening instruments can improve early diagnosis and timely intervention in high-risk children, where long-term improvements have been demonstrated, especially in cognitive and academic performance[22,23]. The EDI test constitutes an ideal instrument for the early detection of developmental alterations in children, comprising important axes that allow the identification of risk factors, warning signs, and alerts, in addition to evaluating developmental milestones in motor, communicative, social, and cognitive areas[24]. Therefore, the opportunity to obtain its cross-cultural adaptation, validity, and reliability for Colombia was evident.

Cross-cultural adaptation processes for instruments should include, among others, translation phases and content and face validity[25]. This study adapted from Mexican Spanish to Colombian Spanish, resulting in adjustments to most items, especially regarding experiential and idiomatic equivalences. Content and face validity were successfully conducted and led to adjustments for greater clarity and comprehension of items, allowing for the final version of the EDI test for Colombia. In its modified Mexican version, the EDI test also developed a face validity process to answer the question: Does the scale appear to measure what it should measure? And does it reflect the domain structure of the phenomenon to be evaluated?[26] This process analyzed the characteristics of purpose and conceptual framework, comprehensibility, replicability, suitability, and ease of use of the test. Subsequently, questions were reorganized into axes, scoring criteria were modified to obtain greater congruence, and observed modality was added to items where necessary, thus obtaining a version that adequately met appearance and content requirements[26].

In addition, it is important to recognize that the EDI test for Colombia showed adequate psychometric properties of reliability, moderate internal consistency, and very good intra-rater reliability. For the latter, it is important to identify that it was lower for the neurological exploration area, which may be related to the expertise and mastery of the evaluator in the test application. Regarding these results, one study mentions that using child development assessment instruments and diagnosis classification of children under 5 years is unreliable when performed only once, as children in

this age group experience highly varied changes and require frequent evaluations during their growth. The tests are not predictive and only provide results that classify the situation at a specific moment. In this sense, child development assessment should focus beyond skill acquisition, including other aspects related to development, such as risk factors[27].

For the Colombian context, it is important to acknowledge recent studies on the validation and reliability of child development instruments. One study aimed to identify the sensitivity and specificity of the Ages and Stages Questionnaires: Social-Emotional, Second Edition (ASQ: SE-2) for ages 6, 12, 18, 24, 30, and 36 months, and conducted a comparative analysis between the ASQ: SE-2 and the Personal-Social Subscale of the Abbreviated Development Scale (EAD-3). The study showed a relationship between both instruments in identifying risk and social-emotional development in the 6-month (X^2 [1, 85] = 7.869, p = 0.005), 18-month (X^2 [1, 97] = 15.966, p = 0.000), and 36-month (X^2 [1, 50] = 11.387, p = 0.001) questionnaires. The ASQ: SE-2 reports optimal specificity and adequate sensitivity levels in the 12 and 18-month questionnaires[28].

Similarly, another study aimed to evaluate the internal consistency, test–retest reproducibility, level of agreement, and convergent construct validity of a cultural adaptation for Colombia of the Child Development Screening Questionnaire for Household Surveys. The study found internal consistency between 0.23 and 0.76, ICC reliability between 0.60 and 0.92, and almost perfect convergent validity (p = 0.96)[29]. Other studies in Latin America also demonstrate solid validity values for these types of instruments[30].

The Canadian Task Force on Preventive Health Care evaluated evidence on the effectiveness of population screening for developmental delay in primary care settings and generated a guideline of recommendations on screening tools to identify this problem. This guide recommends that primary care providers should remain vigilant in monitoring a child's development at each clinical encounter and should focus on confirming a diagnosis in children where difficulties are suspected. In particular, health professionals should remain attentive to deficits in children's performance in gross and fine motor skills, cognition, speech and language, and personal and social skills[31]. Problems related to developmental delay describe below-average skills in one or more domains, which can accumulate throughout life, leading to social and economic difficulties, making it a relevant issue for doctors, parents, educators, and public policymakers[32].

Therefore, it is necessary to develop child development screening processes. While the clinical judgment of professionals is important for detecting these problems, it is essential to use standardized and norm-based instruments, as it is known that more than 30% of cases of children with developmental disorders are not diagnosed in time[33]. This leads to delayed treatments that do not favor a positive and adequate developmental process and consequently result in limited benefits and socioeconomic disadvantages for communities.

Having the EDI test for Colombia will provide professionals with an instrument for the timely detection of warning signs or risk signals for children's development, thus enabling timely interventions that promote a healthy environment for healthy growth and development. Simultaneously, this would implement actions aligned with comprehensive early childhood health care through the new Comprehensive Health Care Routes (*Rutas Integrales de Atención en Salud*) within the framework of the Territorial Comprehensive Care Model (*Modelo de Atención Integral Territorial*)[34].

Adequate and timely information about children's developmental levels is necessary, as there is a demand for population-based diagnostics on well-being, development, and other children's rights[35]. This will enable the design and development of programs that strengthen quality actions to improve living conditions for this population, especially those with greater vulnerability characteristics[35].

The study did not have relevant limitations that hindered its development and the achievement of its objectives.

Given the relevance of conducting child development assessment processes, it is recommended to carry out studies related to the use of the EDI test that considers larger samples and other variables that allow finding correlations and predictions regarding children's development in Colombia.

Conclusion

The cross-cultural adaptation of the EDI test for Colombia resulted in obtaining a test with concept, structure, composition, and content characteristics equivalent to its original Mexican version. In addition, it has sufficient psychometric properties of content and face validity, as well as reliability for its application and consequent characterization of child development in Colombia.

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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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RESEARCH ARTICLE

Validation of a screening tool for developmental problems in children 60-71 months in Mexico

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Abstract

Background: *Early childhood is a critical period for child development. The Child Development Evaluation Test (EDI in Spanish), developed and validated in Mexico, is a screening tool for developmental problems in children from 1 month to 4 years and 11 months.* **Objective:** *To validate group 15 of the EDI test for children aged 60-71 months, comparing sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) using the Battelle Developmental Inventory 2nd edition (BDI-2) in Spanish as the gold standard.* **Methods:** *A cross-sectional analytic study with 46 children aged 60-71 months was conducted at the Hospital Infantil de México Federico Gómez. Children were evaluated using group 15 of the EDI test and BDI-2. The sample was non-probabilistic by convenience. Diagnostic metrics and comparisons were performed globally and in the developmental domain.* **Results:** *The sensitivity and specificity of group 15 for the EDI test were 93.8% (95% confidence interval [CI]: 81.8%-100%) and 73.3% (95% CI: 57.5%-89.1%), respectively. The PPV was 65.2%, and the NPV 95.5%. The highest percentage of false negatives was in the cognitive domain, followed by the adaptive domain.* **Conclusion:** *In this first study, group 15 of the EDI test shows high sensitivity and NPV, allowing early detection in an age group previously not covered, thus facilitating interventions in this group.*

Keywords: *Child Development. Infant health. Child care. Early intervention.*

Validación diagnóstica de una herramienta para la detección oportuna de problemas en el desarrollo infantil de niños de 60-71 meses de edad en México

Resumen

Introducción: *La Primera Infancia es un periodo crítico para el desarrollo infantil. La prueba Evaluación del Desarrollo Infantil (EDI), desarrollada y validada en México, es una herramienta de tamiz para detectar problemas del desarrollo en niños desde un mes de vida y hasta 4 años 11 meses. Esta investigación, realizada en 2019, tuvo como objetivo validar el grupo 15 de la prueba EDI y ampliar el rango de edad de evaluación hasta los 60 a 71 meses, comparando sus métricas de sensibilidad, especificidad, valor predictivo positivo (VPP) y valor predictivo negativo (VPN) con el Inventario de Desarrollo de Batelle, segunda edición (IDB-2), como estándar de referencia.* **Métodos:** *Se realizó un estudio transversal analítico prospectivo con 46 niños y niñas de 60 a 71 meses, evaluados mediante el grupo 15 de la prueba EDI y el IDB-2, en el Hospital Infantil de México Federico Gómez. Los participantes fueron seleccionados mediante muestreo no probabilístico por*

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conveniencia. Se analizaron las métricas diagnósticas y se compararon los resultados globales y por dominios. **Resultados:** *La sensibilidad y especificidad del grupo 15 de la EDI fueron del 93.8% (IC 95%: 81.8%-100%), y 73.3% (IC 95%: 57.5%-89.1%), respectivamente. El VPP fue del 65.2% y VPN de 95.5%. El dominio cognitivo presentó el mayor porcentaje de falsos negativos, seguido del dominio adaptativo.* **Conclusión:** *El grupo 15 de la prueba EDI demostró alta sensibilidad y VPN, permitiendo la detección oportuna en un rango de edad previamente no cubierto, facilitando intervenciones tempranas en este grupo.*

Palabras clave: *Primera infancia. Prueba EDI. Desarrollo infantil. Tamiz.*

Introduction

The National Strategy for Early Childhood Care (ENAPI, for its Spanish acronym), developed within the framework of the Early Childhood Commission of the National System for the Protection of Girls, Boys, and Adolescents (SIPINNA, for its Spanish acronym), establishes that early childhood spans from birth to 5 years and 11 months of age[1]. This strategy, supported by the creation of a Comprehensive Early Childhood Policy approved on April 30, 2019, emphasizes the importance of this period as a foundation for building a better society and country[2].

Health care for children under 5 years of age in Mexico is regulated by NOM-031-SSA2-1999 for Child Health Care, which stipulates growth and development monitoring as basic health-care actions (section 9.16) and promotes community participation in these actions (section 12.2). In Appendix F, behaviors to be evaluated for child development were included through a technical guide[3]. In response to the need for a specific instrument for the timely detection of developmental problems in children under 5 years living in poverty, the Child Development Evaluation Test (EDI, for its Spanish acronym) was designed and validated with funding from the National Commission for Social Protection in Health (CNPSS, for its Spanish acronym), through PROSPERA, a social inclusion program[4].

There are different developmental screening tests used internationally (Table 1), including Ages and Stages Questionnaires (USA)[5], Bayley Infant Neurodevelopmental Screen (USA)[6], Denver II (USA)[7], Psychomotor Development Evaluation Scale (Chile)[8], National Screening Test (PRUNAPE) (Argentina)[9], and the EDI developed and validated in Mexico for the timely detection of developmental problems in children from 1 month of age up to 4 years and 11 months (Table 1)[10].

In Mexico, the international panel of experts, "Validation of Diagnostic Instruments for Child Development Problems in Mexico," concluded that the EDI test is the most appropriate screening instrument in the context of the Mexican population. At the same time, the Battelle Developmental Inventory 2nd edition (BDI-2) is the reference standard for diagnosing developmental delays. Since 2014, the EDI test has replaced the technical guide and, together with the BDI-2 and competency-based early stimulation, forms part of the technical guidelines for early child development that establish care for children under 5 years in this area[4].

However, the EDI does not cover the age range from 5 years to 5 years and 11 months, leaving a diagnostic gap for this group. This situation is especially critical as it corresponds to the transition between preschool and primary education. The absence of a valid tool for this age range limits the possibility of timely identification and intervention[11].

A series of specific developmental milestones for this age range were developed and integrated as group 15 of the EDI test to address this gap. The present study aims to validate these milestones by comparing the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of group 15 against the gold standard, the BDI-2 in Spanish. The hypothesis proposes that these metrics will be > 70%.

Methods

This research was conducted in two phases, each utilizing a different methodology to achieve its objective. In the first phase, a review of national and international literature was undertaken to identify developmental milestones for children aged 5 years-5 years and 11 months. These milestones were incorporated as items in the formulation of group 15 of the EDI test, and areas to be evaluated through questioning and observation were established. In the second phase, a prospective analytical cross-sectional study was conducted. Participants were recruited through the study protocol announcement to the general population, primarily through the official social network of the neurodevelopment research unit at the *Hospital Infantil de México Féderico Gómez* (HIMFG).

A non-probabilistic convenience sampling was used to select participants who met the following inclusion criteria: being between 5 years of age and 1 day before

Table 1. Developmental screening tests in the Americas

Developmental screening test	Language	Administration time (min)	Age range (months)	Sensitivity	Specificity
Ages and Stages Questionnaires (USA)	English and Spanish	10-15	4-60	0.70-0.90	0.76-0.91
Battelle developmental inventory screening 2nd ed.. (USA)	English and Spanish	10-30	0-95	0.72-0.93	0.79-0.88
Bayley infant neurodevelopmental screen (USA)	English	10	3-24	0.75-0.86	0.75-0.86
Denver II	English and Spanish	20-30	0-71	0.56	0.80
Psychomotor development evaluation scale (*Escala de Evaluación del Desarrollo Psicomotor,* Chile)	Spanish	20	0-24	Not reported	Not reported
PRUNAPE National Screening Test (PRUNAPE *Prueba Nacional de Pesquisa*, Argentina)	Spanish	10-15	0-60	0.80	0.93
Child development evaluation test (EDI *Prueba de Evaluación del Desarrollo Infantil*, México)	Spanish	10-15	Total 0-15 16-59	80.5 76.1 88.5	60.5 59.1 62.3

turning 6 years (children 60-71 months of age), being presumably healthy, and having been evaluated at the neurodevelopment research unit of the HIMFG. In addition, parents were required to sign informed consent authorizing the application of the EDI test and the use of the obtained information. Children with any associated chronic disease were excluded.

Data were collected through clinical history, physical examination, the version for group 15 of the EDI test, and the BDI-2 Spanish version.

The EDI test is a screening tool developed and validated in Mexico for the timely detection of child development problems. The 20 items for this group are answered by primary caregivers or are scored through observation of behaviors grouped into five axes: (a) biological risk factors; (b) warning signs; (c) developmental areas (fine motor, gross motor, language, social, and knowledge); (d) alarm signs; and (e) neurological examination (Table 2). Possible results are normal development (green), developmental lag (yellow), or risk of delay (red). Classification in red can be based on results obtained in one or more of the following axes: developmental areas, neurological examination, or alarm signs. Results are classified as red based on results obtained in one or more axes. Tests reported as either yellow or red are considered abnormal[10].

The BDI-2 Spanish version identifies developmental delays in children from birth to 7 years and 11 months. It consists of 341 items applied according to age and corresponding developmental area. These areas are personal-social, adaptive, motor, communication, and cognitive. The Inventory uses a traffic light system to interpret results, as well as standardized scores and a global measure called Total Developmental Quotient (TDQ). This quotient classifies developmental level in ranges from a score below 70, indicating significant delay, to values of 130, interpreted as accelerated development.

The EDI test and BDI-2 test were administered and reviewed by trained personnel from the HIMFG neurodevelopment research unit. Personnel who reviewed the tests did not participate in their administration.

The study was approved by the Research, Ethics, and Biosafety Committees of the HIMFG, file number HIM-AE-02-2019.

Statistical analysis

A descriptive statistical analysis of participants was conducted, using means for normally distributed numerical variables and absolute frequencies and percentages for categorical variables. Sensitivity, specificity, and predictive values were calculated with 95% confidence intervals (CIs) to obtain diagnostic validation metrics. Statistical analyses were performed using IBM SPSS software version 25.

Results

A total of 46 participants who met the inclusion criteria were included from Mexico City, State of Mexico, and Nuevo León. Of the total, 32 (69.6%) were male. The mean age was 64.39 months (Fig. 1).

Table 2. Developmental areas items for children 60-71 months in the child development evaluation test (EDI)

Developmental area	Item
Gross motor	1. Can hop forward on one foot 7 times landing on the same foot? (*¿Puede brincar con un solo pie hacia adelante siete veces cayendo con el mismo pie?)*
	2. Can jump backward with feet together? *(¿Puede brincar hacia atrás con los pies juntos?)*
	3. Can walk in a straight line, touching heel to toe, for at least 5 steps? *(¿Camina siguiendo una línea recta, juntando el talón de un pie con la punta del otro pie, por lo menos 5 pasos?)*
Fine motor	1. Can draw a triangle by copying it? *(¿Puede dibujar un triángulo copiándolo?)*
	2. Can touch the tip of the thumb with the tip of each finger of the same hand consecutively? *(¿Puede tocar la punta de su dedo pulgar con la punta de cada dedo de la misma mano consecutivamente?)*
	3. Can cut paper with round-tipped scissors following a straight line, with 1 cm margin of error? *(¿Puede cortar el papel con tijeras de punta redonda siguiendo una línea recta, teniendo 1 cm de margen de error?)*
Language	1. Speaks clearly enough for others to understand? *(¿Habla con suficiente claridad para que otros lo entiendan?)*
	2. Communicates emotions using words such as: "happy," "sad," "angry?" (if you receive gifts, how do you feel?) *(¿Comunica sus emociones diciendo palabras como: "feliz", "triste", "enojado"? [si recibes regalos, ¿cómo te sientes?].)*
	3. Can follow three-step verbal commands, for example: "clap, give me the pencil, and stand up?" *(¿Puede seguir ordenes verbales de tres pasos, por ejemplo: "aplaude, dame el lápiz y ponte de pie"?)*
Social	1. Most of the time easily shares things with other children? (*¿La mayoría de las veces comparte fácilmente sus cosas con otros niños?)*
	2. Enjoys going to school? *(¿Le gusta ir a la escuela?)*
	3. Easily waits their turn when interacting with peers, teachers, or primary caregivers? *(¿Espera su turno con facilidad cuando interactúa con sus compañeros, maestros o cuidadores primarios?)*
Knowledge	1. When asked to write two numbers or two letters, can do it? (*Cuando le pides que escriba 2 números o 2 letras, ¿lo hace?)*
	2. Can complete sentences with words that mean the opposite? For example: "the rabbit is fast, the turtle is." *(¿Puede completar oraciones con la palabra que significa lo opuesto? Por ejemplo: "el conejo es rápido, la tortuga es.")*
	3. Can identify the value of two or more coins or bills? *(¿Identifica el valor de dos o más monedas o billetes?)*
Warning signs	1. Has persistent headaches, blurred vision, or dizziness? *(¿Presenta dolores de cabeza persistentes, visión borrosa o mareo?)*
	2. Has difficulty brushing teeth, washing and drying hands, or undressing without help? *(¿Presenta dificultad para cepillarse los dientes, lavarse y secarse las manos o desvestirse sin ayuda?)*
	3. For more than 3 days a week, does the child show fear, aggression, shyness, or sadness with greater intensity than children of their age? *(¿Durante más de tres días a la semana el niño presenta miedo, agresión, timidez o tristeza en mayor intensidad que los niños de su edad?)*
Neurological examination	1. Shows altered mobility in any part of the body? (*¿Presenta alteración en la movilidad de alguna parte del cuerpo?)*
	2. Shows alteration or asymmetry in eye movement or facial expression? *(¿Presenta alteración o asimetría en la movilidad de ojos o expresión facial?)*

Source: Child Development Evaluation Manual (EDI), July 2021.

It was found that 50% (n = 23) of participants obtained an abnormal test result (14 red and nine yellow), with the remaining patients having a normal test (23 green).

Of the 46 participants in the sample, 16 (34.7%) presented a TDQ below 90. According to the Battelle Developmental Inventory, a TDQ score below 80 is considered a developmental delay. However, in this study, a

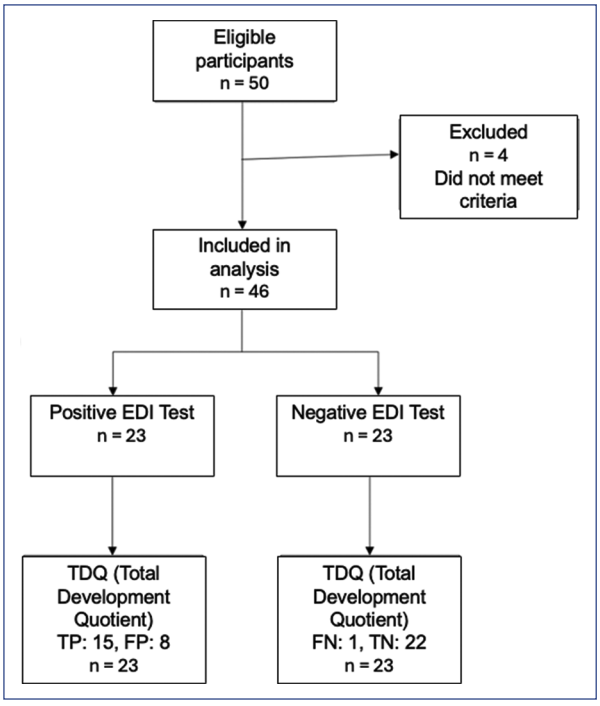

Figure 1. Study participant flow diagram. Results of the index test (EDI) and its comparison with the reference standard (Battelle Developmental Inventory, 2nd edition in Spanish). TDQ: totalt developmental quotient; TP: true positives; FP: false positives; FN: false negatives; TN: true negatives.

cutoff point below 90 was established because a significant number of patients who showed a delay in some developmental domain or subdomain could achieve an average TDQ score.

From the comparison between EDI test results and BDI-2 TDQ (TDQ < 90), a sensitivity of 93.8% (95% CI: 81.8%-100%), specificity of 73.3% (95% CI: 57.5%-89.1%), PPV of 65.2% (95% CI: 45.7%-84.7%), and NPV of 95.5% (95% CI: 87.2%-100%) were obtained (Table 3).

According to the abnormal global result of the EDI test in relation to the developmental domains of the BDI-2 test, the cognitive domain was found to be the most frequently affected (Table 4).

The highest percentages of false negatives were identified in the cognitive domain (in the perception and concepts, reasoning, and academic skills subdomains) and the adaptive domain (personal responsibility subdomain) (Table 5).

Discussion

The sensitivity (93.8%) and specificity (73.3%) of group 15 of the EDI test, compared with the gold standard for developmental assessment (BDI-2), confirmed the proposed hypothesis, exceeding the 70% established as validation criterion. These results indicate the potential of this tool as a valid option for evaluating development in children aged 60-71 months, a previously uncovered age group.

Table 3. Abnormal EDI Test and TDQ < 90 in Battelle Test

EDI test result	TDQ < 90	TDQ ≥ 90	Total
Abnormal (yellow and red)	15 (93.8%)	8 (26.7%)	23 (50%)
Normal (green)	1 (6.3%)	22 (73.3)	23 (50%)
Total	16	30	46

TDQ: total developmental quotient.

When comparing this EDI group with other screening tools, such as Denver II, the EDI showed superior sensitivity (93.8% vs. 56%), although its specificity was lower (73.3% vs. 80%)[7].

It is worth mentioning that this test adhered to the previously established guidelines in the remaining 14 groups of the EDI test, and the sensitivity and specificity of group 15 achieved in this study are superior to those reported for the EDI test in general (sensitivity 80.5% and specificity 60.5%)[10].

Early identification of developmental delays enables referral to therapeutic services, and children referred for early intervention are more likely to achieve progress in developmental milestones[11]. The American Academy of Pediatrics recommends formal developmental evaluation for all children during well-child visits at 9, 18, 24, and/or 30 months. In addition, formal screening tests are recommended, considering administration time and cost, as well as reliability, sensitivity, and specificity[12].

Developmental screening involves using validated tools to identify children at high risk of developmental delay in an apparently normal population, whereas surveillance is the process of monitoring children identified as high-risk through screening[13].

Like the current version for the 14 groups of the EDI test, this study used the same scoring system consisting of green (normal development), yellow (developmental lag), and red (risk of developmental delay).

Regarding the NPV, a green EDI test result indicates that the probability of all BDI-2 areas reporting an average result is 95.7%, reinforcing EDI's utility as a tool for ruling out developmental risks. However, the PPV of 65.2% indicates the need to interpret abnormal results with caution, as an abnormal result does not necessarily

Table 4. Sensitivity and specificity by domain

Battelle developmental inventory 2nd edition	Total development quotient < 90	EDI test sensitivity (%)	EDI test specificity (%)
Adaptive	13	11 (84.6)	21 (63.6)
Personal-social	8	7 (87.5)	22 (57.8)
Communication	11	9 (81.8)	21 (18.6)
Motor	9	8 (88.9)	22 (59.4)
Cognitive	26	19 (73.1)	16 (80)

Table 5. Sensitivity and specificity by subdomain

Battelle developmental inventory 2nd edition Domains and subdomains	Scalar score < 8	EDI test sensitivity (%)	EDI test specificity (%)
Adaptive (ADP):			
Personal care (SC)	7	5 (71.4)	21 (53.8)
Personal responsibility (PR)	23	17 (73.9)	6 (65.3)
Personal-social (P-S):			
Adult interaction (AI)	11	10 (90.9)	1 (62.8)
Peer interaction (PI)	14	11 (78.6)	3 (62.5)
Self-concept and social role (RS)	7	6 (85.7)	1 (56.4)
Communication (COM):			
Receptive communication (RC)	12	10 (83.3)	2 (61.7)
Expressive communication (EC)	10	9 (90)	1 (61.1)
Motor (MOT):			
Gross motor (GM)	7	5 (71.4)	2 (53.8)
Fine motor (FM)	11	10 (90.9)	1 (62.8)
Perceptual motor (PM)	11	8 (72.7)	3 (57.1)
Cognitive (COG):			
Attention and memory (AM)	24	19 (79.2)	5 (81.8)
Reasoning and academic skills (RA)	21	17 (80.9)	4 (76)
Perception and concepts (PC)	25	19 (76)	6 (80.9)

imply generalized developmental delay. During this study, it was observed that patients could present areas of development with below-average results (TDQ < 90) and others with above-average results (TDQ ≥ 90) in the same diagnostic test (BDI-2), so when considering both scores, the global test result, that is the TDQ, results in average or even above average. The false-positive rate for red results in group 15 was 7.3%, so clinical interpretation should be cautious. In addition, the small sample size (46 participants) and the use of non-probabilistic sampling may limit the generalization of these findings.

Parents' concerns regarding development should be addressed through structured developmental assessment[13]. For many families, especially those with young children, pediatric care providers function as gatekeepers for mental health and developmental services; however, providers often fail to identify children with developmental disorders, making it essential to find feasible methods to improve identification for effective treatment[14].

This study provides initial evidence to consider implementing EDI group 15 in national programs. Its high sensitivity and NPV (95.5%) make it an effective screening tool for detecting children without risk. The rationale for conducting developmental assessments is based on the premise that health and development are interrelated[15].

Early intervention is effective in high-risk children and is associated with cognitive and academic performance improvements[16].

Conclusion

Solid foundations establish the importance of timely intervention in early childhood to stimulate development and thus achieve each person's maximum potential.

This intervention must occur as soon as any developmental delay is detected and, even more importantly, it must begin as soon as risk factors are identified that could convert a developmental lag into a delay.

It is known that health-care personnel's clinical judgment alone is not sufficient to conduct an evaluation that identifies patients at risk of developmental delay, so using standardized tools offers an opportunity for timely detection.

EDI test group 15, evaluated in this study as a screening test, offers important advantages for implementation, as the application time, required materials, and necessary training are very accessible. This could benefit the population of children over 5 years (60-71 months of age) who still belong to the early childhood range, for whom no Mexican tool exists to evaluate them adequately at the preschool education boundary and thus prepare their entry into primary education.

Implementing this new group in national programs such as developmental surveillance could close the existing gap in child development evaluation for this age group. However, studies with larger and more representative samples are needed to confirm 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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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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RESEARCH ARTICLE

Cost-effectiveness analysis of child development evaluation test (CDE test or Prueba EDI) in children under 5 years old in Mexico: a simulation model study

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Abstract

Background: *The Health Ministry has incorporated the Child Development Evaluation test (CDE test) as the national screening tool for children < 5 years old. The aim of this study is to analyze the cost-effectiveness of the CDE test compared to standard medical consultation in Mexico.* **Methods:** *The study was conducted with information available until 2020. A cost-effectiveness analysis was conducted from perspective of the public/social sectors in Mexico with a decision tree model to evaluate the strategies. The time horizon was set at 1 year, no discounting applied. Costs were calculated in Mexican pesos (MXN) at 2019 prices and included both direct/indirect costs. Direct costs encompassed CDE test administration, specialist consultations, and rehabilitation sessions. Indirect costs considered transportation expenses and lost wages related to caregiving. To account for variability and uncertainty, a Monte Carlo simulation with 10,000 iterations was performed. Probabilistic sensitivity analysis was conducted to test robustness of the results.* **Results:** *The results confirm that the CDE test consistently outperforms the standard approach, delivering improved outcomes at reduced costs in the majority of scenarios. The incremental net monetary benefit of implementing CDE screening was $44,608 MXN (2019 value), providing additional evidence of its cost-effectiveness.* **Conclusion:** *This study suggests that the CDE test is cost-saving from the public and social sector perspective, generating a net increase in both monetary benefits and health outcomes. Furthermore, its implementation is feasible within the Mexican healthcare system, particularly considering its potential to enhance long-term efficiency.*

Keywords: *Mass screening. Child development. Cost effectiveness. Economic analysis. Screening.*

Análisis de costo-efectividad de la prueba evaluación del desarrollo infantil (Prueba EDI) en niños y niñas menores de 5 años de edad en México: un estudio de modelo de simulación

Resumen

Introducción: *La prueba de Evaluación del Desarrollo Infantil (prueba EDI) es una herramienta de tamizaje para detección de problemas del desarrollo en niños < 5 años. Objetivo: analizar la costo-efectividad de la prueba EDI en comparación con la consulta médica estándar en México.* **Métodos:** *El estudio se realizó con información disponible hasta 2020. Se realizó un análisis de costo-efectividad desde la perspectiva del sector público/social en México con un modelo de árbol de deci-*

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sión para evaluar las estrategias. El horizonte temporal se fijó en un año, sin aplicar descuentos. Los costos se calcularon en pesos mexicanos (MXN) a precios de 2019 e incluyeron costos directos e indirectos. Los costos directos abarcaron la administración de la prueba EDI, consultas de especialistas y sesiones de rehabilitación. Los costos indirectos consideraron gastos de transporte y salarios perdidos relacionados con el cuidado. Para la variabilidad/incertidumbre, se realizó una simulación de Monte Carlo con 10.000 iteraciones. Se realizó un análisis de sensibilidad probabilístico (PSA) para probar la solidez de los resultados. **Resultados:** *Los resultados confirman que la prueba EDI supera consistentemente el enfoque estándar, brindando mejores resultados a costos reducidos en la mayoría de los escenarios. El beneficio monetario neto incremental (INMB) de implementar la prueba EDI fue de $44,608 MXN (valor de 2019).* **Conclusión:** *Este estudio sugiere que la prueba EDI ahorra costos desde la perspectiva del sector público y social, generando un aumento neto tanto en beneficios monetarios como en resultados de salud. Su implementación es factible dentro del sistema de salud mexicano.*

Palabras clave: *Desarrollo infantil. Prueba de tamizaje. Tamizaje masivo. Costo efectividad. Análisis económico.*

Introduction

Investing in early childhood development is a key strategy to reduce social disparities, strengthen the economy, and build more equitable societies. Moreover, early childhood development is one of the most important health determinants, with effects that persist throughout life. According to James J. Heckman, Nobel Laureate in Economics, and different studies, investing in early childhood education is a cost-effective strategy for driving economic growth, with a return of at least $7 for every dollar invested in high quality interventions[1-6].

Child development remains a significant challenge for countries in Latin America, including Mexico. Achieving healthy development requires creating the right conditions to ensure that children grow holistically in physical, socio-emotional, and linguistic-cognitive aspects[7].

In this context, the Health Ministry in Mexico has implemented developmental mandatory assessments at the primary care level to identify developmental risks and warning signs in the national norm NOM-1999-031-SSA2[8]. After the review of evidence for a National expert panel conducted in 2012[9], the Health Ministry has incorporated the use of the Child Development Evaluation test (CDE test) or in Spanish Prueba Evaluación del Desarrrollo Infantil (Prueba EDI) as the national screening tool for every children younger than 5 years old[10], a screening tool designed and validated in the country for the early detection of neurodevelopmental issues in children under the age of 5 years[11] in 2011, given the importance of early intervention in children in that period of age[12,13] This test helps confirm the developmental progress of healthy children and identifies those with delays or problems relative to their age, assessing through 14 different groups the developmental milestones from birth to age five. It was designed to provide a reliable and easy-to-administer instrument for use at the primary healthcare level[14,15].

Although significant progress has been made in this area in recent years, a comprehensive public policy, supported by cost-effectiveness studies, is still needed to implement optimal interventions within the Mexican context, and to reinforce the use of standardized screening tools across the Whole Health Sector.

The aim of this study is to analyze the cost-effectiveness of the CDE test compared to standard medical consultation in Mexico using a simulation model.

Methods

The study was conducted with the information available until 2020. A cost-effectiveness analysis was conducted from the perspective of the public and social sectors in Mexico. The study employed a decision tree model to evaluate the strategies. The time horizon was set at 1 year; therefore, no discounting was applied.

Costs were calculated in Mexican pesos (MXN) at 2019 prices and included both direct and indirect costs. Direct costs encompassed CDE test administration, specialist consultations, and rehabilitation sessions, while indirect costs considered transportation expenses and lost wages related to caregiving[16].

Effectiveness was defined as the proportion of children correctly screened for neurodevelopmental issues, with the Battelle Developmental Inventory-2 (BDI-2) serving as the reference standard for comparison.

Statistical model

The graphical representation of the statistical model is depicted in the decision tree (Fig. 1). The model starts with a square symbol, representing the key question to be answered. The first two branches divide the population into two groups: individuals assessed with the CDE test and those assessed without the CDE test. This is followed by a probability node (green circle).

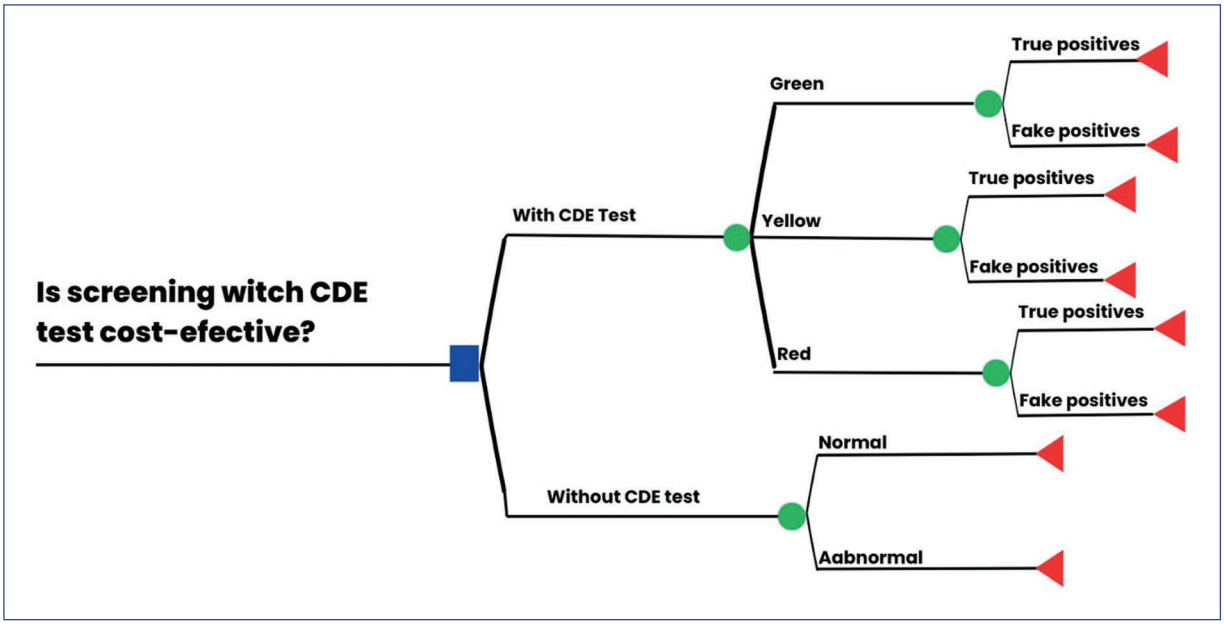

Figure 1. The decision tree for screening child development with and without child development evaluation test.

For the branch representing the group assessed with the CDE test, subsequent branches classify outcomes based on developmental categories: green, yellow, and red. Each category leads to a probability node that distinguishes between true positives and false positives. These probabilities are derived from the ability of the CDE test to identify developmental status when compared to the BDI-2, which serves as the reference for evaluating the test's effectiveness.

The identification of test outcomes is quantified using predictive values:

- True positives: cases accurately identified by the test.
- False positives: cases incorrectly identified by the test, belonging to a different developmental category.

Each branch includes the probability distribution of the category, while the complementary probability (forcing the sum to equal 1) is assigned to the other branch originating from the same node.

In the branch representing individuals assessed without the EDI test, the probability node is divided into two outcomes: cases categorized as having normal development and those categorized as abnormal.

Finally, all branches of the decision tree terminate at red triangles, which represent the resulting distributions for cost and effectiveness.

To account for variability and uncertainty, a Monte Carlo simulation with 10,000 iterations was performed. In addition, a probabilistic sensitivity analysis (PSA) was conducted to test the robustness of the results. The analysis was executed using the TreeAge Pro Healthcare 2019 software.

Ethically, the study was classified as minimal risk, aligning with established guidelines for research involving human populations, there were no personal information used, and all was based in the public data available. This study was approved and registered in the ethics committee from the Hospital Infantil de México Federico Gómez (HIMFG) as a thesis[17].

Results

Transition probabilities were estimated based on a review of the literature and validation studies of the CDE test and are shown in table 1[15,16,18-21]. This analysis demonstrates that the CDE test is a dominant strategy compared to standard medical consultations, as it is both more effective and less costly, as is shown in table 2.

In figure 2, the cost-effectiveness plane highlights the distributions of children screened with and without the CDE test. More than 50% of iterations indicate that the CDE test is cost-saving, demonstrating its potential to reduce economic burden while achieving greater health outcomes.

Figure 3 further illustrates the incremental cost-effectiveness ratios (ICERs) through the distribution of incremental costs and incremental effectiveness associated with the CDE screening strategy. The results confirm that the CDE test consistently outperforms the standard

Table 1. Parameters included in the decision tree model for child development screening in Mexico

Parameters	Base Cost ($, MXN)	References	SA[1]
Direct costs*[2]			
Cost per test application consultation	$115	[A]	±50%
Cost per CDE test*[2]	$ 6.5	[B]	±50%
Cost per specialty consultation	$ 115	[A]	±50%
Cost per rehabilitation session	$ 115	[A]	±50%
Indirect Cost![2]			
Travel for medical care	$ 89	[A]	±50%
Travel for rehabilitation session	$ 89	[A]	±50%
Salary lost per day of medical consultation and/or rehabilitation session	$38.5	[C]	±50%
Transition probabilities			
With EDI test			
Green	0.81	[D]	(0.75 – 0.86)
True positives	0.94	[E]	
False positives	0.06	[E]	
Yellow	0.15	[D]	(0.11-0.16)
True positives	0.88	[F]	
False positives	0.12	[F]	
Red	0.04	[D]	(0.02-0.05)
True positives	0.94	[F]	
False positives	0.06	[F]	
Without EDI test	0.71	[G]	(0.28 – 0.33)
Normal	0.29	[G]	
Abnormal			

*1 SA, Sensitivity analysis.
*2 Costs are presented in Mexican pesos (MXN), one US dollar (USD) is equivalent to $19.56 MXN.
[A] Hospital Infantil de México Federico Gómez 2019 Fee Schedule[16].
[B] Estimated based on the unit cost of $86.76 MXN, the use of a manual for every 15 tests applied plus the unit cost of the pencil for the application of the test.
[C] Ministry of Labor and Social Welfare. CONASAMI. Estimated based on the minimum wage in Mexico 2019, $102.68 MXN[18].
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Table 2. Incremental cost-effectiveness ratio per adequately screened child with CDE test

Strategy	Costs in MXN pesos (mean)	Incremental cost (ΔC)	Effectiveness (mean)	Incremental effectiveness (ΔE)	ICER
With CDE test	$7,326	–3,943	0.60	0.01	-
Without CDE test	$11,269	-	0.59	-	Dominada

ICER: incremental cost-effectiveness ratio. CDE test: child development evaluation test or prueba EDI in Spanish.

approach, delivering improved outcomes at reduced costs in most scenarios. In addition, the strategy is well within Mexico's willingness-to-pay (WTP) threshold, reinforcing its feasibility and economic justification for implementation.

The incremental net monetary benefit (INMB) of implementing CDE screening was $44,608 MXN (2019 value), providing additional evidence of its cost-effectiveness.

Discussion

In this study, a cohort of 10,000 children was simulated. All these children could be screened to assess their neurodevelopment and enable targeted interventions[4,22,23].

During the first 5 years of life, children face a higher likelihood of developmental delays or risks, as these

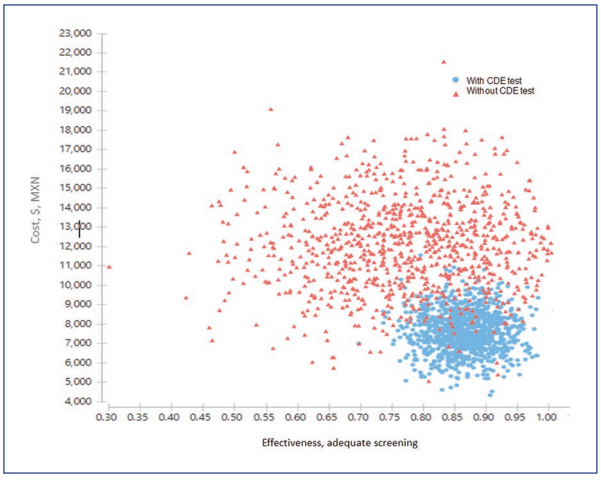

Figure 2. Graphical representation of the cost-effectiveness distributions of screening with and without testing.

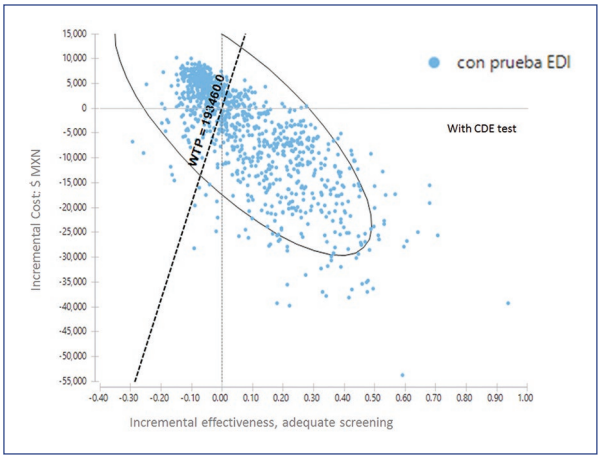

Figure 3. Distribution of incremental effectiveness and incremental cost of screening with child development evaluation test. The willingness to pay (WTP) is included, which is equivalent to a GDP per capita for Mexico ($193,460 MXN, 2019).

years are critical for their overall performance later in life. The presented scenarios compare two options: screening with the CDE test versus routine medical consultations without a specific screening tool. In the latter case, inadequate identification of developmental risks may occur, potentially missing opportunities for timely intervention. Early detection and specific interventions can reduce developmental delays and maximize children's potential[24-26].

The costs associated with the CDE screening strategy were lower than those without it. This difference is likely due to the high opportunity cost of failing to identify children at risk or already experiencing developmental delays[24-27].

Effectiveness was measured by the number of children correctly screened. A decision tree incorporated probabilities for correct identification within the EDI test classification categories: green, yellow, and red, representing normal development, risk of delay, and developmental delay, respectively, compared to results obtained with the IDB-2. The results demonstrated that the CDE screening strategy was dominant, being both less costly and more effective (in terms of correct identification) than the alternative[16,28].

Furthermore, the cost-effectiveness acceptability curve indicated that 100% of the simulations were cost-effective under the presented model. While the use of ICER in decision-making remains debated due to the need for extensive, reliable data, the INMB and incremental net benefit in health offer alternative decision parameters. The implementation of CDE screening, as the cost required to achieve the benefit was lower than the maximum willingness to pay for such a benefit[18].

Uncertainty was addressed through PSA, providing decision-makers with guidance under uncertain conditions and supporting the implementation of the CDE test. In Mexico, funding for strategies and interventions depends on decision-makers' willingness to pay. Proper use of cost-effectiveness analyses is a valuable tool for evaluating resource allocation and optimizing healthcare spending amid increasing constraints.

From a rights-based perspective, every child has the right to reach their full potential. Systematic evaluation ensures equal detection opportunities and equitable access to interventions for at-risk children. It also facilitates continuous improvement efforts and impact assessments[20,21,29-31].

Promoting strategies that position childhood well-being, including developmental evaluations, on the political agenda are essential for evidence-based decision-making. Such strategies can significantly enhance the quality of life and well-being of children in Mexico[32,33].

Study limitations

The study faced several limitations. The inherent uncertainty of the model and its parameters could impact the results. Costs are constrained by temporal monetary value changes, the costs were calculated with the evidence available and published in 2019 and until today more information is needed to improve the analysis. The model assumes the CDE test focuses on detecting developmental delays but spans multiple

domains, and effectiveness was considered constant across ages despite potential variability. Future studies should evaluate the cost-effectiveness of CDE across age groups and specific domains, as well as the long-term sustainability of its demonstrated effects.

Conclusion

In Mexico, this study suggests that the CDE test is cost-saving from the public and social sector perspective, generating a net increase in both monetary benefits and health outcomes. Furthermore, its implementation is feasible within the Mexican healthcare system, particularly considering its potential to enhance efficiency in the long term. In addition, its inclusion represents a significant opportunity as a social policy for children, aligned with a rights-based approach. More studies are needed to get better information to be able to have a better estimate of both economic and health benefit.

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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 study does not involve patient personal data nor requires ethical approval. The SAGER guidelines do not apply.

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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RESEARCH ARTICLE

Association between development level and nutritional status in children under 5 years of age in primary care

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Abstract

Background: *Malnutrition is a risk factor for childhood development disorders. Although undernutrition is recognized as a public health problem, the impact of overweight/obesity on childhood development remains unknown. The objective is to determine the effects of undernutrition, overweight, and obesity on development in children aged between 1 and 59 months in rural/urban areas of Mexico.* **Methods:** *The Childhood Development Evaluation (EDI, for its acronym in Spanish) test was administered to children 1-59 months of age who visited primary care units in Guanajuato State, Mexico, between 2013 and 2015. The World Health Organization classification (weight/height ratio) was used for nutritional status. Logistic regression adjusted by sex, age, rural/urban, and level of marginalization, used to calculate odds ratios (OR) to stablish the association between nutritional status and developmental outcomes.* **Results:** *34,972 participants were included. 50.3% were male, 39.5% had a very low level of marginalization, 58.6% lived in urban areas, and 55.0% were beneficiaries of a conditional cash transfer program. Age distribution: 31.9% between 1 and 12 months old; 17.5% between 13 and 24 months old; 16.3% between 25 and 36 months old; and 34.3% between 37 and 59 months old. Overall 85.8% of participants had normal nutritional status, whereas 9.1% were identified as malnourished, and 5.0% were classified as overweight or obese. 79.1% had typical development. The OR for atypical development was 1.820 (95% confidence interval [95% CI], 1.671-1.981) for mild undernutrition; 2.796 (95% CI: 2.195-3.562) for moderate undernutrition; 14.903 (95% CI: 8.149-27.257) for severe undernutrition; and 1.160 (95% CI: 1.030-1.307) for overweight/obesity.* **Conclusion:** *Undernutrition and overweight/obesity are factors that increase the risk of developmental problems in children < 5 years of age.*

Keywords: *Obesity. Overweight. Malnutrition. Infants. Child development. Mass screening.*

Asociación entre el nivel de desarrollo y el estado nutricional en niños menores de 5 años atendidos en el primer nivel de atención

Resumen

Introducción: *La malnutrición es un factor de riesgo para anormalidades del desarrollo infantil. A pesar de ser un problema de salud pública, aún no se conoce el impacto que tiene el sobrepeso u obesidad en este aspecto. El objetivo es dar a*

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conocer el impacto de la desnutrición, sobrepeso y obesidad sobre las alteraciones en el desarrollo de niños de 1-59 meses en áreas rurales/urbanas en México. **Métodos:** *Se aplicó la prueba Evaluación del Desarrollo Infantil (EDI) a niños de 1-59 meses que acudieron a unidades de primer nivel de atención del estado de Guanajuato, entre 2013 y 2015. Se utilizó la clasificación de la OMS para determinar el estado de nutrición, tomando en cuenta la relación peso/estatura. Para determinar la asociación entre estado nutricional y desarrollo se calculó con razón de momios de prevalencia (RMP) mediante regresión logística, ajustada por sexo, edad, localidad y nivel de marginación.* **Resultados:** *Se incluyeron 34,972 participantes: 50.3% de sexo masculino, 39.5% de muy bajo nivel de marginación, 58.6% en localidades urbanas y 55.0% beneficiarios Prospera. Por edad, 31.9% de 1-12 meses; 17.5% de 13-24 meses; 16.3% de 25-36 meses y 34.3% de 37-59 meses. El estado nutricional: normal en el 85.8%, desnutrición 9.1% sobrepeso/obesidad 5.0%. 79.1% con desarrollo normal. RMP para desarrollo anormal: desnutrición leve 1.820 (IC 95% 1.671-1.981); desnutrición moderada 2.796 (IC 95% 2.195-3.562); desnutrición severa 14.903 (IC 95% 8.149-27.257); y 1.160 (IC 95% 1.030-1.307) para sobrepeso/obesidad.* **Conclusión:** *La desnutrición y el sobrepeso/obesidad son factores que incrementan el riesgo de problemas en el desarrollo en niños menores de cinco años.*

Palabras clave: *Obesidad. Sobrepeso. Desnutrición. Desarrollo infantil. Tamizaje masivo.*

Introduction

Childhood development is a continuous process of change; developing children gradually master increasingly complex movements, thoughts, emotions, and social relationships[1]. The first 5 years of life entail a series of sensitive developments related to children's neurological circuits as they acquire specific learning skills[2]. During this critical period, brain functioning achieves optimal development; however, this process can be influenced by various factors, including the nutritional status of the child and the surrounding environment[2,3].

The brain amounts to 10% of a newborn's body weight; this proportion diminishes throughout life until it reaches 2% of adult body weight. However, this process is not linear: by the end of the 1st year of life, the brain has reached 70% of its adult size, representing 15% of the infant's body weight; by the 2nd year, the brain is at 77% of its final size, weighing 20% of the infant's total body weight[4].

The Childhood Development Assessment (EDI, as abbreviated in Spanish) screening test was developed and validated in Mexico to detect disorders in childhood development with 81% sensitivity and 61% specificity. The results of the test are ordinal, with color-coding in green for typical development, yellow for developmental lag, and red for risk of delay[5] This test is useful and reliable[6] and has been successfully implemented in diverse contexts[7-10] and is recommended as the national screening tool for Mexico[11].

Undernutrition is a pervasive problem in developing countries; although its prevalence has decreased in recent years[12-14], there has been a concurrent rise in overweight and obesity, which have posed a significant challenge to healthcare systems. This phenomenon is particularly pronounced in Mexico, where a progressive increase in obesity and overweight since the 1980s has led to its second-highest rate of adult obesity globally. Moreover, Mexico has the fourth-highest rate of child obesity and overweight worldwide, with a nearly 40% prevalence[13]. This has led to a significant increase in the risk of cardiovascular diseases, disability, and pre-mature death in adulthood[15,16].

A wide range of studies have found a close relationship between malnutrition and neurodevelopment; research has found that infants who are underweight for their age tend to have lower neurodevelopmental scores than those who have good nutritional status[17]. In particular, Alam et al. analyzed data from a cohort of 1,575 children from eight countries (Bangladesh, Brazil, India, Nepal, Pakistan, Perú, South Africa, and Tanzania), finding that neurodevelopmental deficits are greater when nutritional deficits (stunting) begin before 6 months of age[18]. However, research on the possible developmental effects of overweight and obesity in the 1st years of life has been limited.

This study investigates the effects of undernutrition, overweight, and obesity on developmental disorders (assessed using the EDI test) in infants and pre-schoolers who live in rural and urban areas in Mexico.

Methods

A cross-sectional and prospective study was conducted. The study group constituted children between 1 and 59 months of age who had well-child visits at 318 primary care units in the state of Guanajuato, Mexico, between December 2013 and June 2015.

In the well-child visits, psychologists conducted the EDI test for all participants. These tests were standardized, as previously described[19,20]. Standardized weight

and height assessments were performed, with standard equipment used for these assessments (scales, a measuring rod, and a stadiometer). Nutritional status was classified into normal, undernutrition, overweight, and obesity following the World Health Organization standard[21,22], based on the weight/height ratio.

Statistical analysis

The data were compiled in a Microsoft Excel spreadsheet and were analyzed using the Statistical Package for Social Sciences, version 25.0.

For the descriptive analysis, qualitative data are presented using absolute and relative frequencies. Ages are grouped into intervals, and weight and height are measured to assess nutritional status, categorized into the following groups: normal, undernutrition (mild, moderate, and severe levels), and overweight/obesity. For the inferential analysis, the prevalence odds ratio (POR) and 95% confidence intervals (95% CIs) are calculated with a logistic regression model, using the overall EDI test result as the dependent variable (normal: green; abnormal: yellow or red), stratified by age intervals. The independent variables were sex (reference: female), age group (reference: 1-12 months old), nutritional status (reference: normal), beneficiary of the Prospera program (reference: without); type of district (reference: urban), level of marginalization (reference: very low), and interaction of the type of district as a composite variable (reference: rural) × (level of marginalization, ≥ low).

Ethical aspects

Parents were asked for verbal consent before measurements were taken. The study was approved by the Hospital Infantil de México Federico Gómez Ethics, Biosafety, and Research Commission, under registration number HIM/2013/063. The data were collected by personnel responsible for health jurisdiction registration during well-child visits at the primary care level. These data were encoded using anonymizing numbers; no personally identifying information was used.

Results

The study group included 34,972 participants between 1 and 59 months of age. Table 1 presents the general characteristics of this population; 50.3% were male, 39.5% lived in areas with a very low level of marginalization, and 58.6% lived in urban districts. The age distribution was as follows: 31.9% were 1-12 months old; 17.5% 13-24 months old; 16.3% 25-36 months old, and 34.3% 37-59 months old. In addition, 55% (n = 19,243) were beneficiaries of the Prospera program, and 45% (n = 15,729) did not have access to this program.

Table 1 also shows participant's nutritional status; most participants had a normal nutritional status (85.8%), 9.1% were undernourished (of these, most had mild undernutrition), and 5.0% were overweight or obese. It is worth highlighting that these proportions were similar across the four age groups. In terms of development, EDI test results showed that 79.1% had normal development (green), 17.2% had a lag (yellow), and 3.7% had a risk of delay (red).

Figure 1 presents the distribution of EDI test results according to the nutritional status category, indicating that participants with undernutrition (n = 3,191) also had the highest proportion of yellow (24.5%) and red (8.8%) results compared with those with normal nutritional status (16.4% and 3.2%, respectively) or overweight/obese (17.5% and 3.8%, respectively). In addition, the greater the degree of undernutrition, the higher the proportion of yellow and red results; for 56.7% of the 60 participants with severe undernutrition (stunting), the EDI test result was red.

Finally, table 2 presents the logistic regression analysis results of the factors studied. It shows that a higher degree of undernutrition increased the risk of atypical development: prevalence odds ratio (POR) 1.820 (95% CI: 1.671-1.981) for mild undernutrition, POR 2.796 (95% CI: 2.195-3.562) for moderate undernutrition, and POR 14.903 (95% CI: 8.149-27.257) for severe undernutrition (stunting). In addition, overweight/obesity was also identified as a risk: POR 1.160 (95% CI: < 1.030-1.307). In this final group, we tried to identify the development area that was most affected; we determined that the gross motor area was affected to a significantly greater extent than other areas from a statistical perspective, but this was true only for certain age groups: POR 1.52 (95% CI: 1.16-1.99) for the 1-12 month age group and POR 1.86 (95% CI: 1.25-2.74) for the 37-59 month age group.

Discussion

The findings of this study confirm that in a pediatric population under 5 years of age, undernutrition significantly affects neurodevelopment; in addition, the findings indicate that there is a greater risk of developmental disorders in children who are overweight or obese. Overall, our findings add to previous evidence identifying the coexistence of the public health problems of

Table 1. Distribution of sample characteristics by age group

Characteristics of the study population	1-59 months old		Age group in months							
			1-12		13-24		25-36		37-59	
	n = 34,972	(%)	n = 11,160	(%)	n = 6,121	(%)	n = 5,690	(%)	n = 12,001	(%)
Sex										
Female	17,376	(49.7)	5,538	(49.6)	3,046	(49.8)	2,796	(49.1)	5,996	(50.0)
Male	17,596	(50.3)	5,622	(50.4)	3,075	(50.2)	2,894	(50.9)	6,005	(50.0)
Nutritional status (weight/height)										
Normal	30,022	(85.8)	9,718	(87.1)	5,215	(85.2)	4,821	(84.7)	10,268	(85.6)
Undernutrition mild	2,844	(8.1)	672	(6.0)	505	(8.3)	547	(9.6)	1,120	(9.3)
Moderate	287	(0.8)	76	(0.7)	69	(1.1)	50	(0.9)	92	(0.8)
Severe	60	(0.2)	27	(0.2)	14	(0.2)	9	(0.2)	10	(0.1)
Overweight/obesity	1,759	(5.0)	667	(6.0)	318	(5.2)	263	(4.6)	511	(4.3)
Degree of marginalization										
Very low	13,809	(39.5)	3,952	(35.4)	2,371	(38.7)	2,401	(42.2)	5,085	(42.4)
≥ Low	21,163	(60.5)	7,208	(64.6)	3,750	(61.3)	3,289	(57.8)	6,916	(57.6)
Beneficiary of Prospera										
Yes	19,243	(55.0)	3,564	(31.9)	3,286	(53.7)	3,729	(65.5)	8.664	(72.2)
No	15,729	(45.0)	7,596	(68.1)	2,835	(46.3)	1,961	(34.5)	3,337	(27.8)
Type of district										
Urban	20,503	(58.6)	6,696	(60.0)	3,249	(53.1)	3,282	(57.7)	7,276	(60.6)
Rural	14,469	(41.4)	4,464	(40.0)	2,872	(46.9)	2,408	(42.3)	4,725	(39.4)
Developmental level										
Normal	27,655	(79.1)	9,397	(84.2)	4,905	(80.1)	4,458	(78.3)	8,895	(74.1)
Developmental lag	6,019	(17.2)	1,532	(13.7)	982	(16.0)	911	(16.0)	2,594	(21.6)
Risk of delay	1,298	(3.7)	231	(2.1)	234	(3.8)	321	(5.6)	512	(4.3)

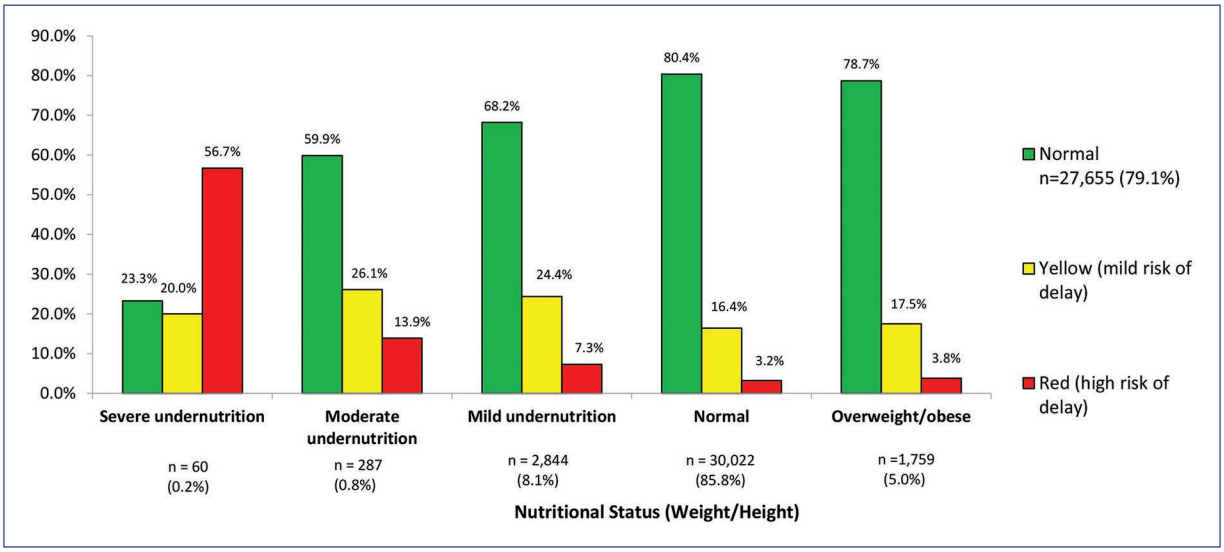

Figure 1. Differences in the distribution of child developmental assessment test results by nutritional status category (weight/height).

undernutrition and obesity, which represent a double burden, particularly in low- and middle-income countries[14].

Undernutrition has been significantly reduced in Mexico in recent decades; however, it shows a continued prevalence of 2.8%[13]. This problem still affects a

Table 2. Crude and adjusted prevalence odds ratio (POR) for disorder in child development (atypical EDI test result)

Independent variable	POR (95% CI)	
	Crude	Adjusted
Sex		
Female*	1.000	1.000
Male	1.308 (1.242-1.377)	1.318 (1.25-1.389)
Age group (months)		
1-12*	1.000	1.000
13-24	1.321 (1.219-1.433)	1.309 (1.205-1.423)
25-36	1.473 (1.358-1.597)	1.446 (1.329-1.574)
37-59	1.861 (1.744-1.987)	1.836 (1.712-1.969)
Nutritional status		
Normal*	1.000	1.000
Undernutrition	1.911 (1.757-2.078)	1.820 (1.671-1.981)
Mild	2.746 (2.165-3.483)	2.796 (2.195-3.562)
Moderate	13.493 (7.413-24.56)	14.903 (8.149-27.257)
Severe	1.109 (0.986-1.247)	1.160 (1.030-1.307)
Overweight/Obesity		
Beneficiary of Prospera		
No*	1.000	1.000
Yes	1.211 (1.149-1.276)	1.050 (0.911-1.113)
Type of district		
Urban*	1.000	1.000
Rural	0.812 (0.770-0.856)	0.425 (0.381-0.474)
Level of marginalization		
Very low*	1.000	1.000
Low	1.275 (1.208-1.345)	1.057 (0.988-1.130)
(Type of district) × (marginalization level)		
Urban district and very low level of marginalization*.	-	1.000
Rural district and≥Low level of marginalization.	-	2.343 (2.062-2.662)

*Reference category. 95% CI: 95% confidence interval. The shaded cells have non-significant confidence intervals. For the crude POR, we obtained the Exp (B) and 95% confidence interval (Wald) through a model with (a) binomial probability distribution; (b) logit function; (c) dependent variable: the overall result in the EDI test (reference category result: typical or green; atypical: yellow or red), and d) independent variable: each variable individually: (1). sex (reference: female); (2). age group (reference: 1-12 months); (3). nutritional status (reference: normal); (4). beneficiary of Prospera (reference: no); (5). type of district (reference: urban); (6). marginalization level (reference: very low); (7). interaction term: (type of district = rural) × (marginalization level ≥ low).

significant number of children, with long-lasting impacts including those on school performance, as described in multiple studies[17,18].

As well, in recent years childhood obesity in Mexico represents a critical public health concern as the nation exhibits one of the highest rates of the condition globally[23,24]. This issue is particularly concerning considering the potential health complications that overweight or obese children and adolescents might experience in adulthood. These complications include an increased risk of developing diabetes mellitus and cardiovascular diseases at younger ages. The results of this study indicate that overweight and obesity also affect neurodevelopment, leading to other potential problems in the long run, such as cognitive challenges. These findings indicate the need to reflect, reinforce, and expand the strategies implemented to improve nutrition at early stages of life by enhancing families' eating habits, particularly those of children and adolescents[25].

Notably, this is among the first studies in the world to show a deleterious effect of overweight/obesity on neurodevelopment in the 1st years of life, particularly in the motor areas. So far, most published studies on the possible effects of overweight on child neurodevelopment have been conducted in gestation; overall, these studies have found that children of mothers who gain more weight during their pregnancy or who are obese before pregnancy have an increased risk of developmental disorders[26]. Therefore, it is necessary to perform more studies to accurately identify the impact that overweight and obesity have on childhood development; this could help clarify the underlying mechanisms and long-term effects of these conditions on children's,

adolescents,' and young adults' cognitive, motor, and emotional capacities. This line of research was initiated by Black et al. in 2013[24].

Finally, intervention programs such as Prospera have been shown to be effective in mitigating the negative impacts of adverse socioeconomic factors on the population (in this case, on neurodevelopment). This indicates the relevance of formulating public policies that focus on early detection and attention to nutritional and childhood development problems in a multisectorial approach[27,28]. Furthermore, this study advocates for the utilization of the EDI test and analogous tools to identify developmental disorders in a timely manner in cases of malnutrition and obesity.

Conclusion

The findings of this study confirm that neurodevelopment in children under 5 years old is influenced by both undernutrition and overweight/obesity.

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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 obtained approval from the Ethics Committee for the analysis of routinely obtained and anonymized clinical data, so informed consent was not necessary. Relevant guidelines were followed.

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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RESEARCH ARTICLE

Effect of a federal early education program in Mexico on the developmental level of children aged 13-48 months: national survey

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Abstract

Background: *Early childhood development is crucial. The objective of this study was to evaluate, on a national scale, the level of development of children enrolled in the federal childcare program, according to the length of stay in the childcare centers and by geographic area.* **Methods:** *A national cross-sectional study was conducted. The study population comprised 231,058 children aged between 13 and 48 months, enrolled in 9200-day care centers across the 32 states of Mexico. The developmental level was measured using the Child Development Evaluation test. The effect of length of stay was analyzed by logistic regression, using odds ratio of prevalence and 95% confidence intervals.* **Results:** *Of the total number of participants, 53% were male, and the 37-48 month-old group was the largest (45%, n = 103,976). The length of stay ranged from 1 to > 24 months. The proportion of children with normal developmental outcomes increased alongside the length of stay, from 72.3% for children with < 6 months of stay to 88.7% for those who attended centers for > 24 months. By geographical region, Guerrero and Oaxaca, two low-income states, showed the best results, along with the highest-income states. The distribution for each area of development and geographic area are shown.* **Conclusion.** *At the national level, long-term enrollment in daycare centers favors normal development. Particularly important is the high result in low-income regions, and it could be an equalizing strategy as a public policy. The different results among areas could help to improve the curricula.*

Keywords: *Early childhood. Early education. Screening. Child development. Developmental screening.*

Efecto de un programa de educación inicial en méxico en el nivel de desarrollo infantil de niños y niñas de 13 a 48 meses de edad: medición nacional

Resumen

Introducción: *El desarrollo infantil temprano es crucial. El objetivo del estudio fue evaluar, a nivel nacional, el nivel de desarrollo de niños inscritos en un programa de edicación inicial (PEI), de acuerdo con su tiempo de permanencia y por área geográfica.*

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Métodos: *Estudio transversal analítico, nacional. Población de estudio: 231,058 niños de 13 a 48 meses de edad, inscritos 9,200 estancias infantiles, en los 32 estados de México. Se midió el nivel de desarrollo con la Prueba Evaluación del Desarrollo Infantil (EDI). Se analizó el efecto del tiempo de estancia mediante un análisis de regresión logística, mediante razón de momios de prevalencia (RMP) e intervalos de confianza al 95% (IC95%).* **Resultados**: *Del total, el 53% fue de sexo masculino y, el grupo de edad 37 a 48 meses fue el mayor (45%, n = 103,976). El tiempo de permanencia en el PEI fue desde < 1 hasta > 24 meses. La proporción de niños con desarrollo normal aumentó por tiempo de permanencia, pasando del 72.3% en niños con < 6 meses de permanencia, al 88.7% para quienes estuvieron > 24 meses. Por región geográfica, Guerrero y Oaxaca, dos estados de bajo ingreso están entre los que tuvieron mejores resultados, junto con estados de más altos ingresos. Se muestran los resultados por área y entidad federativa.* **Conclusión:** *El mayor tiempo de permanencia de los niños en el PEI favorece el desarrollo normal, particularmente en regiones geográficas de bajo ingeso, y puede ser una política que permita la equidad. Los diferentes resultados por área pueden servir para mejorar la curricula de las estancias infantiles.*

Palabras clave: *Educación inicial. Tamizaje en masa. Desarrollo infantil. Tamizaje de desarrollo. Niñez temprana.*

Background

Early childhood development (ECD) is a crucial stage in the first 6 years of human life and represents a critical period marked by the fastest rate of growth for all brain structures. This stage lays the foundation for optimal health, basic learning, and school success, as well as social and economic participation throughout life[1]. The period between 2 and 5 years of age presents an opportunity to implement educational interventions, promote positive parenting styles, and enrich childcare environments to foster ECD. However, it is estimated that only 38.8% of children aged 3-4 years in low- and middle-income countries have access to early childhood education services[2].

A fundamental and effective strategy to promote proper development during early stages is to increase the participation of all children in early childhood education programs. The benefits of these programs have been widely documented, supporting policy recommendations for the implementation of early childhood education and childcare assistance initiatives[3,4]. Studies conducted with preschool children have established a positive influence of high-quality preschool childcare on skill development across most developmental domains. Furthermore, longitudinal effects have been demonstrated, showing improvements in receptive language and math skills, cognitive abilities, attention levels, behavioral problems, and sociability. All of the above suggests that children with higher-quality preschool experiences can achieve greater developmental progress over a 5-year period[5,6].

In addition, it has been reported that early inclusion in early childhood education programs can promote, protect, and support children's development, particularly during the first 2-3 years of life. These results indicate that the long-term effects of the early childhood experience depend, in part, on classroom experiences during at least the first few years of school[7].

According to the United Nations Children's Fund, the economic case for establishing childcare centers is based on the premise that social policy has an economic impact. Good nutrition and education provided at an early age through comprehensive programs foster the development of optimal physical and intellectual capacities, which form the productive reserve of future society[8]. Likewise, there is strong evidence that the consistently positive economic returns of high-quality preschool programs surpass those of most other educational interventions, particularly those starting during school-age years, such as smaller class sizes in primary grades, grade retention, and youth job training[5].

In Mexico, in the absence of services for the care of infants and the inability of the potential population to pay for them, in 2006, the Childcare Program was established, as well as an Early Education Program (PEI, in its Spanish acronym) created by the National Secretary of Social Development (SEDESOL) together with the National System for Family Integral Development (DIF) that serves children between 1 and 3 years and 11 months old, or until the age of 6 years for children with disabilities[9]. This program supports parents and guardians in poverty who are working, studying, or seeking employment and who state that they do not have access to childcare services from public security institutions or private resources[10]. As of December 31, 2016, the program provided care to 321,330 children, only 37.84% of the target population[11]. In contrast, although preschool education has been compulsory in Mexico since 2002[12], according to data from the Organization for Economic Co-operation and Development, the preschool enrollment rate for 2017 in Mexico was only 46%[13].

Therefore, between 2014 and 2015, a pilot study was conducted in two states of the country to evaluate the association between the length of time spent in PEI and the developmental level of children under 5 years of age. The study showed an increased probability of achieving normal development in children who stayed in PEI for more than 6 months, compared to those who had been in the program for only 1 month, regardless of age[14]. As a follow-up to these initial observations and with the purpose of generating additional evidence on the effect of this educational strategy, the objective of this study was to evaluate, on a national scale, the level of development of children enrolled in a Federal Early Education Program (PEI) from Mexico, according to the length of stay in the childcare centers and by geographic area.

Methods

A cross-sectional, population-based, comparative study was conducted in the 9,200 DIF/SEDESOL child care centers located across the 32 states of the Mexican Republic. Children aged 1 to 3 years who were enrolled in the children's facilities within the November 2017 to January 2018 period were included. For each participant, the variables sex, age, length of time at child care centers, and state were recorded. The development areas were assessed using the Child Development (CDE) test or *"Prueba Evaluación del Desarrollo Infantil"* or *"Prueba EDI"* in Spanish[15], a screening tool developed and validated in Mexico, for the timely detection of child development problems in children from 1 month of life to 1 day before their sixth birthday with the result expressed using the traffic light (green, yellow, or red) system[16].

The CDE test was administered by the personnel responsible for each daycare center included in the study. They followed a standardized protocol after completing adequate training. The application of the tests was supervised to ensure the quality and standardization of the information. The supervisors collected the completed test results forms and downloaded the data electronically, and then it was centralized and structured in the final database.

Description of the instrument

The CDE test is made up of 26-35 items, divided into five areas: (a) biological risk factors, (b) warning signs, (c) alarm signals, (d) neurological examination, and e) developmental areas (fine motor, gross motor, language, social, and cognitive). The possible outcomes are normal development (green), developmental delay (yellow), and risk of developmental delay (red). The CDE test has adequate sensitivity and specificity to identify the level of development, both globally and by domain[17,18]. The sensibility and specificity for only the developmental areas axis of the CDE test compared with a diagnostic evaluation are high[19] and have been used before as a measurement for development[14]. In this study, the developmental assessment was using the developmental axis globally and by area.

Statistical analysis

The sample was characterized per month interval for each state, by age, sex, and length of stay in absolute frequencies and percentages. The dependent variable, the CDE test score, was recorded on an ordinal scale (green, normal; yellow, developmental delay; and red, risk of delay); however, for the purposes of this study, children were categorized under normal development (green) and abnormal development (yellow and red), both in the global assessment and for each developmental area. The χ^2 test was used to determine the differences between the states in terms of the overall CDE score and according to each area of development; a comparison was made, taking into account the length of stay in the program, divided into five categories: < 6 months, 6-11 months, 12-17 months, 18-23 months, and ≥ 24 months. Statistical significance was determined using a two-tailed test and set at $p < 0.05$.

In addition, the odds ratio (OR) was calculated as the probability of obtaining a normal (green) result depending on the length of stay in the PEI, together with their 95% confidence intervals (95% CIs). A multivariate analysis was performed to identify the overall effect of the length of stay in the PEI (reference category: < 6 months in the program) and the normal result in global development, using a logistic regression model, with the CDE test result as the dependent variable, while sex, age group, state, and time spent in the program were considered independent variables. All analyses were performed using the IBM SPSS version 27.0 package.

Ethical aspects

Since 2013, the CDE test since 2013 has been established as the official screening tool in Mexico for child development evaluation and is used across the country in the health sector[20,21]. Before taking the different

measurements, parents were asked for their verbal consent. The notification was provided 1 week before the measurements were taken through posters and banners that communicated that the children's development would be evaluated in every daycare center. Each family member was informed of the results obtained in the developmental assessment and was also guided to establish an action plan where areas of opportunity were identified to improve the children's development. For that purpose, a material was provided that resumed the results of the CDE test narratively and actions that could be realized by the teacher, also with the perception of the family and guidelines for activities at home were delivered to each participant's family. If the child got a red result (high risk of developmental delay) was referred for further evaluation at a primary health-care facility following the national guidelines for CDE[21]. The nominal information was only used by the daycare centers routinely, and no personal data were collected in the database; all the information was anonymized when captured. The study was approved for the ethics committee with the register HIM/2013/063.

Results

A total of 231,058 children aged 13-48 months were included and enrolled in 9,200 childcare centers. As shown in table 1, all 32 Mexican states participated but with different proportions, the lowest being Baja California Sur (0.5%) and the highest being the State of Mexico (12.3%); this is in correspondence with the population inhabiting each state. As can also be observed, of the total number of children evaluated, 53% (n = 122,461) were male, while in terms of age distribution, the 13-24 month group had the lowest proportion (15%; n = 34,659), followed by the 25-36 month group (40%; n = 92,423) and the 37-48 month group (45%; n = 103,976).

There were also differences in terms of the length of stay in the daycare centers; at the national level, the group that stayed 12-17 months was the largest (29%), with the smallest being the 7.6% who remained in the facility for 18-23 months. As can also be shown in table 1, the proportions of the length of stay were similar in each state.

Relationship between the length of stay in PEI and the developmental assessment

Fig. 1 shows the results of the CDE evaluation according to the length of stay in the PEI. The proportion of children with a normal result (green) increased progressively with the length of stay. Thus, 72.3% of the children with < 6 months of attendance obtained a green result, and this was obtained by 79.8% of the 6-12month group (79.8%), and the highest percentage (88.7%) was obtained by the group of children who attended the program for more than 24 months.

The result of the CDE test by area of development in the 25,946 children who stayed for more than 24 months in the centers is presented in table 2, both at the national level and for each of the 32 states. This shows that the social area obtained the highest rate (92.92%), followed by language (92.02%), gross motor (90.46%), knowledge (87.78%), and, finally, fine motor (81.84%) areas. It should be noted that Baja California Sur, Coahuila, Guerrero, Oaxaca, and Sonora had the highest percentages of children who obtained green results.

Comparison of EDI results between the < 6 months and > 24 months of permanence groups

For greater clarity with regard to how the length of stay has beneficial effects on development, the group of children who remained < 6 months and the group with > 24 months of stay were compared in each state. figure 2 presents all developmental areas, figure 3 shows information concerning the gross motor area, figure 4 describes the fine motor area, figure 5 presents the language area, figure 6 provides insight into the social area, and figure 7 describes the knowledge area. Overall, it can be observed that the group that has attended the program for the longest time achieved better development, and the areas with the greatest differences between less and more time spent in the program are the language (Fig. 5) and social (Fig. 6) areas. It should be noted that the percentage difference between the < 6-month and > 24-month groups was statistically significant ($p < 0.001$) in practically every state, with some exceptions, such as the gross motor area in Queretaro ($p = 0.094$) and Quintana Roo ($p = 0.159$); the fine motor area in Baja California Sur ($p = 0.120$), Chihuahua ($p = 0.108$), and Hidalgo ($p = 0.231$); and the knowledge area in Hidalgo ($p = 0.229$), Queretaro ($p = 0.078$), and Quintana Roo ($p = 0.136$).

Finally, table 3 presents the results of the multivariate analysis to determine the influence of the length of stay in the PEI on a normal outcome, both overall and by area of development, using the OR of prevalence. It can be seen that compared with the group of < 6 months of permanence, there is an increasing tendency for

Table 1. Characteristics of the population that participated in the early childcare program (PEI by its acronym in Spanish), by state (in alphabetical order)

State	%	n	Sex	Age (years)			Length of stay in PEI (months)					
			Male	1	2	3	< 1	1-5	6-11	12-17	18-23	≥ 24
Aguascalientes	2.1	4883	53.0	17.8	40.1	42.1	21.9	10.2	21.9	25.3	8.4	12.4
Baja California	0.5	1207	52.8	17.1	37.9	45.1	14.8	13.6	24.6	25.0	8.7	13.3
Baja California Sur	0.5	1060	54.6	14.9	43.4	41.7	20.0	9.3	29.0	24.7	10.0	7.0
Campeche	1.3	3035	51.7	17.1	44.6	38.3	24.2	20.3	19.8	24.1	4.2	7.3
Chiapas	5	11572	54.3	20.1	44.1	35.7	19.3	14.0	23.6	27.9	6.9	8.3
Chihuahua	2.5	5676	51.3	18.6	39.7	41.7	20.6	10.7	25.0	23.4	9.6	10.8
Mexico City	4.7	10861	52.2	14.9	39.2	45.9	20.9	8.7	21.7	28.9	6.1	13.7
Coahuila	2.8	6380	53.4	22.6	40.8	36.6	25.1	13.8	22.6	23.2	5.7	9.7
Colima	1.4	3321	52.2	16.1	41.9	42.0	26.9	14.6	20.9	22.5	7.5	7.6
Durango	2.4	5616	54.2	19.4	40.4	40.3	26.7	9.2	19.6	23.4	10.5	10.7
Guanajuato	4.8	11028	53.3	13.4	41.3	45.3	16.5	7.1	25.5	30.6	7.7	12.7
Guerrero	3.4	7873	52.4	15.4	43.8	40.8	17.0	7.7	20.0	32.4	10.7	12.2
Hidalgo	2.4	5593	53.9	15.9	40.2	43.9	21.9	12.6	22.6	25.2	9.0	8.7
Jalisco	5.7	13113	53.2	14.7	39.2	46.1	23.0	8.1	25.1	25.3	7.8	10.7
State of Mexico	12.3	28483	53.6	9.9	37.4	52.6	16.8	6.2	24.4	35.0	4.0	13.6
Michoacan	3.7	8619	52.5	15.6	41.8	42.6	18.8	10.8	20.5	28.5	9.5	11.9
Morelos	3.4	7871	53.0	13.1	37.4	49.5	24.2	7.0	22.6	25.9	10.0	10.2
Nayarit	2.1	4909	52.0	18.0	41.0	41.0	17.9	10.5	24.2	31.7	4.8	10.9
Nuevo Leon	1.5	3352	52.2	14.9	40.0	45.1	19.2	10.4	18.9	29.0	9.8	12.6
Oaxaca	2.2	5158	51.7	15.6	42.3	42.1	19.3	10.6	24.3	24.4	11.2	10.1
Puebla	5.3	12,274	54.1	17.3	42.0	40.7	27.0	11.4	20.4	25.6	6.9	8.8
Queretaro	1.5	3475	54.4	15.3	40.2	44.5	25.8	7.2	24.6	27.3	7.1	8.1
Quintana Roo	0.9	1992	51.4	13.6	40.9	45.6	21.7	10.1	24.6	25.4	8.0	10.1
San Luis Potosi	2.1	4895	53.9	20.1	44.2	35.7	17.1	12.8	23.1	25.8	10.9	10.2
Sinaloa	4.8	11,147	52.9	18.6	38.5	42.9	27.7	8.7	16.5	29.6	3.4	14.1
Sonora	2	4588	53.2	15.6	38.6	45.8	24.1	6.6	18.8	27.7	10.9	11.9
Tabasco	2.3	5409	53.3	14.5	42.4	43.1	19.7	8.0	21.5	30.6	8.7	11.5
Tamaulipas	2.8	6563	53.1	15.3	41.3	43.4	20.0	8.9	25.3	28.4	6.6	10.8
Tlaxcala	2.2	5037	52.6	12.5	39.4	48.1	13.8	10.6	25.2	26.6	12.3	11.6
Veracruz	6.8	15,758	53.2	12.1	38.3	49.6	20.8	8.7	22.5	27.2	9.5	11.3
Yucatan	2.1	4843	53.5	17.0	42.6	40.5	21.3	13.8	19.3	29.0	6.7	9.9
Zacatecas	2.4	5467	51.3	19.8	41.0	39.2	18.4	12.7	22.8	25.8	8.1	12.1
National	100	231,058	53.0	15.3	40.3	44.4	21.1	9.7	22.4	28.0	7.6	11.2

PEI: early education program.

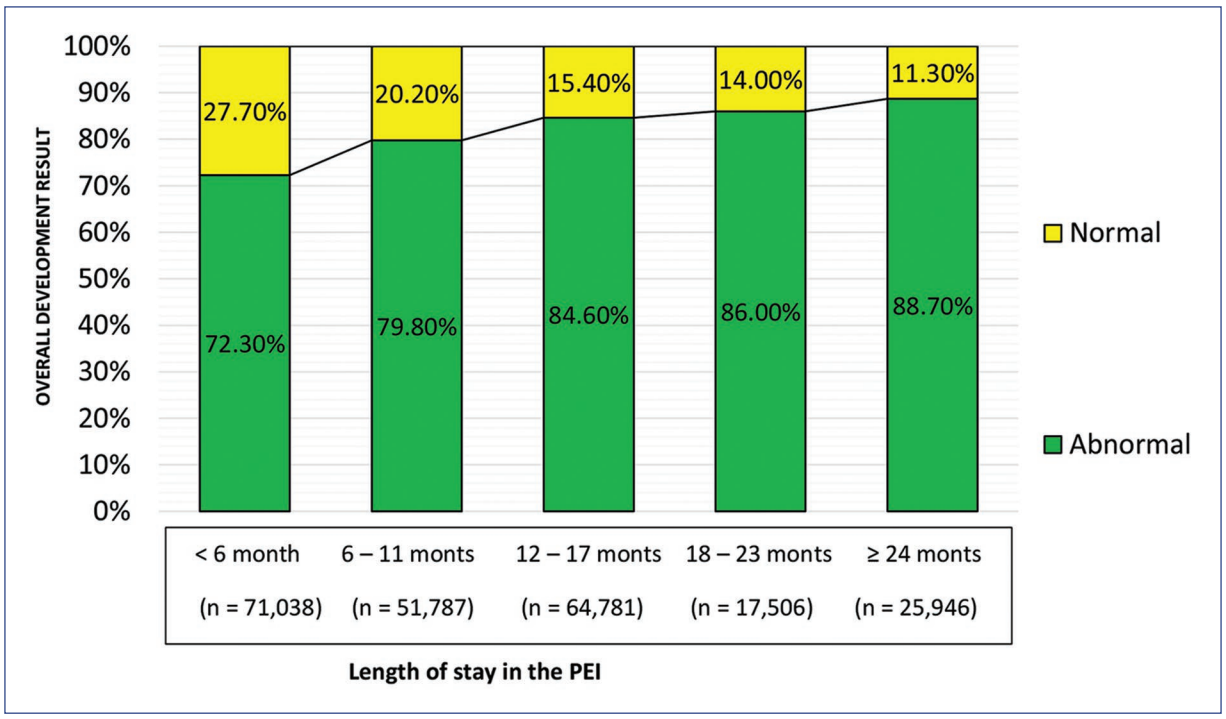

Figure 1. Overall results in all developmental areas were evaluated by length of stay in the PEI (early education program, for its acronym in Spanish).

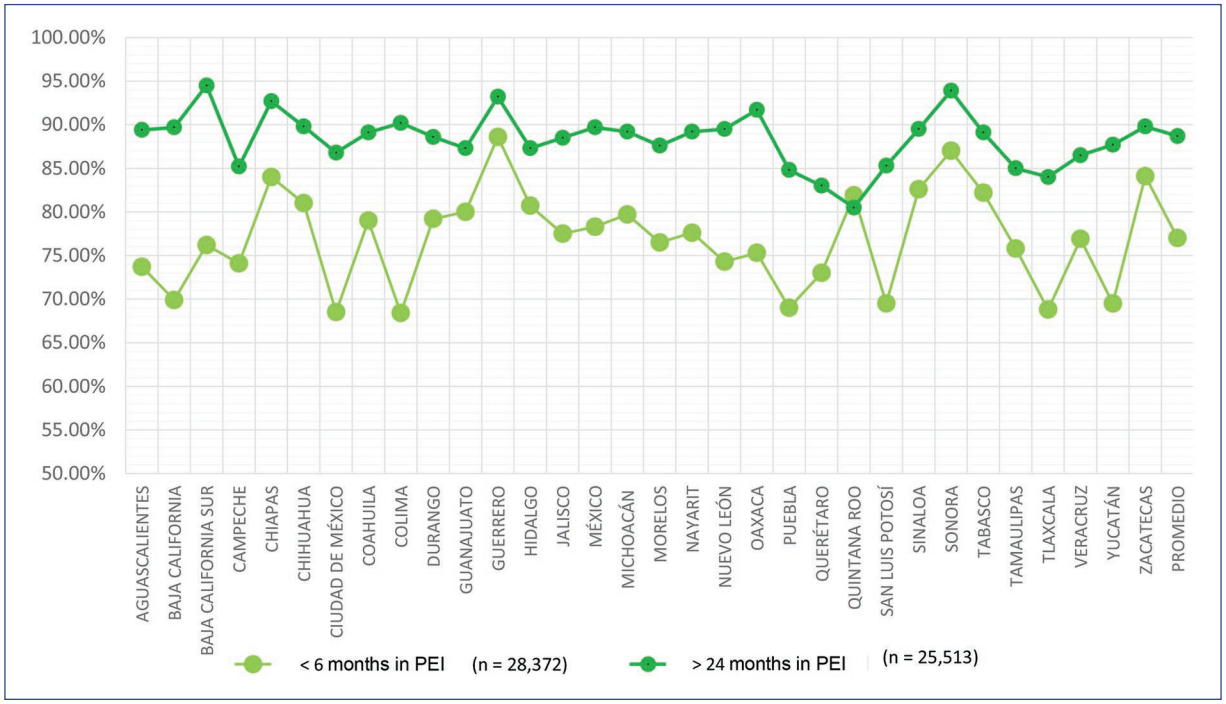

Figure 2. Population percentages by each State of the country (alphabetic order) with normal results in all developmental areas according to length of stay in the PEI (early education program by its acronym in Spanish).

Table 2. Percentage of children who received a normal result in the child development evaluation test (global and by area) who remained in the PEI (early education program, by its Spanish acronym) for more than 24 months (n = 25,946), by state (alphabetic order)

State	n (%)	Global result (%)	Gross motor (%)	Fine motor (%)	Language (%)	Social (%)	Knowledge (%)
Aguascalientes	605	89.10	90.60	84.00	93.40	93.90	87.10
Baja California	160	89.40	94.40	90.60	93.80	94.40	86.90
Baja California Sur	74	94.60	93.20	89.20	95.90	95.90	91.90
Campeche	221	85.50	92.80	81.40	89.10	96.40	84.60
Coahuila	529	92.70	93.60	86.00	94.10	95.30	90.70
Colima	358	89.80	94.50	82.20	92.00	91.80	91.10
Chiapas	1,581	88.80	90.50	82.60	90.90	90.40	88.30
Chihuahua	550	90.50	91.90	79.90	93.60	94.70	86.00
Mexico City	822	86.90	84.80	79.00	89.70	92.00	88.00
Durango	600	88.50	89.50	83.80	92.30	93.50	88.00
Guanajuato	1,397	87.50	91.30	84.40	92.30	93.00	87.70
Guerrero	961	93.20	95.50	89.30	95.20	93.40	92.30
Hidalgo	487	87.50	87.10	78.90	91.40	93.00	84.80
Jalisco	1,400	88.60	89.90	79.80	93.30	93.30	88.90
Mexico	3,880	89.70	90.50	85.20	92.50	93.70	89.60
Michoacan	1,027	89.00	91.70	83.60	94.00	94.70	90.20
Morelos	805	87.70	90.60	79.30	89.70	94.90	85.70
Nayarit	536	88.80	91.00	76.90	92.00	93.30	88.10
Nuevo Leon	424	89.40	89.20	83.00	90.10	91.70	88.20
Oaxaca	523	91.60	89.10	81.50	92.40	96.20	90.80
Puebla	1,079	84.80	87.80	79.40	91.40	91.50	84.80
Queretaro	281	82.60	85.80	70.80	88.30	90.00	80.80
Quintana Roo	201	80.60	89.10	78.60	90.00	91.50	82.10
San Luis Potosi	498	85.50	87.30	77.70	90.00	88.60	85.50
Sinaloa	1,572	89.20	91.40	83.00	91.90	93.60	89.10
Sonora	545	93.90	95.80	86.60	96.10	94.50	96.30
Tabasco	623	89.10	94.10	84.30	90.20	92.30	90.50
Tamaulipas	709	85.00	89.70	77.30	89.00	87.70	86.70
Tlaxcala	582	84.00	84.20	77.50	91.10	89.50	84.00
Veracruz	1,775	86.40	89.70	82.90	92.90	92.00	88.20
Yucatan	478	87.90	89.50	80.50	93.30	94.40	85.10
Zacatecas	663	90.00	88.70	79.60	92.60	92.20	87.00
National	25946	88.37	90.46	81.84	92.02	92.92	87.78

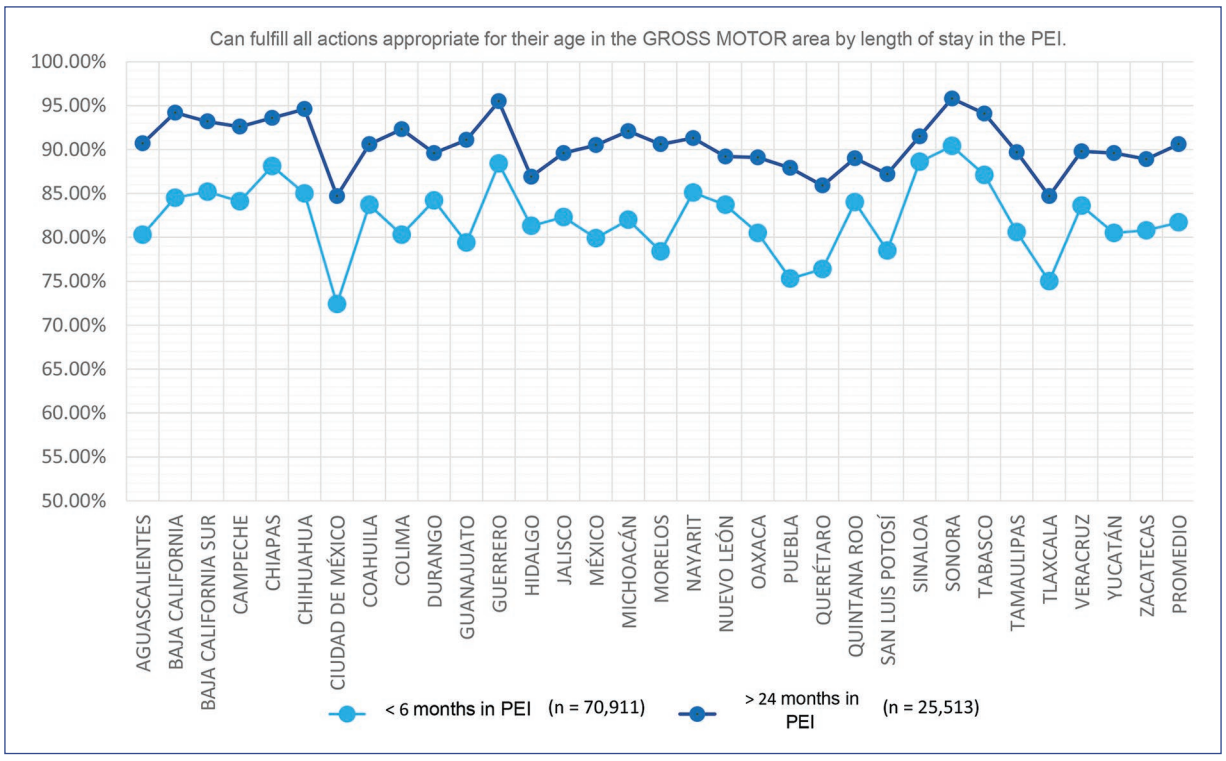

Figure 3. Population percentages by each state of the country (alphabetic order) that has completed all age-appropriate actions in the gross motor based on their age by length of stay in the PEI (early education program by its acronym in Spanish).

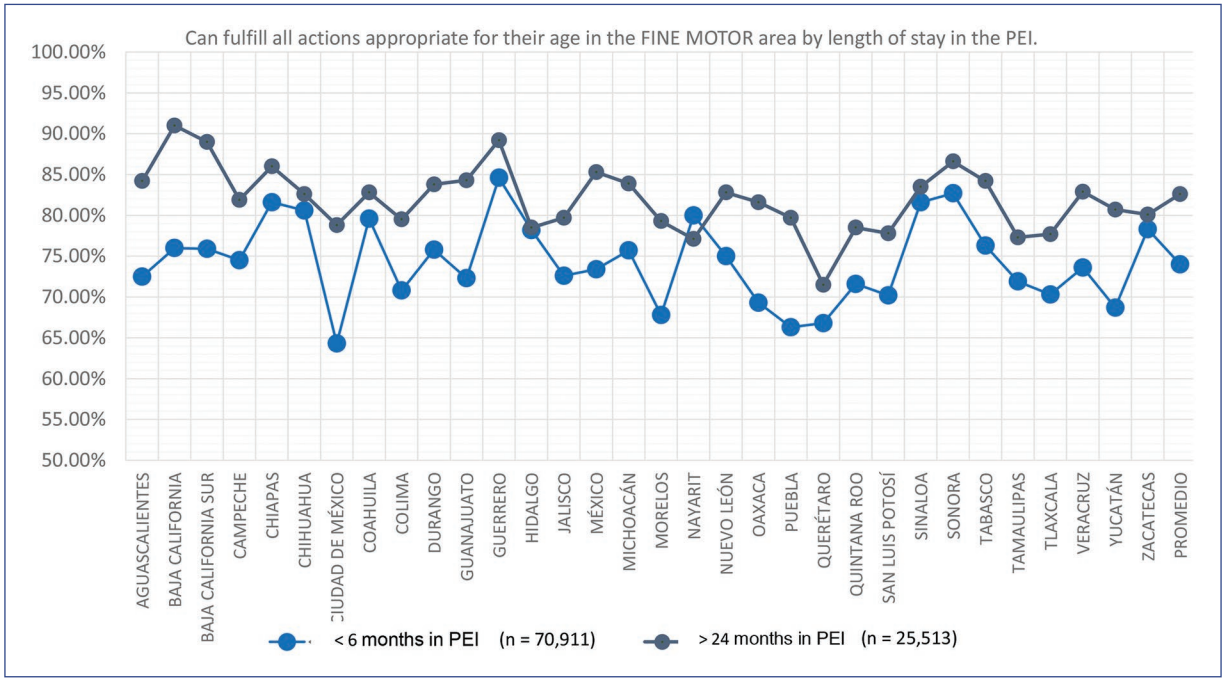

Figure 4. Population percentages by each state of the country (alphabetic order) that has completed all age-appropriate actions in the fine motor based on their age by length of stay in the PEI (early education program by its acronym in Spanish).

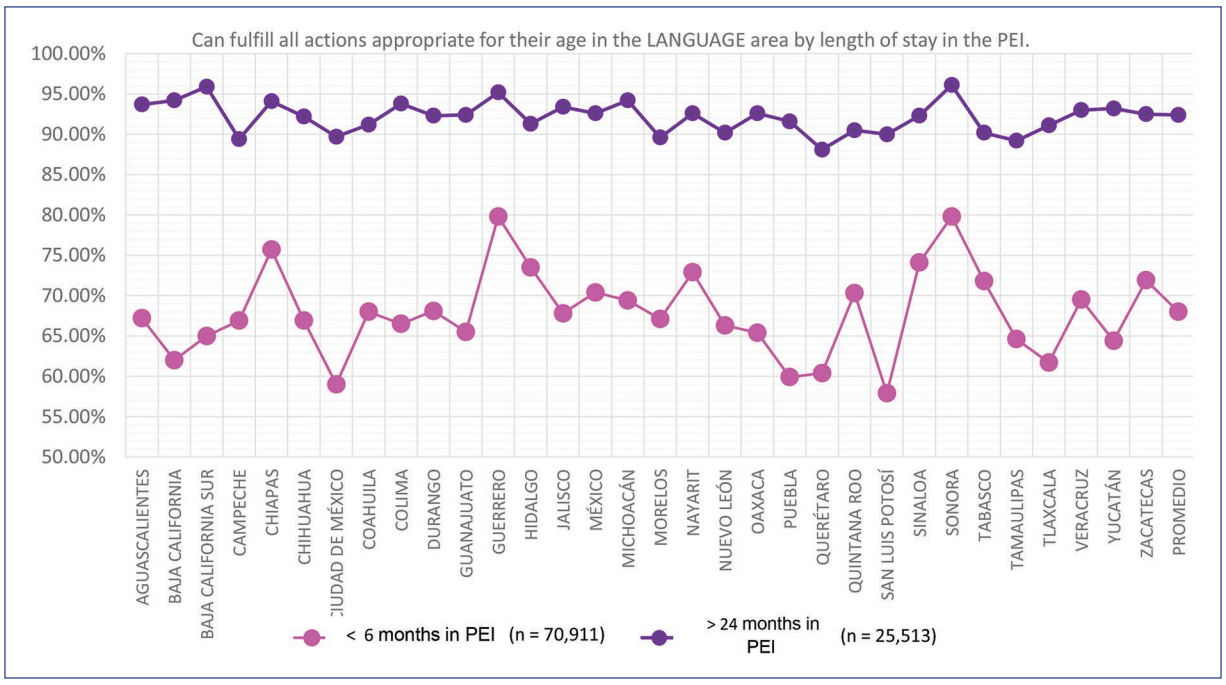

Figure 5. Population percentages by each state of the country (alphabetic order) that has completed all age-appropriate actions in the language based on their age by length of stay in the PEI (early education program by its acronym in Spanish).

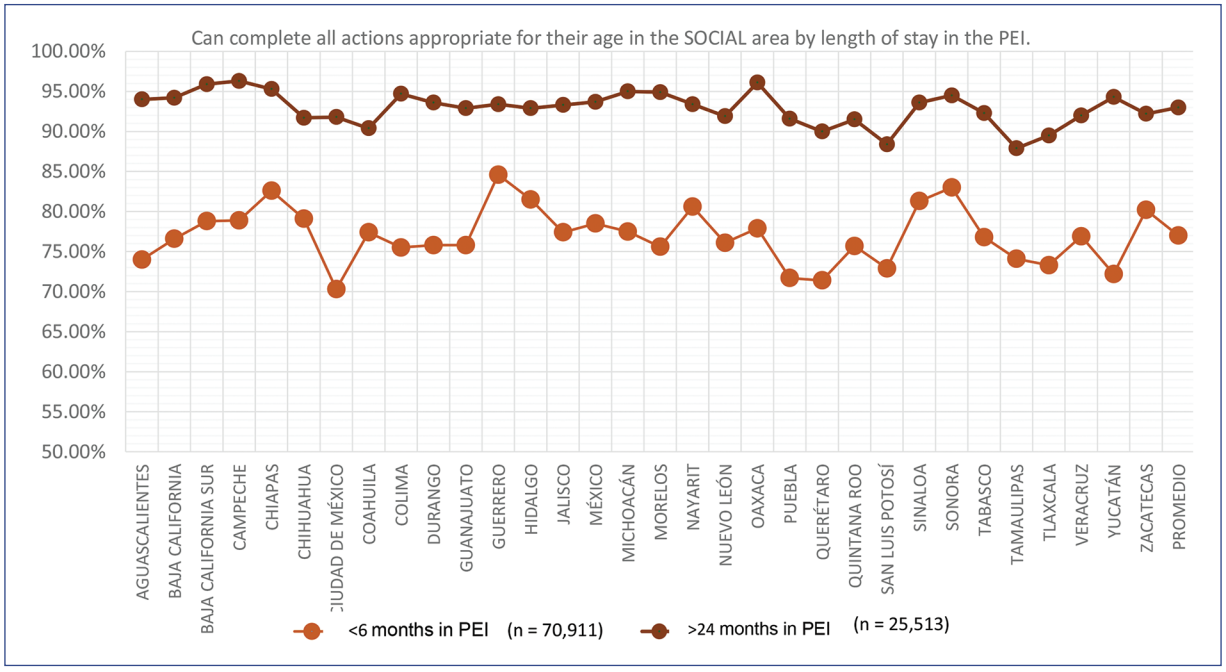

Figure 6. Population percentages by each state of the country (alphabetic order) that has completed all age-appropriate actions in the social based on their age by length of stay in the PEI (early education program by its acronym in Spanish).

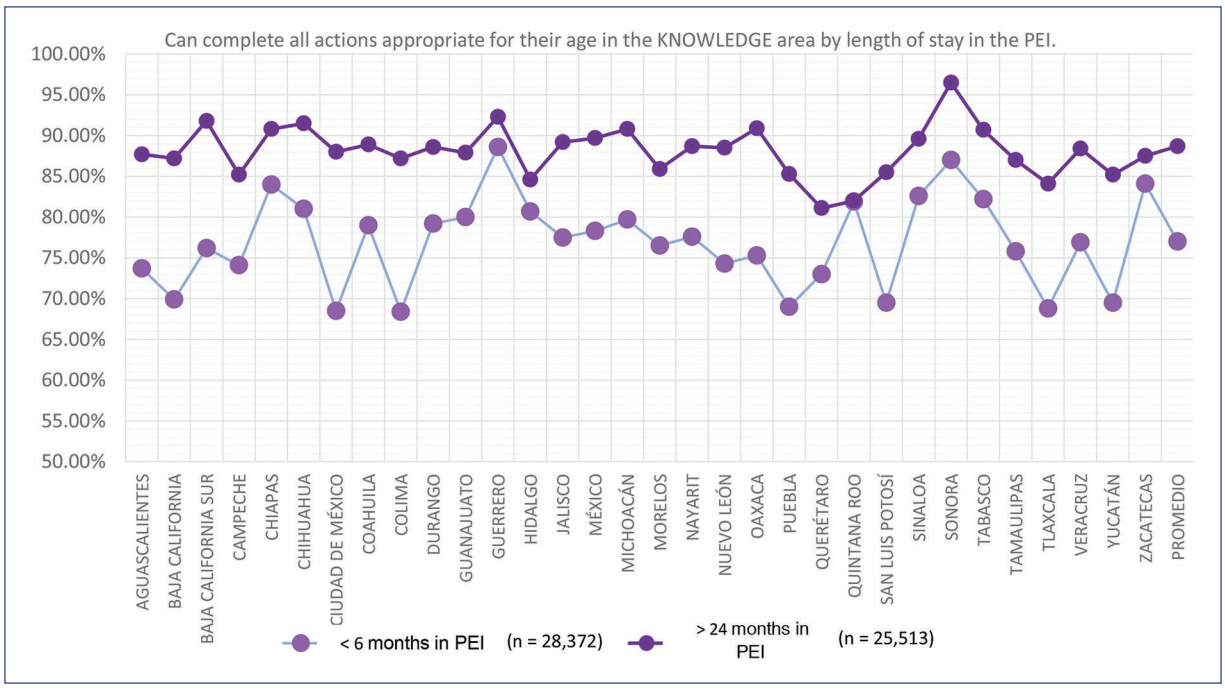

Figure 7. Population percentages by each state of the country (alphabetic order) that has completed all age-appropriate actions in the knowledge based on their age by length of stay in the PEI (early education program by its acronym in Spanish).

Table 3. Association between length of stay in the PEI and normal outcomes in overall development and specific areas

Length of stay in the PEI	Global EDI results* OR (95% CI)**	Normal result by area of development* OR (95% CI)				
		Gross motor	Fine motor	Language	Social	Knowledge
< 6 months	1.0	1.0	1.0	1.0	1.0	1.0
6-11 months	1.4 (1.3-1.4)	1.5 (1.4-1.5)	1.2 (1.1-1.3)	1.4 (1.4-1.5)	1.4 (1.4-1.5)	1.6 (1.5-1.7)
12-17 months	1.7 (1.7-1.8)	1.7 (1.6-1.8)	1.5 (1.5-1.6)	1.8 (1.8-1.9)	2.0 (1.9-2.1)	2.1 (2.0-2.2)
18-23 months	2.0 (1.9-2.1)	2.3 (2.1-2.5)	1.5 (1.5-1.7)	2.3 (2.1-2.4)	2.5 (2.3-2.9)	2.3 (2.2-2.6)
> 24 months	2.4 (2.3-2.5)	2.6 (2.4-2.8)	2.0 (1.9-2.2)	3.4 (3.1-3.7)	3.2. (2.9-3.5)	3.0 (2.7-3.2)

*Adjusted by sex, age, and state.
**OR (95% CI): odds ratio or prevalence (95% confidence interval); PEI: early education program.

longer lengths of stay to produce greater OR; thus, for the overall rating of the group of 6-11 months of permanence, the OR was 1.4 (95% CI 1.3-1.4), whereas the OR obtained for the 12-17 months group was 1.7 (95% CI 1.7-1.8), that for the 18-23 months group was 2.0 (95% CI 1.9-2.1), and the > 24-month group achieved an OR of 2.4 (95% CI 2.3-2.5). This trend was obtained for all of the developmental areas; however, it was more evident for the language, social, and cognitive areas.

Discussion

This study, which included a very large number of children, demonstrated the beneficial effect of activities carried out in daycare centers on neurodevelopment in children under 5 years old, with the observation that the longer the stay, the more evident the developmental progress, particularly in the areas of language, social, and cognitive skills. These results are consistent with

the pilot study conducted before this investigation[14]. These findings reinforce the idea that the inclusion of children in daycare programs from an early age favors their development[22-24], thus justifying continued support for these types of establishments at the national level.

It is worth highlighting the results in the area of language development, as the longer the permanence in the PEI, the greater the probability of normal language development, up to 3.4 times more for the group of children who remained more than 24 months in the program. This is interesting, as previous studies conducted in Mexico have reported a greater risk of language developmental delay in the general population[25,26]. Thus, it is possible to assume that if families are recommended to enroll their children under 5 years old in daycare centers, this backlog could be reversed. Although it is necessary to acknowledge that the breakthrough does not seem as significant in the fine motor area. This type of national evaluation of federal programs could help to improve the curricula.

The results of this study are not novel, since similar results have been published demonstrating the positive influence of preschool education on psychomotor development in children aged 5 and 6 years old, but it should be noted that the children who benefit most from these educational programs are those who grow up in vulnerable families[4,7,24].

Previous studies conducted by our research group have found, using the CDE test, a decrease of up to 3.1% in the proportion of children with abnormal development at 3 years old when compared to 1-year-old children[25]. At the same time, a recent study conducted using the CDE test between 2019 and 2022 detected a probability of global developmental delay of 42.1% (95% CI: 40.3-43.9), identifying male sex (OR 2.2, 95% CI: 1.9-2.6) as a risk factor[26] From this information, as part of the analyses performed for this study, age and sex were considered possible confounders in the logistic regression model; as shown in table 3, in each of the OR, the length of stay remained an independent variable that was associated with normal development when adjusted for age and sex.

To understand the positive influence on child development in daycare centers, the positive and negative points of enrolling children in these facilities must be contrasted. Because the benefits of childcare programs include that they facilitate parents' employment through providing a substitute for the care of children, increasing household income, and providing better food, thus maintaining the health of members of the family. In addition, unlike at home, learning activities are offered in daycare centers, which certainly help to improve children's language and knowledge. Likewise, certain group activities of children attending daycare centers facilitate and enhance social interaction with same-age peers, not to mention the fact that many of these centers offer healthy foods that, without a doubt, are of great help in maintaining children's nutritional status (particularly in low-income families)[22].

However, the disadvantages of daycare centers are mainly focused on the detrimental effects of the absence of parents; it is possible that compared to what happens at home, there is a decrease in the attention given to the child, limiting personalized care. Likewise, it should be considered that children attending daycare centers are frequently exposed to infectious diseases owing to contact with contagious staff or peers, as well as accidents attendant on physical activities and joint games. Finally, it is important to keep in mind that the progress in the development of each child also depends on the quality of the psycho-pedagogical and educational activities offered at each facility[9].

In addition, it has been noted that some parents worry about their children's attendance at daycare centers, for instance, on the grounds that the care provided by those outside of the child's parents could be insufficient compared to what they could get at home. However, from a sociocognitive perspective, children require social interaction with adults, which is fundamental for language development, cognition, and emotional regulation. In this regard, the effects of attending daycare centers from an early age were evaluated in a prospective longitudinal study, in which 1,201 children aged 18 months were divided into two groups, those who attended daycare centers with individual care and those who were part of group care activities. The results showed that children in group childcare obtained better scores in cognitive ability and better guidance and commitment than infants in individual care[23]. The results of that study are consistent with this report. Thus, it would be appropriate to say that children who attend daycare centers develop better skills which can help them progress more effectively in subsequent stages of life. However, further longitudinal studies are needed that will compare the development of children who attend daycare with children who remain at home.

In addition to the analysis of ECD services in Latin-American Countries[10], in Mexico in 2012 was conducted a study that analyzed the different programs of early childhood provided by the public sector, showing great social disparities in access because the ECD programs were based on a right for the adults that are in the formal

sector instead of a right for the children[27]. In this study, differences between states (high vs. low income) on outcomes in developmental areas, foster the need to provide quality services to promote optimal child development[28,29]. The ECD services, such as the PEI and the use of CDE test results, could also function as a bridge between the educational sector and the family, as an opportunity to talk about their concerns about development and ideas to implement at home. This is of particular importance because it has been shown in Mexico that better levels of language in children are associated with access to books, preschool, and support to learning[30]. To really get a change in ECD an intersectoral policy is needed that could articulate the efforts, considering children at the center of that policy[31-33].

The limitations of the study are that there is not a representative sample of ECD levels in children by geographical region, sex, and age, neither we could not show the impact on ECD level for the different PEI interventions available, and the results could only apply to the children that are users of the specified ECD program. Another limitation is that neither familiar, emotional, or other health conditions were evaluated. Further studies including these factors and other programs are needed, together with the deep analysis of the children with and without the regular assistance to any ECD service, and later the transition to the formal educational sector. The strengths of the study are that ECD test is used as a public policy in the health sector and the results of the ECD test used in the PEI daycare centers are recognized as a reference tool for further evaluation in primary health facilities. Furthermore, the fact that the program was federal and with unified contents, materials, daycare facilities, and educational contents helped to see the differences among geographical regions without those confusing factors included in previous.

Conclusions

This study showed at the national level, that long-term enrollment in daycare centers (PEI) favors normal development. This seems particularly important in low-income regions because could be an equalizing strategy as a public policy. The different results among in developmental areas could help to improve the curricula of daycare centers, and in this way, the ECD measurement with the CDE test could be both a tool for identifying children that individually need further attention, and a regional level to analyze the impact of the program and areas of opportunity. We hope that the results of new national representative surveys, be able to compare the results within the country and between countries. Further studies are needed to corroborate these findings. The need for monitoring development periodically in early childhood educational services is highlighted.

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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 obtained approval from the Ethics Committee for the analysis of routinely obtained and anonymized clinical data, so informed consent was not necessary. Relevant guidelines were followed.

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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RESEARCH ARTICLE

Effects of 6 months of permanence in an early intervention program on the developmental level of children 18-42 months of age in poverty: cohort study

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Abstract

Background: *The Child Care Facilities Program (PEI, for its Spanish acronym) in Mexico targets parents of children aged 1-3 years living in poverty, providing education and care strategies 5 days a week. This study aimed to evaluate the impact of a 6-month stay in childcare centers on the developmental levels of children under 4 years old.* **Methods:** *A longitudinal, before-and-after study was conducted. Children aged 12-42 months enrolled in the PEI were included in the study. All participants remained in the program for 6 months from the first measurement. The overall and area-specific developmental levels were assessed using the Early Childhood Development Assessment (EDI, for its Spanish acronym) test. The percentages of developmental levels (normal, delayed, and at risk of delay) were compared between the baseline and 6-month assessments using the McNemar test.* **Results:** *The study included 1835 children, of whom 52% were male. The age distribution was as follows: 28.1% were 12-24 months old, 48.4% were 25-36 months old, and 23.5% were 37-42 months old. At baseline, 80.5% (n = 1,476) of the children were classified as having normal overall development, 16% had developmental delay, and 3.5% were at risk for delay. After 6 months, the percentage of children with normal development increased to 90.1%, while those with developmental delay and those at risk for delay decreased to 8.7% and 1.2%, respectively. Similar improvements were observed across various developmental areas, except in the knowledge area.* **Conclusions:** *A 6-month stay in childcare centers is beneficial for improving the developmental levels of children under 4 years old, both overall and in motor, language, social, and cognitive areas.*

Keywords: *Child development. Childcare centers. Educational programs. Infants. Preschoolers.*

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Efectos de seis meses de permanencia en un programa de intervención temprana sobre el nivel de desarrollo de niños de 18-42 meses de edad en situación de pobreza: estudio de cohortes

Resumen

Introducción: *El Programa de Estancias Infantiles (PEI) de México se enfoca a padres de niños de 1-3 años de edad en situación de pobreza, e incluye estrategias de educación y cuidado, cinco días a la semana. El objetivo de este estudio evaluar el efecto que permanecer seis meses en el PEI, sobre el nivel de desarrollo de niños menores de cuatro años.* **Métodos:** *Estudio longitudinal y comparativo, de antes y después. Se incluyeron niños y niñas de 12-42 meses inscritos al PEI. Todos los participantes permanecieron en el programa seis meses a partir de la primera medición. El nivel de desarrollo, global y por áreas se evaluó con la prueba Evaluación del Desarrollo Infantil (EDI). Se comparó el porcentaje de nivel de desarrollo (normal, rezago y riesgo de retraso) entre la evaluación basal con la realizada a los seis meses con la prueba McNemar.* **Resultados:** *Se incluyeron 1,835 niños; 52% sexo masculino, el 28.1% de 12-24 meses edad, 48.4% de 25-36 y 23.5% de 37-42. Al inicio, el 80.5% (n = 1,476) se clasificó con desarrollo global normal, el 16% con rezago en el desarrollo y el 3.5% con riesgo de retraso. A los seis meses después, incrementó el porcentaje con desarrollo normal a 90.1%, disminuyendo los otros dos grupos a 8.7% y 1.2%, respectivamente. Por áreas del desarrollo se encontraron resultados similares, con excepción del área de conocimiento.* **Conclusiones:** *La permanencia <6 en el PEI en niños <4 años es favorable para mejorar su nivel de desarrollo, tanto global como por áreas.*

Palabras clave: *Desarrollo infantil. Estancias infantiles. Programas educativos. Lactantes. Preescolares.*

Introduction

Globally, there has been a growing increase in public investment over the years to promote neurodevelopment in young children; this policy aligns with the United Nations (UN) 2030 Sustainable Development Goals, which includes the target: "ensure that all girls and boys have access to quality early childhood development, care, and pre-primary education so that they are ready for primary education[1]."

In various countries, particularly low-income ones, one of the pillars for improving child development is early inclusion in education programs, such as kindergartens (preschool education) or institutions with trained personnel for childcare[2]. Early age refers to the period from birth to 5 years of age; this period is critical as it establishes the foundations of brain architecture and forms the structure for developing new cognitive, social, and emotional skills[3].

In the international context, numerous publications have demonstrated that the implementation of government programs to promote early childhood development (ECD) in children under 5 years of age effectively supports optimal development by improving the acquisition of cognitive skills[3-5]. Long-term effects observed among participants in these programs include a higher proportion of high school graduates, increased years of education, higher income levels, and reduced teenage pregnancy rates[6]. The benefits are not solely individual, as from a macroeconomic perspective, data indicate a return of three to seven dollars for every dollar invested in these programs[6-8].

In Mexico, although preschool education has been mandatory since 2002, by 2019, it was estimated that only 7.1% of children aged 0-35 months attended some form of childcare or early education program, while 62.4% of children aged 36-59 months attended preschool education[9]. Despite these figures, it is important to recognize that strategies targeting vulnerable populations have been implemented over the years, which directly or indirectly benefit child development. For example, in 2006, the Mexican Child Care Facilities Program (PEI, for its Spanish acronym) was created by the Ministry of Social Development (*Secretaría de Desarrollo Social*, SEDESOL) to support childcare for children between one and 3 years 11 months of age, as well as children under 6 years with disabilities. The families benefiting from this program are those where mothers, fathers, or guardians worked, sought employment or studied and were also living in poverty without access to public or private childcare facilities[10,11]. By 2012, it was estimated that the PEI had served a total of 1.05 million children, indicating that if the program were discontinued, 34% of beneficiaries would have to leave their jobs to care for their children[12].

Since its creation, the PEI has undergone modifications based on various evaluations[13,14], becoming an integrated and standardized model to address children's educational and healthcare needs. In general terms,

these childcare facilities operate 8 h daily, Monday through Friday, and the attending children, besides receiving two meals per day, participate in various social, motor, cognitive, and interactive activities that promote early childhood development[15].

Between 2014 and 2015, our group conducted a cross-sectional study to evaluate the association between time spent in the PEI and developmental levels in children under 5 years; the results showed that longer attendance to the PEI was associated with an increased frequency of children with normal global development (assessed using the Child Development Evaluation test [EDI, for its Spanish acronym]), as well as across developmental areas, with language and social areas showing the highest scores. Specifically, in the group with ≥ 24 months of attendance at childcare facilities, the adjusted prevalence odds ratio (POR) for achieving a normal global result was 3.46 (95% CI 2.13 - 5.60)[16].

To follow-up on these initial observations, the present research aimed to evaluate the effect of PEI on the developmental level of children under 4 years of age after 6 months of attendance at childcare facilities through a longitudinal study.

Methods

This was a prospective cohort study that included all children aged 12-48 months attending PEI childcare facilities in the states of Baja California and Campeche between November 2014 and June 2015. Children who were 42 months or older at the time of the first evaluation, as they would be over 48 months at the second evaluation, and children who stopped attending childcare facilities before the second evaluation were excluded from the study.

For each participant, age, sex, attendance time at the childcare facility before the start of follow-up, and the presence of any disability were recorded. The latter was defined as any person who presents one or more physical, mental, intellectual, or sensory deficiencies due to congenital or acquired reasons, whether permanent or temporary[11].

Development assessment was conducted using the EDI test at the beginning of the study and 6 months later. EDI is a screening tool developed and validated in Mexico to detect developmental problems in children between 1 month and 5 years. This test has adequate sensitivity and specificity to identify developmental levels both globally and across developmental areas: fine motor, gross motor, language, social, and knowledge. The results, both overall and by developmental area, are based on a traffic light system - green, yellow, and red - classifying each child as having normal development, developmental lag, or risk of delay, respectively[17,18]. In the present study, results are described for motor, language, and social areas for children aged 12-48 months, while the knowledge area was only evaluated in children over 36 months; thus, for this latter area, results are only shown for the 37-48 months group (n = 431).

The staff responsible for each facility included in the study administered the EDI test. For proper administration, staff previously attended a training course, reinforcing learning with brief videos about the evaluation technique for each EDI item. In addition, each childcare facility had a supervisor who verified the correct application. This supervisor collected the forms completed for each participant to proceed with electronic data capture. Information was centrally consolidated, and the final database was structured. This study was part of project HIM/2013/063, approved by the Ethics and Research Committees.

Statistical analysis

For the descriptive analysis, qualitative measurement variables are presented as absolute frequencies and percentages, while quantitative variables, which did not have a normal distribution, are expressed as median and interquartile range (IQR).

For inferential analysis, Chi-square was used for comparison between groups, and McNemar's test was used to compare proportions between developmental levels before and after 6 months in the PEI. $p < 0.05$ was established as statistically significant. Analyses were performed using IBM SPSS version 27.0.

Results

Figure 1 presents the flowchart of the participant selection process; as shown, the eligible population was 2395 participants. However, 561 children did not complete the second evaluation, resulting in a total analyzed population of 1834 children for this study.

Table 1 describes the characteristics of participants at the time of the first evaluation. Of the total, slightly more than half were male (n = 948, 51.7%); while by age group, the majority corresponded to children aged 25-36 months (48.4%), followed by 12-24 months (28.1%), and the 37-42 months group (23.5%). It should be noted that 16 children had some form of disability (0.9%).

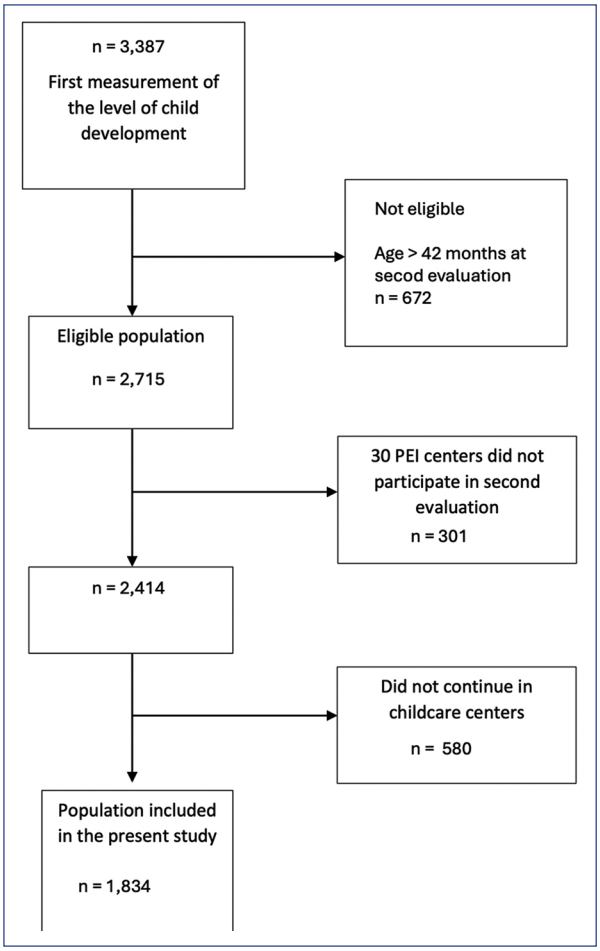

Figure 1. Flow diagram of the population included in the study, starting from the baseline measurement.

As also observed, the length of stay in childcare facilities varied, with the largest proportion having < 6 months (n = 806, 43.9%), compared to the smallest proportion who had ≥ 24 months (n = 95, 5.2%). To contrast this information, table 2 presents the most relevant finding: by age group, the majority of participants were between 37 and 48 months old (48.8%).

Global development evaluation, before and after 6 months

Table 3 presents the results of the global development evaluation using the EDI test, both for the baseline measurement and at 6 months. As observed, 80.5% (n = 1,476) were classified with normal development (green), followed by developmental lag (yellow) in 16%, and risk of delay (red) in 3.5%. While in the evaluation, 6 months later, the number of children with normal development increased to 90.1% (n = 1,652), with the other two groups decreasing to 8.7% and 1.2%, respectively.

It is worth highlighting that, when analyzing the data from table 3 by cohort, according to the first evaluation, there were changes in all three groups. Thus, from the normal development group, 84 (5.7%) children moved to lag and 23 (1.2%) to risk of delay. Meanwhile, of the 229 classified as yellow, the majority moved to green (77.9%), 20.1% maintained the same classification, and six children (2.0%) were classified as red. Finally, of the 64 children initially classified with risk of delay (red), in the second evaluation, half moved to green, 16 (25%) to yellow, and another 16 maintained the same classification. The percentage change between the first and second evaluations was statistically significant ($p < 0.001$).

Evaluation by developmental areas, before and after 6 months

Figure 2 graphically presents (in traffic light format) the percentage change children experienced after 6 months of follow-up across the five developmental areas. The X-axis of each graph shows the total cases for each category (green, yellow, and red), while the Y-axis corresponds to the percentage by category, according to the second evaluation. As observed, there was a percentage improvement in all areas in the second evaluation for participants initially classified with developmental lag (yellow) or risk of delay (red) after 6 months of staying in the facilities. However, it should be noted that a small percentage of children were initially classified as having normal development but moved to lag in the second evaluation.

Figure 2A shows information about the gross motor area; in the first evaluation, 94.7% (n = 1,737) obtained a normal result, 4.9% (n = 89) showed developmental lag, and 0.4% (n = 8) showed risk of delay. For the second evaluation, 98.7% (n = 1714) maintained this result in the normal development group, and 1.3% (n = 23) moved to developmental lag. Of the 89 participants with lag, 93.3% (n = 83) changed to normal, and 6.7% (n = 6) remained with lag ($p < 0.05$). Of the children with a risk of delay result (n = 8) in the first evaluation, five improved, two changed to normal status and three to developmental lag, and the last three maintained the same result.

Improvement was most notable in the fine motor area (Fig. 2B) compared to the other four areas. As shown, in the second evaluation of the 115 initially classified with developmental lag, 101 (87.8%) changed to normal, but only one case moved to risk of delay. Meanwhile,

Table 1. Characteristics of the population studied in the first evaluation (n = 1,834)

Study variables	Total n = 1,834		Distribution by age group (months)					
			12-24		25-36		37-42	
	n	(%)	n	(%)	n	(%)	n	(%)
			515	(28.1)	888	(48.4)	431	(23.5)
Sex[a]								
Male	948	(51.7)	269	(52.2)	461	(51.9)	218	(50.6)
Female	886	(48.3)	246	(47.8)	427	(48.1)	213	(49.4)
Disability[b]								
Yes	16	(0.9)	2	(0.4)	4	(0.5)	10	(2.3)
Length of time in the program at the start of the study[c]								
< 30 days	111	(6.0)	55	(10.7)	45	(5.1)	11	(2.6)
1-5 months	695	(37.9)	339	(65.8)	276	(31.1)	80	(18.6)
6-11 months	383	(20.9)	117	(22.7)	198	(22.3)	68	(15.8)
12-17 months	438	(23.9)	4	(0.8)	306	(34.5)	128	(29.7)
18-23 months	112	(6.1)	0	-	63	(7.1)	49	(11.4)
≥ 24 months	95	(5.2)	0	-	0	-	95	(22.0)

[a]Chi-square test for differences by sex and age p = 0.883.
[b]Lambda test for disability and age (years) p = 0.109.
[c]Kendall's Tau-b between program permanence and age 0.443; p < 0.001.

Table 2. Characteristics of the study population in the second evaluation, at 6 months

Study variables	Total n = 1,834		Distribution by age group (months)					
			12-24		25-36		37-48	
	n	(%)	n	(%)	n	(%)	n	(%)
			187	(10.2)	750	(40.9)	897	(48.8)
Sex[a]								
Male	948	(51.7)	98	(52.4)	393	(52.4)	457	(50.9)
Female	886	(48.3)	89	(47.6)	357	(47.6)	440	(49.1)
Disability[b]								
Yes	16	(0.9)	0	-	4	(0.5)	12	(1.3)
Length of stay in the childcare program[c]								
6-11 months	812	(44.3)	186	(99.5)	389	(51.9)	237	(26.4)
12-17 months	364	(19.8)	1	(0.5)	209	(27.9)	154	(17.2)
18-23 months	439	(23.9)	0	-	150	(20)	289	(32.2)
≥ 24 months	219	(11.9)	0	-	2	(0.3)	217	(24.2)

[a]Chi-square test for differences by sex and age p = 0.824.
[b]Lambda test for disability and age (years) p ≤ 0.001.
[c]Kendall's Tau-b between program permanence and age. p < 0.001.

all children with risk of delay result (n = 17) showed improvement, as 11 changed their result to normal, and six moved to developmental lag (p < 0.05).

In the language area, highly favorable percentage changes were also observed in the 6-month evaluation. As shown in figure 2C, of the 185 children with developmental lag results, 80.5% (n = 149) changed to normal results, but 5 (2.7%) changed to risk of delay. Meanwhile, of the 44 children initially classified with risk, 31 (70.4%) had a higher evaluation in the second assessment, 24 moved to normal, and seven to developmental lag (p < 0.05). However, we highlight that this area showed the highest percentage (3.3%) of children who, being normal at the start, moved to a lower classification in the second evaluation, as shown in figure 2C.

Table 3. Comparison of global developmental evaluation results, using the child development assessment test, at baseline and after 6 months of staying in childcare facilities (n = 1,834)

Initial Result	Total, n (%)	Subsequent result					
		Green n (%)		Yellow n (%)		Red n (%)	
		1,652	(90.1)	159	(8.7)	23	(1.2)
Green	1,476 (80.5%)	1,391	(94.2)	84	(5.7)	1	(0.1)
Yellow	294 (16%)	229	(77.9)	59	(20.1)	6	(2)
Red	64 (3.5%)	32	(50)	16	(25)	16	(25)

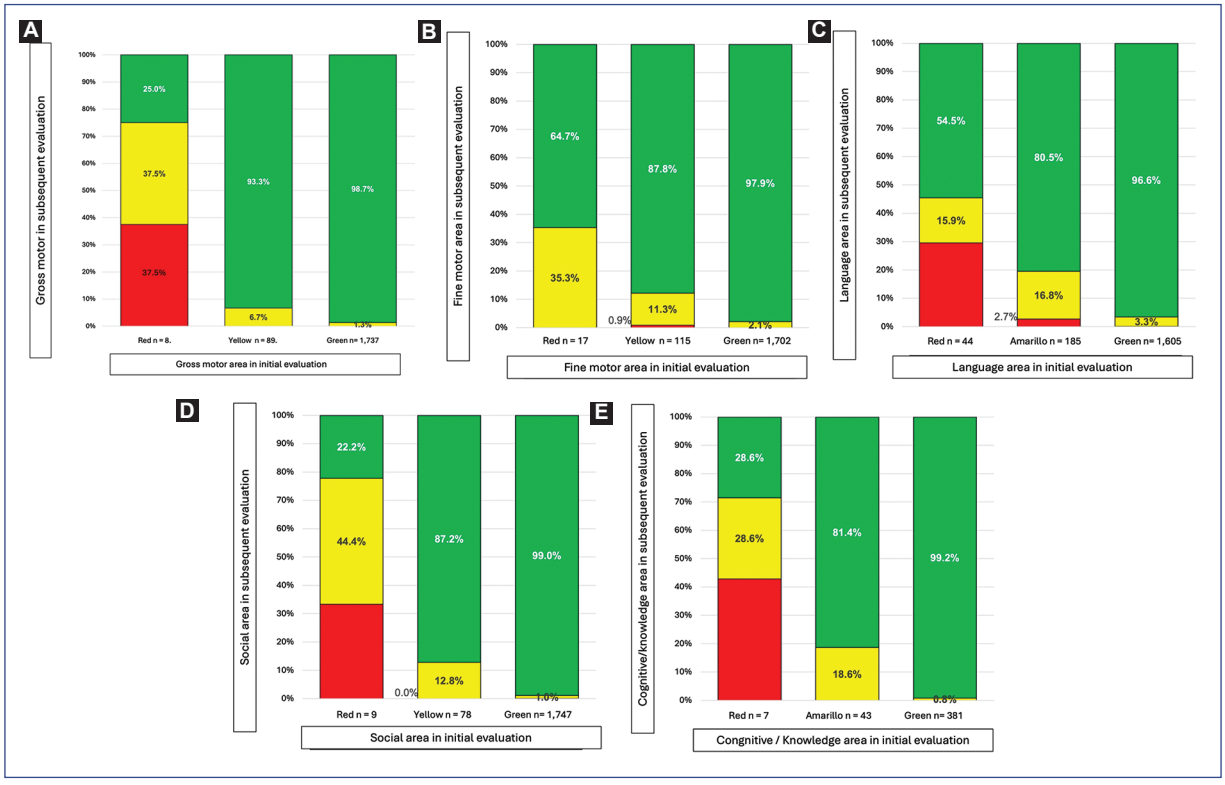

Figure 2. Comparison of baseline and subsequent results for the five evaluated developmental areas. **A:** gross motor. **B:** fine motor. **C:** language. **D:** social. **E:** knowledge/cognitive.

Regarding the social area, it was observed that of the total children with normal results (n = 1,747), in the second evaluation 17 (0.97%) were classified as having developmental lag and one (0.1%) moved to risk of developmental delay. In the case of the 78 with developmental lag, 87.2% (n = 68) changed to normal, and 12.8% (n = 10) remained with lag. Among the nine children at risk of developmental delay, the most significant improvement was observed, with four transitioning to developmental lag and two achieving normal development, $p < 0.05$ (Fig. 2D).

Finally, the knowledge area showed the smallest percentage change in improvement in the risk of delay group; of the seven children initially classified in this category, only 2 (28.6%) moved to normal, 3 (42.9%) to developmental lag, and another three maintained the same result. For the 43 children with developmental lag, in the second evaluation, 81.4% (n = 35) moved to

normal, and the rest maintained the same classification, $p < 0.05$ (Fig. 2E).

Discussion

The findings of this study confirm the benefits of incorporating childcare facilities (in this study, belonging to the PEI program) for children from early life stages to promote optimal development. The different results presented showed a very significant favorable change in the percentage of children who initially did not have development considered normal after staying 6 months in these centers.

These results corroborate previous findings in which our group, through a cross-sectional study, reported that children who spend more time in childcare facilities show an increased prevalence of normal development[16]. However, it should be emphasized that, unlike the previous study regarding the association between longer stay and improved neurodevelopment, the prospective design of the present research provides greater validity from both methodological and causality perspectives.

It is interesting to highlight that studies evaluating child development in the general population using the EDI test[19] have reported a 3.1% decrease in the proportion of children with normal development at age 3 when compared to 1-year-old children. According to the results of this study, it is possible to consider that attendance at childcare facilities could be a protective factor to prevent or improve developmental problems, similar to what has already been documented by other authors regarding the benefits of preschool education[5,6,20].

In 2011, an evaluation of the PEI was carried out, and a positive impact was found in personal-social and communication areas[13,14]. The results of the present study are consistent in both developmental areas. However, it was also possible to determine that there is a positive effect on gross motor, fine motor, and cognitive areas. To understand these benefits, one should consider the different activities carried out in childcare facilities, which include interaction with children of similar ages through integration in games or during mealtimes. In addition, in these facilities, educational activities include drawing, painting, cutting, and singing, among others, together with physical activities, both individual and in group.

A notable point is what was observed in the knowledge development area, as it showed the lowest percentage of benefit; this could be due to the smaller number of children evaluated compared to other areas or because there are factors both within the facilities and external that were not evaluated in this study. For example, children spend limited time in the facilities, with more time spent at home, so it is possible that they do not continue practicing what they learned at home, or there could be a deleterious effect of malnutrition. Therefore, further studies are necessary to determine the role of these potential confounding factors.

Furthermore, the results of this study should be interpreted with some caution, as they likely cannot be extrapolated to other populations. What seems most important to note is that the studied population corresponds to a highly vulnerable group due to their low socioeconomic status. Hence, it is recommended to conduct studies that evaluate whether the positive effect of childcare facilities on neurodevelopment is observed in other population groups without social or economic disadvantages, and even by gender.

Conclusion

A 6-month stay in childcare facilities for children under 4 years of age is favorable for improving their development level, both globally and in motor, language, social, and cognitive areas.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical considerations

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author has this document.

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RESEARCH ARTICLE

Play prescription: intervention delivered at primary health care facilities to promote child development through activities at home

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Abstract

Background: *Play is a fundamental component of children's social, emotional, cognitive, and physical development. This study focused on assesses a play-based intervention method to promote overall child development based on parental involvement, delivered at primary care facilities.* **Methods:** *Quasi-experimental study was conducted with children 24-59 months old, regularly attending the monthly stimulation sessions in primary care facilities in the state of Puebla, Mexico, from November 2015 to April 2016. Play interventions were administered over six sessions each month 1-h length individually for the dyad, included free play time, and each session one activity at home that include the five areas of development and with some materials provided but encouraged to use more available at home. The Child Development Evaluation (EDI) test was administered at baseline, 3 and 6 months after the intervention. A comprehensive data set encompassing demographic variables was collected and analyzed. McNemar test was used to assess developmental changes over time.* **Results:** *The sample consisted of 276 children, 60.5% were male, median age 40 months (interquartile range: 34-46). All participants attend the six sessions and conducted activities daily at home. Overall, the percentage of children with abnormal result with EDI test was 77.2% at baseline and 17.4% final measurement at 6 months ($p < 0.001$), with mild-delay decreased from 39.9% to 6.9% and high-risk of delay from 37.3% to 10.5%.* **Conclusion:** *The play intervention resulted in a clinically and statistically significant improvement in the developmental outcomes of the children, both with normal/abnormal result at baseline.*

Keywords: *Play. Health primary care. Child development. Mass screening. Developmental screening. Parenthood.*

Te receto un juego: intervención otorgada en unidades de salud del primer nivel de atención para promover el desarrollo infantil a través de actividades en casa

Resumen

Introducción: *El juego es una actividad esencial para el desarrollo social, emocional, cognitivo y físico. Se evaluó una intervención lúdica para promover el desarrollo infantil en forma global a partir del involucramiento familiar otorgada en unidades de atención primaria a la salud (APS).* **Métodos***: Estudio cuasiexperimental, con niños y niñas de 24-53 meses de*

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edad que acudían regularmente a sesiones de estimulación temprana en APS del estado de Puebla, entre noviembre de 2015 y abril de 2016. Se administró una intervención lúdica a lo largo de 6 sesiones en forma mensual, de forma individual para cada diada, incluían juego libre y una actividad lúdica por sesión para realizar en casa diariamente utilizando algunos materiales otorgados y lo disponible en su casa o localidad. Se evaluó la intervención la prueba Evaluación del Desarrollo Infantil (EDI) basal, a los 3 y 6 meses. Se registraron variables demográficas. Se analizó el cambio en el desarrollo con la prueba de McNemar. **Resultados***: La muestra estuvo compuesta por 276 niños(as), 60.3% de sexo masculino, mediana de edad 40 meses (rango intercuartilar: 34-46 meses). De forma global el porcentaje de participantes con resultado anormal en la prueba EDI fue de 77.2% basal y 17.4% a los 6 meses (p < 0.001); el grupo de rezago disminuyó de 39.9% a 6.9% y riesgo de retraso de 37.3% a 10.5%.* **Conclusión***: La intervención lúdica mejoró el desarrollo de los niños en forma clínica y estadísticamente significativa, tanto en niños con desarrollo normal como alterado.*

Palabras clave: *Atención primaria en salud. Desarrollo infantil. Juego. Tamizaje masivo. Tamizaje del desarrollo.*

Introduction

Child development is a process in which children learn to master increasingly complex ways of thinking, feeling, movement, and relating to others. This takes place when children interact with the people and objects in their environment[1]. Emphasis should be placed on the developmental stage of early childhood, as approximately 90% of the brain's neural circuits associated with cognitive functioning, socialization, movement, sensory perception, and emotional regulation are established in the first 5 years of life[2,3].

Therefore, children's earliest years are extremely important in their development. From a macroeconomic perspective, investing in the development of children is a priority, given that the estimated rate of return is approximately 7 times the initial investment in early childhood[4-6]. Thus, promoting child development should be a national priority, especially in developing countries[7,8] due to the substantial incidence of neurodevelopmental disorders in these countries. For instance, according to a meta-analysis by Bitta et al.[9], in 2017, a review of 51 investigations in low- and middle-income countries showed a median pooled prevalence for all neurodevelopmental disorders of 7.6 (95% confidence interval; 7.5-7.7)/1000 children from 0 to 18 years old. In Mexico, according to Unar-Munguía et al., in the National Continuous Survey of Health in 2022 (ENSANUT 2022), 3.7% of children has some risk of developmental delay[10], but only 27.1% national wide had at least one child development evaluation, which let the real prevalence of developmental problems unknown.

Although the dictionary defines the word "play" as merely "engaging in an activity with a sense of joy and exclusively for the purpose of recreation or develop capacities,[11]" it has been recognized that play is essential for the social, emotional, cognitive, and physical development of children, and its impact is greater during early childhood[12], because when children play, they develop some of the most important abilities to be a lifelong learners[13]. In addition to its inherent ability to elicit pleasure, play has a substantial influence over the fostering of cognitive, emotional, and social skills. Research has shown that play promotes healthy early childhood development, as it teaches children to cooperate, solve problems, and handle conflict. Furthermore, it enhances resilience, motor abilities, and cognitive skills[14]. In the pediatric care context, play can be used as a therapeutic tool to enhance a child's adaptation to the hospital environment, thereby reducing anxiety and increasing cooperation with treatment. This underlines the role of play as a key resource to be used as an intervention to strengthen child development[15].

Programs that integrate play as an intervention strategy have a strong impact on motor and cognitive development. For example, the Supporting Play Exploration and Early Development Intervention program targeting children with neurodevelopmental risks found that early and intensive interventions in early childhood promote motor skills and problem solving[16,17]. As part of these initiatives, the importance of actively involving parents is highlighted, not only as mere observers but also as key participants in structured recreational activities. This approach also reflects how play can overcome sociocultural barriers and become a bridge between different spaces of learning and parenting[18].

Play has been shown to contribute to child development by modifying brain architecture and promoting the development of cognitive and social skills. Studies in primates have shown that play activities have co-evolved with brain systems that are responsible for complex behaviors (e.g., when using tools or in social innovation), which highlights the importance of play in the construction of fundamental competencies in humans[19].

Furthermore, playing in the pediatric age is key as a social bond since it promotes skills between children and parents, to plan, organize, and regulate emotions and the acquisition of social skills[18]. Depending on the culture context, children learn different skills through play, becoming a fundamental aspect to intervene positively in their development[20], so healthcare professionals should encourage parents of allocating time for these activities, pointing out the importance of playful learning as a complement to didactic learning[21,22].

Although there are various institutional programs for the care of neurodevelopmental disorders in patients' homes, in Mexico, these interventions generally focus only on the affected areas. With the assistance of a group of experts, a play-based didactic intervention was designed for parents to implement at home. This intervention aims to strengthen early childhood development, specifically in the cognitive, communicative, motor, and social domains, through direct parental involvement. This paper presents the results of this intervention.

Methods

A quasi-experimental study was conducted, between November 2015 and April 2016, with the participation of 88 health units from eight of the 10 health jurisdictions in the state of Puebla, Mexico.

Convenience sampling was used to recruit boys and girls who met the following criteria: children between the ages of 24 and 53 months that are periodically receiving well-child control appointments, evaluation using the Evaluation of Child Development (EDI)[23] and had participated regularly in monthly early stimulation sessions delivered in primary care facilities, all as a part of the national guidelines for the National Center for Child Well Being[24], who had not yet begun formal schooling and whose parents or guardian have given written informed consent to participate in the study, in which the main change from the regular services that they were used to receive was that the monthly sessions would be conducted individually instead of in group, by a psychologist instead of the health professionals, and targeting play strategies to promote development at home. Elimination criteria were participants whose address changed during the follow-up period, participants who did not attend all counseling sessions or did not realized the activities at home and express their interest to stop the intervention or retired the consent. The intervention was registered in the medical record at the primary care facility and the information was registered as a part of the rutinary activities of the health facilities and reported to the federal programs. The data were anonymized, and no personal information was registered for this study.

Demographic characteristics of the participants were collected in terms of age, sex, degree of marginalization, and type of area (urban or rural).

Play-based intervention

The panel of experts who designed the intervention included pediatricians, pediatric neurologists, psychologists, and physiotherapists. The intervention consisted of daily activities to be performed at home, focusing on the five areas of development (fine motor, gross motor, language, social, and knowledge). It comprises multiple components and emphasizes various play-based activities, using eight pieces of didactic materials to complement the planned activities. The panel's primary goal was to prioritize interaction and play; therefore, the provided didactic materials were considered secondary. It is important to mention that the use of home or community-sourced materials (such as toys, balls, small stones, or playdough) for play was encouraged.

The prescription of the play-based intervention was carried out by professional psychologists but was divided into six sessions given monthly. Each session was planned to be 1 h long. During the first session, the materials were provided, and parents or caregivers were invited to engage in play with their children and collaboratively devise games or activities with them. At the end of each session, parents/caregivers were asked to carry out the learned activities at home daily, for at least 5 min, on one or more occasions throughout the day. At home, on completion of the activities prescribed, parents/caregivers were instructed to write down each of the activities performed.

The second to sixth sessions involved checking the compliance of the activities prescribed in the previous month by reviewing the records (in diaries or videos) made by the parents/caregivers. Furthermore, the psychologists asked the children to perform the activities from the previous month to assess their progress. Finally, a new activity was prescribed; thus, by the end of all the sessions, a total of six different play-based activities were assigned.

As an example, below we describe one of the activities that were prescribed to parents/caregivers. One activity for children aged 2-3 years involved placing the didactic materials on the floor, approximately 20 cm

apart, and showing them how to walk around the materials. The child should also jump over each piece, and then do it again, but after changing the position of the pieces, on different occasions. The jumps could be done with one or both feet. This exercise is focused on gross motor skills. To promote other development areas, children were invited to sing a song (language skills) and clap at each step or tap their fingertips to maintain the rhythm (fine motor skills). In addition, they had to arrange the pieces on the floor, along with other materials, to create a different path that could be followed. Finally, they were instructed to put the pieces away. If a child had sibling(s), they were invited to include the sibling(s) so that the children could take turns, and each one could design his or her own path (social skills). Furthermore, they would identify or name the objects that they were touching or stepping on by color, shape, or other characteristics (knowledge skills).

Outcome assessment

The effectiveness of the intervention was evaluated by assessing child development with the EDI test[25]. The overall result of the EDI test is the sum of the combination of data obtained from the five areas of development, neurological axis, and alarm signs and is categorized into three: green (normal or above), yellow (developmental delay), and red (risk of delay)[26]. This test was applied by the same psychologists who prescribed the intervention, on three occasions: initial visit, at 3 and 6 months of follow-up. Before the start of the study, the psychologists were standardized for the application of the EDI test. It is worth mentioning that all children included in the analysis, based on the records of parents/caregivers, carried out the prescribed daily activities on at least 28 days of each month.

Statistical analysis

Qualitative data are presented as frequencies and percentages, while quantitative data are presented as median and quartiles since the distribution was not normal. The McNemar test was used to compare proportions before and after the intervention. $p < 0.05$ was considered statistically significant. All analyses were performed using the Statistical Package for the Social Sciences statistical package version 30.0.

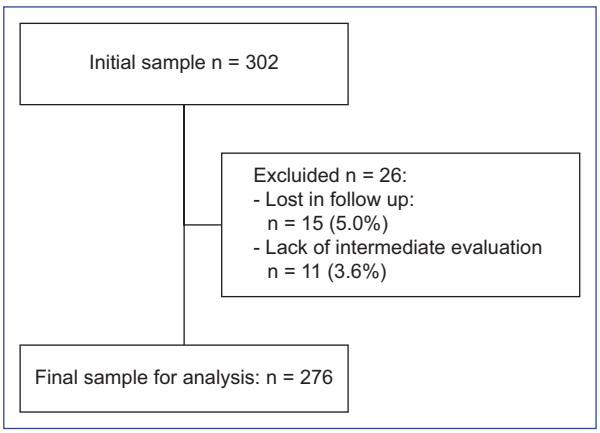

Figure 1. Flow diagram of the participants that were analyzed in this study.

Ethical aspects

This study was part of the project HIM/2013/063, which is related to aspects of improving developmental assessment at the first level of care. Consent was obtained from the children's parents or guardians who had accepted to take part in the study. They were informed that no financial compensation would be provided and that the resources would be provided at no cost. All participants' personal information was handled confidentially.

Results

As shown in figure 1, the eligible population consisted of 302 children, but 26 were excluded, resulting in a total of 276 study participants aged 2-4 years.

Table 1 presents the descriptive statistics of the participants. There was a higher proportion of boys (60.5%) than girls (39.5%); by age, both at the beginning and end the largest group were 3 years old (54% and 46.7%, respectively) although there were children that during the study change to a different group age for the EDI test, more than half lived in rural areas, and the vast majority had a high level of marginalization (42%).

The results of the effectiveness of the play-based intervention are presented in table 2. At baseline, in the developmental assessment by EDI, most children had some degree of impairment (n = 213, 77.2%), with a similar proportion classified in the yellow and red categories. Only 63 children (22.8%) had a normal result (green). When compared with the final assessment at 6 months, it was clearly observed that most children were classified as green (n = 228, 82.6%). This difference in

Table 1. Participants' general characteristics

n = 276	n (%)	%
Sex		
Female	109	39.5
Male	167	60.5
Age	At the beginning	At the end
2 years old	87 (31.5)	40 (14.5)
3 years old	149 (54)	129 (46.7)
4 years old	40 (14.5)	107 (38.8)
Rural	153	55.4
Urban	123	44.6
Attended all monthly appointments	276	100
Attend to educational service (preschool)	97	35.1
Level of marginalization		
Very low	65	23.5
Low	38	13.8
Average	41	14.9
High	116	42.0
Very high	16	5.8

Table 2. EDI test results of the participants (n=276) at baseline, intermediate (3 months) and final (6 months)

Result	Baseline (%)		3 months (%)		Final (%)	
Green	63	22.8	42	15.2	228	82.6
Yellow	110	39.9	173	62.7	19	6.9
Red	103	37.3	61	22.1	29	10.5

proportions before and after the intervention was statistically significant ($p < 0.001$).

As also shown in table 2, at 3 months, the number of cases in the yellow category increased significantly, from 110 to 173. Interestingly, this increase was not only due to a decrease in the number of patients classified in the red category (which was expected if the intervention improved the child's development) but also because 21 patients initially classified in the green category had a lower global score in the second assessment (as a new subtest of EDI was administered according to the new age).

Figure 2 shows the individual changes in developmental assessment after the intervention, compared to the initial classification. As can be seen, except for two children, practically all participants who were initially classified as green remained in the same category at the end. Among the 110 children classified as yellow, the vast majority (95.5%) improved their development and moved to the green category, although two remained in yellow and three moved to red. Finally, in the group of 103 children classified as red in the baseline evaluation,

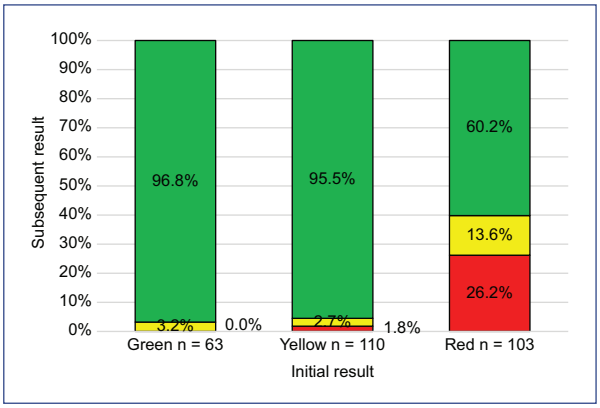

Figure 2. Change in child development score (EDI test) through provision of counseling and didactic materials.

76 (73.7%) improved, with most moving to green; however, it is noteworthy that 27 children (26.2%) maintained the same classification.

Discussion

Child development is an ongoing process of change in which increasingly complex levels of skills are acquired by a child in different domains. This process occurs through the interaction between the developing child and their environment, specifically with the people and objects that they encounter[1]. This is why interventions aimed at enhancing early childhood development must encompass diverse environments[22,26,27].

For preschool children, play is one of the main activities that they engage daily. For this reason, the expert panel developed a play-based intervention to promote optimal development in children. This intervention was not aimed solely at children but was designed to involve parental participation.

According to Ackermann et al.[28], a play of good quality must have, among other characteristics, the process which (a) not necessarily involve any product, (b) need motivation, (c) it is about alternate possibilities, leading to imagination, creativity, and innovation, (d) it is important to had some reflections about the sharing of feelings and relationships, (e) take advantage of the previous experiences, (f) help in real life activities, (g) could be individual or in group, and (h) had an integrative mechanism that binds together all that we learn, know, feel, and share. Those characteristics were taken in consideration while planning the activities, and for that reason the involvement of the family, the environmental materials and having an opportunity for feedback was a crucial elements of this intervention.

To determine the effectiveness of this intervention, it was deemed important to include children with some degree of neurodevelopmental impairment when planning this study. Therefore, as shown in the results, the proportion of children classified as green, yellow, and red is approximately similar, since the children were selected through a convenience sampling process. This point needs to be addressed because, in middle- and low-income countries, the prevalence of developmental disorders has been reported to be over 40%[7,9]; in this study, 70% of the participants had some developmental delay, this figure should not be interpreted as the real prevalence of this type of condition.

According to ENSANUT 2022, national wide related to children < 5 years old, only 27.1% of children had at least one developmental screening. From those children whose mothers knew the result 96.3% has normal result, 1.8% mild risk of delay and 1.9% high risk of delay the primary caregivers 59.4% and 57.3% received counseling at health children visit in primary care about play and physical activity or early stimulation, respectively[10]. It reinforces not only the importance of conducting child development evaluation but also to increase the awareness of play as a crucial element for promoting adequate development.

The results obtained from the study suggest that a play-based intervention appears to be effective not only in improving neurodevelopment but also in maintaining its normal level. These findings are consistent with those of the literature, which demonstrates that play fosters the development of executive functions and strengthens the relationship between parents and children[14,21].

Although most participants improved, it is worth noting that 27 of the 103 children who were in the red at baseline remained in this category until the end of follow-up. It is likely that these participants did not improve due to underlying causes, such as intellectual disability, or a specific language development disorder. These organic factors are not amenable to modification by the study intervention. These participants were contacted in a timely manner for further diagnosis and treatment. As is specified in the Mexican normativity[24], all the children with red result, abnormal neurological examination, and alarm signs should be referred as soon as identified for further attention, and the activities conducted in this study could be complimentary but not exclude that mandatory action.

Another aspect to comment on is that in the 3-month evaluation, the number of cases classified as yellow increased. This increase was partly due to approximately 30% of those classified as green at baseline moving to the yellow category. When reviewing each of these cases, we noticed that the score dropped because the EDI was used for different age groups in the first and second assessments. Therefore, the second score does not reflect a delay. As shown in the results, by the third assessment, practically all were classified as normal, using the same EDI. This is important because the intervention shows better results when lengths 6 months and the intermediate results should be evaluated with caution.

Despite the encouraging results, we must consider the study's limitations. The study design was not a randomized clinical trial, so it cannot be assured that the increase in the EDI score was due only to the effect of the intervention, since there was no control group. Another limitation that has already been mentioned is that the case selection process was biased, so the findings cannot be extrapolated to the entire population. In addition, the EDI was administered by the same psychologists who provided the intervention; ideally, a different person (blinded) should have conducted the evaluation. All the above suggests the need for more studies with better design to determine the true effect of this intervention. Likewise, it would be important to identify which domains of development are improved specifically, beyond the global evaluation.

Conclusion

The results of this study confirm that a play-based intervention seems to be effective in promoting child development and that these strategies should involve parents in the dynamics of care and promotion of good health. In the future, it is important to conduct studies to adequately assess its efficacy.

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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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RESEARCH ARTICLE

Parental knowledge and caregiving practices related to early childhood development

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Abstract

Background: *Early childhood development (ECD) is a critical period for achieving milestones in cognitive, motor, and socioemotional development. Parental knowledge of ECD influences the manner in which children are stimulated, as evidenced in previous studies, particularly in developing countries. This study examined parents' understanding of ECD, their stimulation and caregiving practices, and the sources of information that they utilize in the Mexican context.* **Methods:** *A descriptive cross-sectional field study was conducted using a questionnaire validated by a panel of experts and a pilot test. A total of 536 mothers and fathers from socioeconomic levels C–, D+, and D/E residing in three Mexican cities were surveyed using non-probability convenience sampling. The questionnaire inquired about respondents' knowledge, stimulation practices, and sources of information related to ECD.* **Results:** *In all, 60% of the surveyed parents did not consider the first 3 years of life as a relevant learning stage. Although 44.3% of mothers and 37.6% of fathers identified early learning (at 0-3 months), few socioemotional activities were considered relevant. Only 33% were familiar with the term "early stimulation," and television was the most consulted medium (30%).* **Conclusions:** *It is necessary to raise awareness among parents about the importance of play, as well as socioemotional and communicative activities in ECD. The quality of information disseminated through mass media should be improved and public policies to strengthen parental education should be promoted.*

Keywords: *Early childhood development. Early stimulation. Early education. Parenthood.*

Conocimiento parental y prácticas de crianza relacionadas con el desarrollo infantil temprano

Resumen

Introducción: *El desarrollo infantil temprano (DIT) es de crucial para alcanzar los hitos en el desarrollo cognitivo, motor y socioemocional. El conocimiento parental sobre el DIT influye en las formas en que se estimula a los niños, y estudios previos ha evidenciado estas brechas, especialmente en países en desarrollo. Este estudio examinó el conocimiento de los padres sobre el DIT, sus prácticas de estimulación y cuidado, y las fuentes de información consultadas, en un contexto mexicano.* **Métodos:** *Se realizó un estudio de campo transversal descriptivo mediante un cuestionario validado por expertos y una prueba piloto. Se encuestó a 536 padres y madres de niveles socioeconómicos C–, D+ y D/E en tres ciudades mexicanas, usando muestreo no probabilístico por conveniencia. El cuestionario indagó sobre los conocimientos, prácticas de estimulación y las fuentes de información relacionadas con DIT.*

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Resultados: *El 60% de los padres encuestados no consideró los primeros tres años de vida como relevantes para el aprendizaje. Aunque el 44.3% de las madres y el 37.6% de los padres identificaron el aprendizaje temprano (0-3 meses), pocas actividades socioemocionales se consideraron como relevantes. Solo el 33% conocía el término "estimulación temprana," y la televisión fue el medio más consultado (30%).* **Conclusiones:** *Se requiere sensibilizar a los padres sobre la importancia del juego y las actividades socioemocionales y comunicativas en el DIT. Es necesario mejorar la calidad de información en medios masivos y promover políticas públicas para fortalecer la educación parental.*

Palabras clave: *Desarrollo infantil temprano. Estimulación temprana. Educación inicial. Parentalidad.*

Introduction

Early childhood development (ECD) is a process of change in which children learn to master increasingly complex levels of movement, thought, feelings, and relationships with other people; this process occurs when children interact with their biophysical and social environment[1]. During the first 5 years of life, 90% of neuronal circuits are formed, including those involved in sensory, cognitive, and linguistic functions. This period is therefore critical for the subsequent development of the individual[2].

A parent's understanding of ECD exerts a profound influence on their parenting practices and, consequently, on the developmental outcomes of their children[3,4]. Several risk factors have been identified as being detrimental to childhood development, with primary risk factors including poverty, malnutrition, health problems, and an under-stimulating environment[5-7]. The recognition of this problem has led to the creation of programs that encourage social interactions and responses so that successful attachment can be established between parents and their children[8]. Thus, in recent years, different studies have focused on the concept of parental cognition to integrate their values, beliefs, goals, and knowledge of childhood development and educational practices[3,9,10].

Previous studies have revealed significant gaps in parents' understanding of ECD. For example, many caregivers do not know when children begin to interact with their environment or mistakenly assume that long-term memory is established after 6 months of age. This creates the false notion that if young children are exposed to violence, they will not experience repercussions[11]. This absence of relevant knowledge can negatively impact parenting practices. Caregivers may fail to recognize the significance of early stimuli and adverse experiences, which can affect their children's cognitive, emotional, and social development. These findings have primarily been observed in developed countries; however, data from developing countries are limited. Therefore, it is imperative to assess the extent of this knowledge in the Mexican population to generate culturally relevant data.

This study examined the extent of parents' knowledge regarding ECD in a developing country, the practices they implement to stimulate this development, and the primary sources of information they utilize to acquire this knowledge.

Methods

To achieve the objective of this research, it was conducted in two stages. In the first stage, the questionnaire was developed and validated. In the second stage, parents' knowledge of ECD was examined.

Stage I

Some tools that were previously developed and validated in other countries[8,12-14] do not fit our population for sociocultural reasons; hence, it was considered necessary to develop a new culturally relevant questionnaire.

This questionnaire was designed to explore parents' knowledge of childhood development during the first 3 years of life. It also aimed to identify the stimulation practices that parents use with their children and their sources of information regarding their children's development.

A group of 10 experts developed the questionnaire. This group constituted members of both civil associations and public health institutions, including psychologists, pediatricians, and pediatric neurologists with expertise in ECD. This group of experts developed a first version of the questionnaire, which was validated by a panel; the experts reviewed each question in terms of clarity, relevance, and content. Following a deliberative process aimed at reaching a consensus, adjustments were implemented to address the identified discrepancies. These adjustments were deemed necessary to ensure the questionnaire's capacity to accurately represent the dimensions under investigation. Following this, a pilot test was conducted with a group of 15 mothers and fathers of children under 3 years old. The test was conducted at the

Table 1. Example of question types and questionnaire response forms

Dimension	Sample question	Type of question	Type of response
Demographic data	What is the highest level of education you have completed?	Closed-ended	Predefined options (elementary, middle school, high school, etc.)
	How old are you?	Open-ended	Numerical response
Parents' profile	How old were you when you had your first child?	Open-ended	Numerical response
	How many children do you have?	Closed-ended	Predefined options
Parental knowledge	When do you think children begin learning?	Open-ended	Open response
	What would you say are the main things children learn between 0 and 3 years of age?	Open-ended	Responses coded according to categories: motor, cognitive, language, etc.
Relationship with the child	How often do you perform the following activities with your child (e.g., singing, dancing, talking, etc.)?	Likert-type scale	Very often, Somewhat often, Regularly, Not often, or Never.
Sources of information	When you have doubts or need information about your child's care, what do you do?	Closed-ended (multiple)	Yes/No for options such as doctor, internet, family, books, etc.

neurodevelopmental research unit of the "Hospital Infantil de México Federico Gómez" to verify that the questions were comprehensible.

After the pilot test, the group of experts adjusted the questions based on the feedback received from the parents, thus achieving a final version of the questionnaire by unanimous consensus of the panel.

The subsequent stage delineates the structure of the questionnaire, including its final characteristics, implementation modalities, and the results obtained. Table 1 shows an example of the types of questions and the response formats used in each section of the questionnaire.

Stage II

A descriptive cross-sectional field study was conducted. The sample size was determined based on a 95% confidence interval for proportion; it included a standard error of 4.22%, which determined the need for 541 parents to be interviewed. A non-probability convenience sample was used to select the participants.

Data collection was conducted between September 11 and 18, 2015, using a traditional field survey method. The face-to-face surveys were conducted by trained staff using tablets in high-inflow areas such as parks, shopping malls, markets, hospitals, and health centers in Mexico City, Guadalajara, and Monterrey.

Table 2. Demographic characteristics of the surveyed fathers and mothers

Characteristics	Parents surveyed	
	n = 536	(%)
Location		
Mexico city	215	(40.1)
Guadalajara	162	(30.2)
Monterrey	159	(29.7)
Socioeconomic level		
D–	160	(29.9)
D+	218	(40.7)
C	158	(29.5)
Age (years) at the time of the interview		
< 20	116	(21.6)
21-30	280	(52.2)
31-40	127	(23.7)
> 40	13	(2.4)
Educational level		
Primary school	37	(6.9)
Secondary school	322	(60.1)
High school or higher	177	(33.0)
Occupation		
Studying/working	219	(40.9)
Home	308	(57.5)
Unemployed	9	(1.7)
No. of children		
1	316	(59.0)
2	142	(26.5)
≥ 3	78	(14.6)
Gender of respondent		
Male	165	(30.8)
Female	371	(69.2)

Table 3. Responsible for childcare according to child's age group

Study question	Age of youngest child (months)							
	0-12		13-24		> 24		Total	
	n = 184		n = 171		n = 181		n = 536	
Total	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Sex of youngest child								
Female	96	52.2	83	48.5	87	48.1	266	49.6
Male	88	47.8	88	51.5	94	51.9	270	50.4
Who takes care of the child?								
Mother	157	85.3	141	82.5	152	84.0	450	84.0
Father	16	8.7	14	8.2	10	5.5	40	7.5
Other	11	6.0	16	9.4	19	10.5	46	8.6
Who bathes the child?								
Mother	162	88.0	149	87.1	159	87.8	470	87.7
Father	14	7.6	14	8.2	8	4.4	35	6.5
Other	8	4.3	16	9.4	14	7.7	31	5.8
Who changes the child?								
Mother	155	84.2	145	84.8	161	89.0	461	86.0
Father	17	9.2	15	8.8	9	5.0	41	7.6
Other	12	6.5	11	6.4	11	6.1	34	6.3
Who feeds the child?								
Mother	156	84.8	143	83.6	157	86.7	456	85.1
Father	16	8.7	14	8.2	10	5.5	40	7.5
Other	12	6.5	14	8.2	14	7.7	40	7.5

Table 4. Period in which parents believe that an infant's learning begins

Period	%	n
During pregnancy	5.4	29
From birth	24.1	129
From 1 to 3 months	18.1	97
From 4 to 6 months	12.1	65
From 7 to 12 months	25.7	138
From 12 to 24 months	6.5	35
> 36 months	2.6	14
When they can speak	0.9	5
When they can walk	1.3	7
When they begin to go to school	2.8	15
Do not know	0.4	2
Total	100	536

Mothers and fathers with children under 3 years of age were interviewed. They had socioeconomic levels of C– (monthly income between $13,500 and $23,000 MXN), D+ (between $7,500 and $13,500 MXN), and D/E (< $7,500 MXN) and were available to participate in a face-to-face survey that lasted approximately 30-40 min. The socioeconomic classification of the participants was determined using the system of the "Asociación Mexicana de Agencias de Investigación de Mercado y Opinión Pública" (AMAI)[15]. These socioeconomic levels were considered because they represent 87% of family households in Mexico according to the "Encuesta Nacional de Ocupación y Empleo" (ENOE)[16].

On contacting the participants, the surveyors identified themselves as members of a survey-conducting specialized agency. They explained the general objectives of the study, highlighted the importance of the respondents' answers, and informed them that their participation was voluntary, without any personal data collected, there were no retribution for participation, and that the approximate duration of the survey would be 30-40 min focused on questions about their parenthood. Furthermore, they guaranteed the confidentiality of participant information through a privacy notice and informed them about data handling. Finally, they requested verbal consent from the participants before starting the survey. No personal information or sensitive personal data were collected, and all data were anonymized since the first data collection.

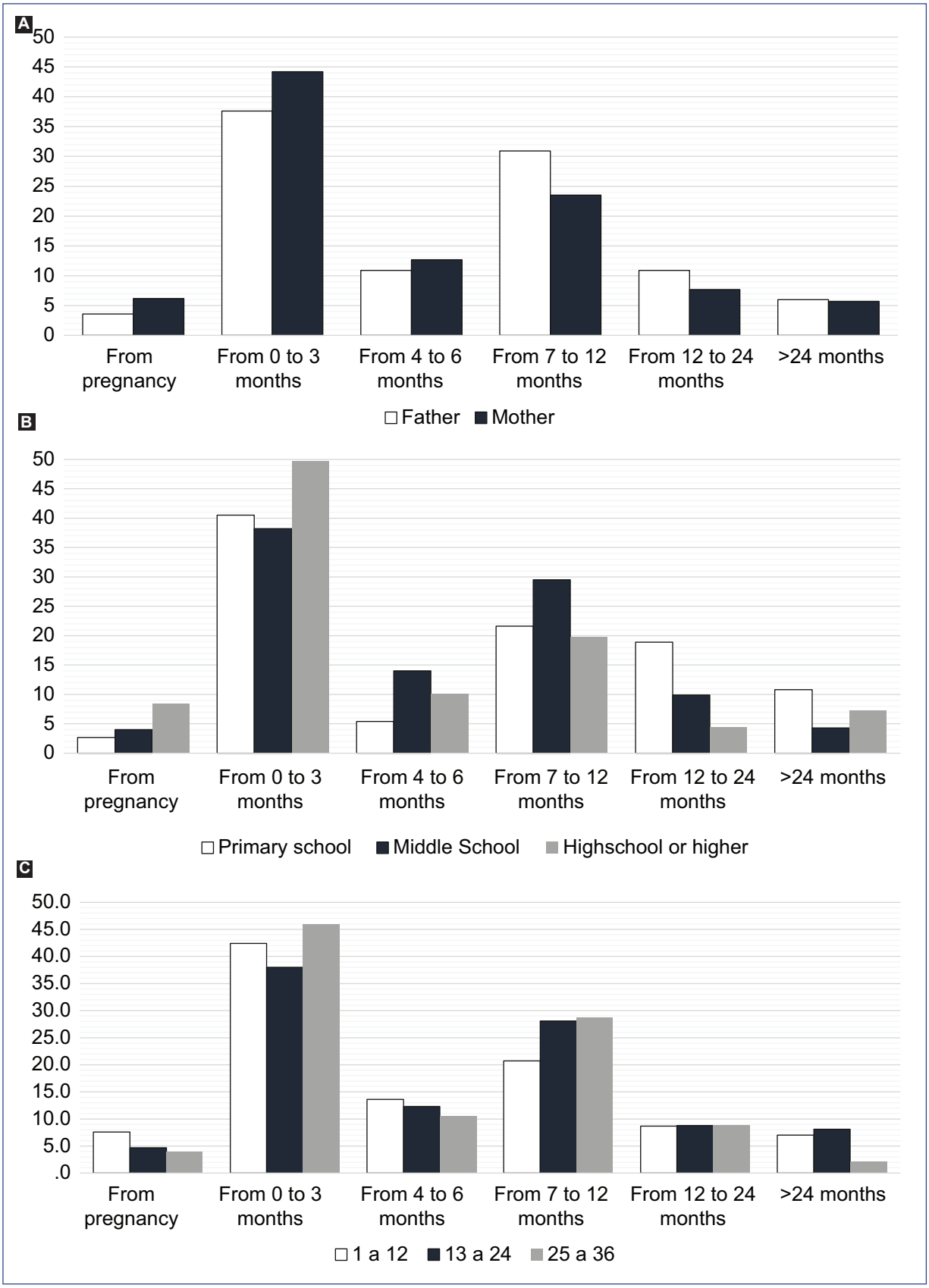

Figure 1. Parents' responses to the question "at what age do children start learning?." **A:** comparison by sex of those interviewed. **B:** comparison by academic level of those interviewed. **C:** comparison by age group of the youngest child.

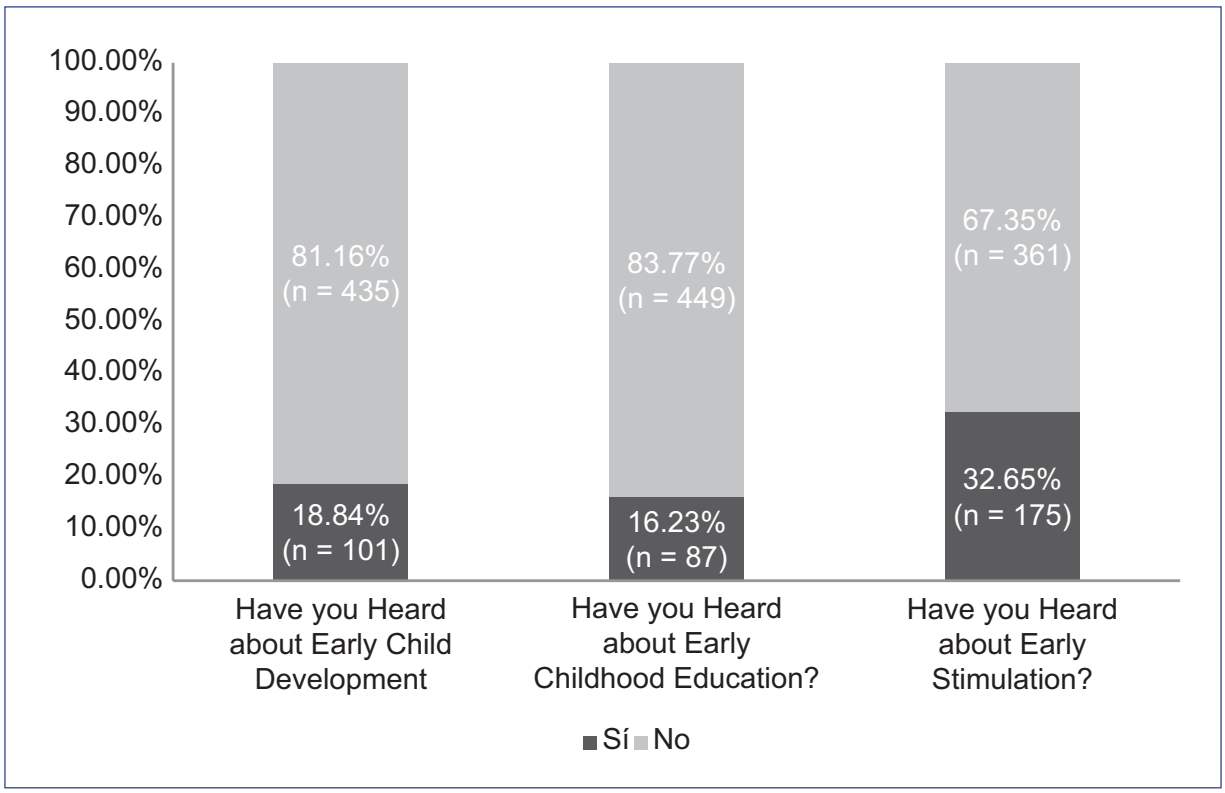

Figure 2. Parents' knowledge of terms related to early childhood development (n = 536 respondents). Percentage of parents who have heard about early childhood development, early education, and early stimulation.

Instrument

The questionnaire comprised three sections, each containing different types of questions. Open-ended questions were used to explore parents' perceptions and knowledge, and closed-ended questions were employed to collect structured information; Likert-type scales were used to measure frequencies. Table 1 summarizes the types of questions and response formats used in each section of the questionnaire.

The first section collected general information through 15 questions designed to obtain sociodemographic data such as age, gender, place of origin, socioeconomic status, number of children, and their ages.

The second section aimed to explore parents' knowledge of ECD and their caregiving practices. It included 10 questions, both structured and open-ended. Multiple-choice questions were employed to identify children's main caregiver as well as the person in charge of looking after the children in terms of bathing, feeding, and diaper changing. In addition, one of the questions concerned how many hours a day the participants spent taking care of their children. Open-ended questions were used to investigate parents' perceptions of the age at which children begin to learn and what they consider to be the first thing they learn.

Thereafter, participants were shown a series of prepared cards with 16 activities that parents perform on a daily basis with their children, such as singing, dancing, talking, playing, hugging, and going to the park. Participants were asked to rank these activities by importance and to indicate which ones they considered the most important. Based on these answers, the researchers grouped the activities into different developmental domains, such as adaptive, socioemotional, motor, communication, and cognitive. Finally, participants were shown a list of specific activities, adjusted according to their child's age group (0-12 months, 13-24 months, and 25-36 months), and they were asked to evaluate the frequency with which they performed each action using a five-point scale: very often, somewhat often, regularly, not often, or never.

The third section focused on the sources of information used by parents to care for their baby. Three

Table 5. Distribution of activities by developmental area that parents consider to be the first and the most important thing that babies learn

Development area	Activity	The baby learns it first		It is the most important thing the baby learns	
		%	n	%	n
Adaptive	Suction	1.5	8	2.2	12
	Breast/bottle feeding	3.2	17	0.9	5
	Asking for food	5.2	28	3.4	18
	Eating	17.9	96	17.2	94
	Sphincter control	0.6	3	2.1	12
Cognitive	Identifying things	1.1	6	2.1	12
Communication	Crying	9.7	52	3.2	18
	Babbling	5.8	31	1.1	6
	Identifying voices	2.8	15	0.6	3
	Simple words	6.3	34	3	17
	Speaking	8	43	16.8	98
	Listening	3	16	0.6	3
	Imitating words	0.6	3	1.9	10
Motor	Sitting	1.9	10	1.3	7
	Crawling	4.3	23	5	29
	Walking	4.5	24	22.4	130
	Head support	1.1	6	0.9	5
	Grasping objects	0.9	6	1.1	6
Not learned	Breathing	1.3	7	0.4	2
	Seeing	2.1	11	0	0
	Moving	1.1	6	0.4	2
Personal-social	Laughing	2.6	14	1.7	10
	Identifying people	6	32	3.4	20
	Playing	1.3	7	1.9	11
	Other activities	7.2	38	6.4	6
Total		100	536	100	536

questions were included to identify whom parents turn to when in doubt about their child's development, with options including doctor, relatives, friends, professional journals, and the internet. Multiple-choice questions were used to determine which media parents considered most appropriate and the extent of their perceived credibility. Finally, the questionnaire explored whether parents were familiar with the terms "early childhood development," "early education," and "early stimulation." For this, open-ended questions were used to inquire more deeply into participants' knowledge of these concepts.

Analysis of results

A descriptive analysis was performed with absolute frequencies and percentages for sociodemographic characteristics, as well as for responses related to care practices, activities, and sources of information. The statistical software package SPSS version 25 was used.

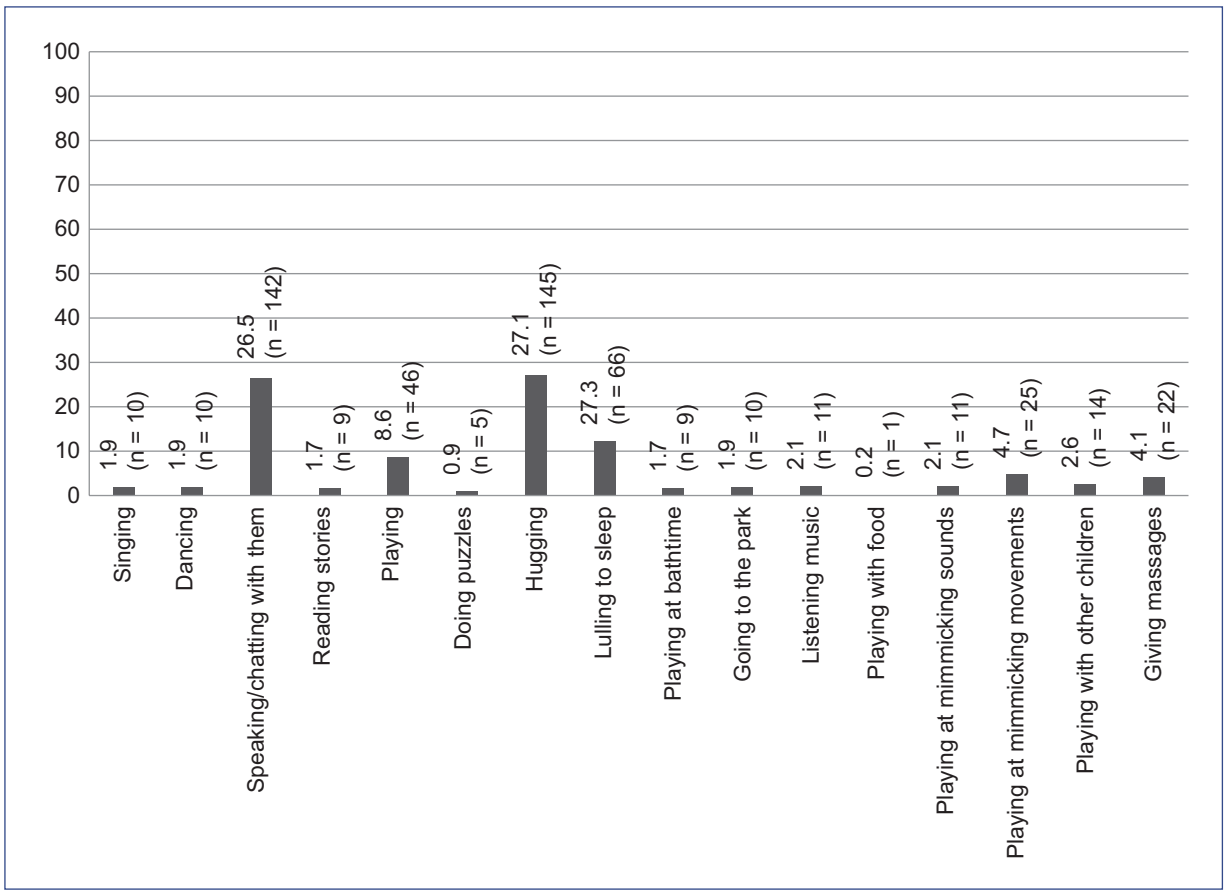

Figure 3. Activities that parents consider most important for early childhood development. n = 536 respondents.

Results

The study included 541 questionnaires, of which five were excluded from the results because they contained errors in data collection. Table 2 shows the demographic characteristics of the respondents. The most represented age group was 21-30 years (52.2%, n = 280), followed by 31-40 years (23.7%, n = 127). Most participants were female (n = 371; 69%). Furthermore, 59% (n = 316) reported having only one child at home, and 70.6% (n = 378) belonged to socioeconomic levels D+ or D–. The highest level of education for 322 respondents (61%) was secondary school.

Table 3 shows children's caregivers according to the child's age group. For all age groups, regardless of the sex of the children, it was found that the mother was the primary caregiver and was in charge of most of the activities related to childcare, with a percentage between 82.5% (n = 141) and 89% (n = 161).

In addition to the sociodemographic characteristics, this study focused on three main objectives: analyzing parents' knowledge of ECD, exploring the practices they use to stimulate such development, and examining the sources of information they use to obtain knowledge related to ECD. The results are shown below, organized according to these objectives.

Parents' knowledge of ECD: The results showed that 25.7% (n = 138) of the interviewees indicated that their children began learning between 7 and 12 months of age (Fig. 1). Furthermore, 24.1% (n = 129) of the respondents considered that their children began learning from the moment that they were born. A smaller percentage of respondents, 5.4% (n = 29) indicated the onset of learning occurs in the prenatal period (Table 4).

Regarding parents' knowledge of ECD, we found that only 32.65% (n = 175) of the respondents had heard of early stimulation, 18.84% (n = 101) had heard of ECD, and only 16.23% (n = 87) of respondents had heard about early education (Fig. 2).

Practices performed by parents to stimulate childhood development: According to 27.8% of respondents, skills from the adaptive domain of development were the first things that their children learned. Of these skills, "eating"

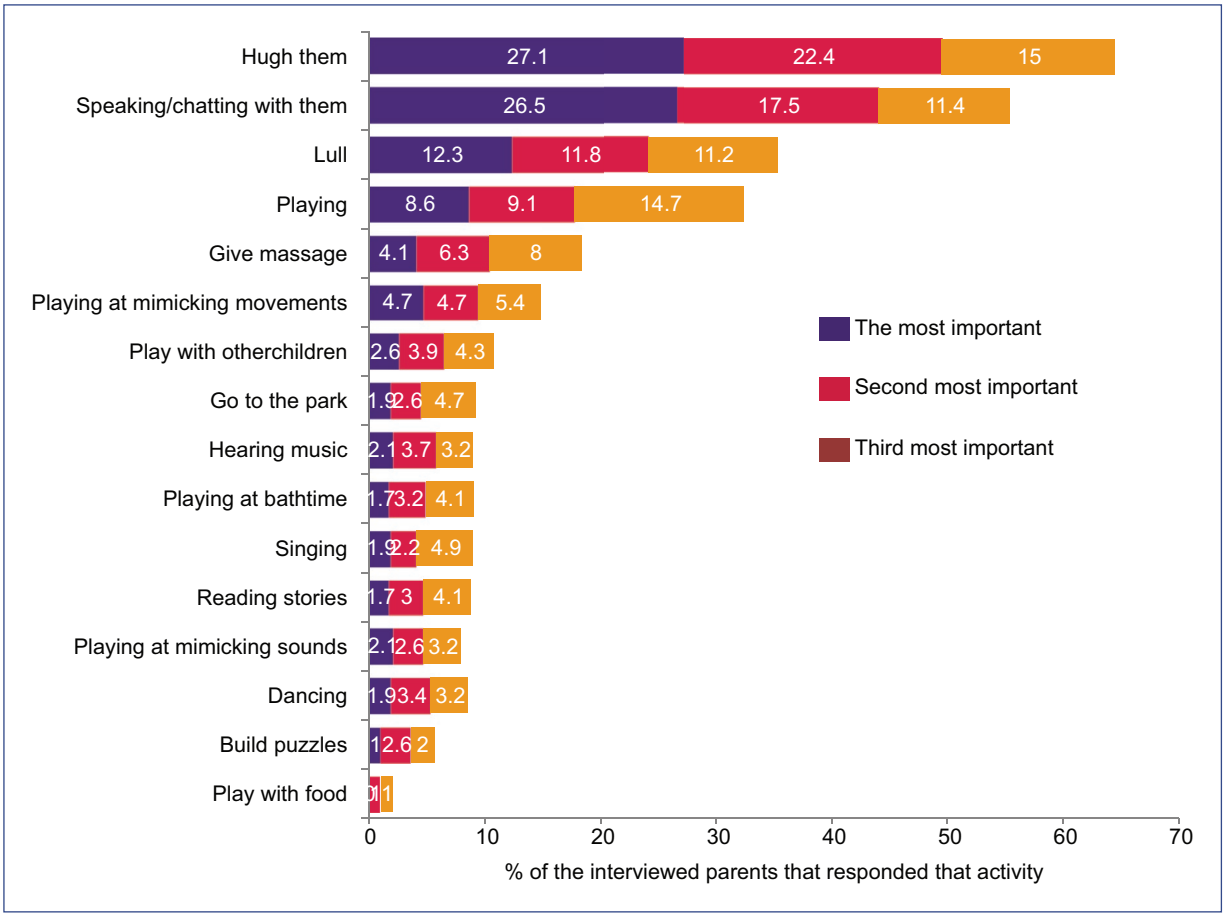

Figure 4. Percentage distribution of the importance given by parents to activities that can be performed in the initial years of life.

was the most frequently mentioned (17.9%). When asked about the most important thing to learn in the first 3 years of life, participants mentioned the motor domain most frequently, with "walking" being the most commonly mentioned skill (22.4%); others indicated "eating" (as part of the adaptive domain; 17.2%) and "speaking" (as part of the communication domain; 16.8%) (Table 5).

When parents were asked about the most important activities they perform with their children, 27.1% (n = 145) mentioned "hugging" and 26.5% (n = 142) "talking" (Figs. 3 and 4).

When asked about the source of information they considered most appropriate for obtaining information regarding childhood development, 30% (n = 161) of respondents indicated television, followed by school or daycare (19.3%, n = 103) and the internet (15.7%, n = 84). However, 16.8% (n = 90) of respondents considered television as the least suitable media to obtain information about ECD, followed by work (14.9%, n = 80) and radio (15.7%, n = 84) (Fig. 5).

Discussion

This study provides culturally relevant data as it is to our knowledge of the few studies in Mexico that examines parents' knowledge of ECD. The results of this study indicate that 60% of parents do not consider the first 3 years of life to be a sufficiently significant stage of learning or development. This finding matches what was reported by Ertem et al. in Turkish mothers, who are unaware that behaviors such as vocalizations and social smiling, as well as brain development in general, occur early in life[8].

Different studies have reported that parents' understanding of the moment when children begin to learn has important implications. On the one hand, if parents consider that skills are acquired later, they may not sufficiently stimulate their children or detect delays in development, which may have a negative impact[8]. On the other hand, if they consider that skills should be acquired earlier than expected, this could lead to

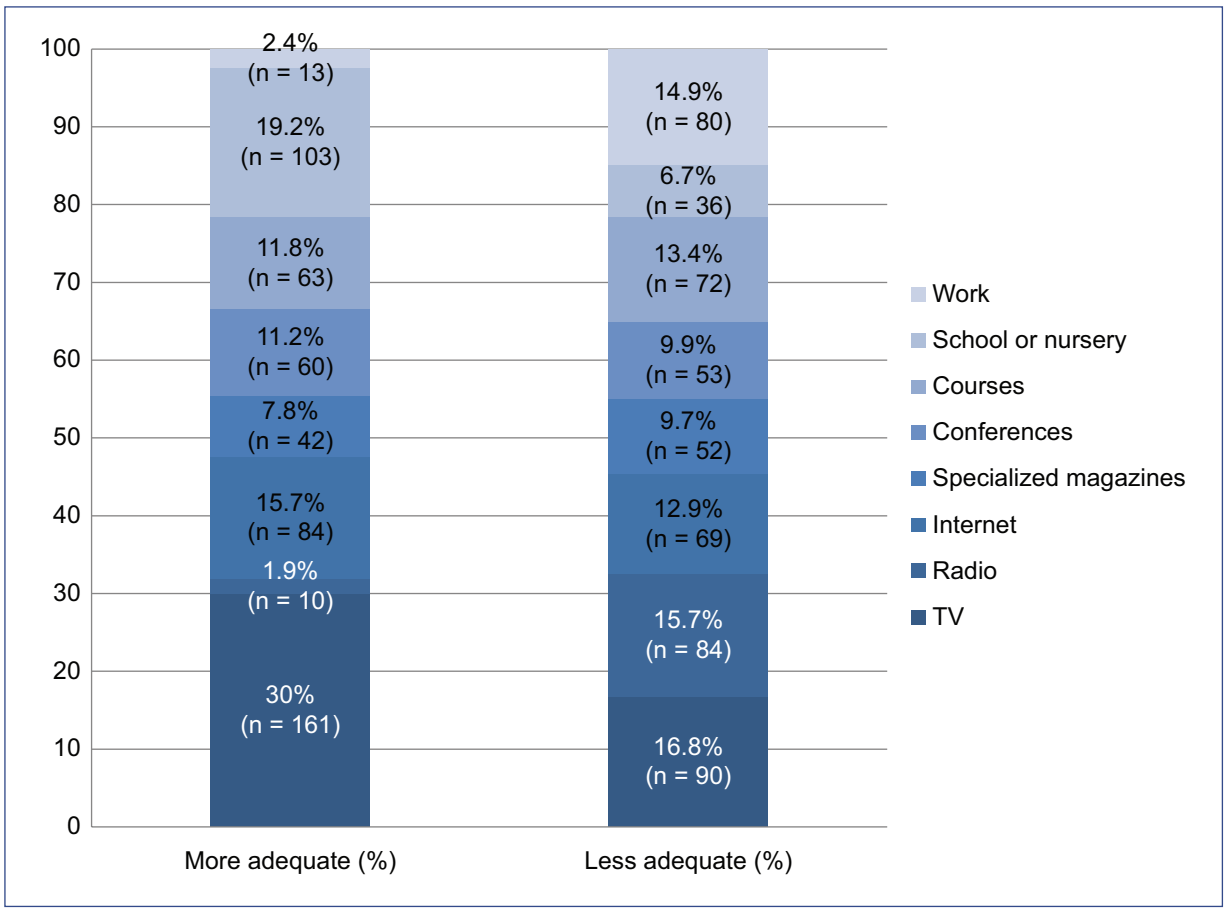

Figure 5. Parents' perceptions of the most and least appropriate media to search for information on early childhood development (ECD) (n = 536). Percentages of parents' responses regarding the means they consider most appropriate and least appropriate for obtaining information about ECD.

unrealistic expectations and reduced toleration of the child's behaviors, which are risk factors for negative parenting practices such as abuse[17,18].

In addition, only 33% of respondents had heard about early stimulation, 19% about ECD, and 16% about early education, which indicates a lack of access to accurate information regarding these concepts. This may limit parents' ability to implement informed practices for the care and development of their children.

It was found that the activities parents perform to stimulate their children's development do not necessarily match with the domains that they consider most important in childhood development. For example, only 11% of parents who responded that hugging their children is an important activity for development consider that the socioemotional domain is important in children's learning. Activities such as lulling the child to sleep or massaging them were identified as being only 12% and 0% important, respectively, in the socioemotional domain. Thus, although parents frequently performed activities that correspond to the socioemotional domain, they did not identify these activities as essential for children's learning.

Similarly, the participating parents identified "eating" (17.9%), "walking" (22.4%), and "talking" (16.8%) as the most significant skills during the initial years of life. This reflects a greater valuation of motor and adaptive skills, whereas communication and socioemotional skills, although practiced, are not recognized as a priority.

This disconnection between what parents do and the impact it has on ECD indicates the need to sensitize parents about the importance of their actions. In particular, the findings highlight the need to communicate the importance of attachment and affection, as well as that of playing and performing communicative activities, which are valuable means of learning and for ECD.

Regarding parents' sources of information, it was found that parents' information was based on beliefs and ideas shared by family and friends, which was

normally incomplete and/or incorrect; this finding matches with the results of similar studies[8,11,12,15]. In our study, 30% of respondents indicated that television was their main primary source of information for topics related to ECD; however, 16.8% of responders also considered it to be the least appropriate source, which shows an ambivalent perception of its usefulness and reliability. Furthermore, options such as conferences, courses, and specialized journals were rarely selected as suitable media, which could reflect low accessibility to or knowledge about these alternatives. It is very important to evaluate the type of information that is provided by a source and implement strategies to improve its quality to allow for the proper use of mass media; according to Dichtelmiller and colleagues, differences in development of up to one standard deviation can be found among children of parents with better knowledge regarding ECD[19].

Mexico has witnessed a substantial surge in investment directed toward ECD over the past decade, along with the emergence of initiatives tailored to the most disadvantaged segments of society[20]. However, it is imperative to implement and strengthen early education and childhood development programs, taking into consideration the findings of Heckman and colleagues; from a macroeconomic perspective, for every dollar invested in ECD, three to seven dollars are recovered[21-23]. Consequently, there is a compelling need to enhance the training of primary care health professionals and pediatricians in the area of ECD. This enhancement is crucial for facilitating the timely detection of developmental delays and improving the quality of information provided to parents.

Although fathers are increasingly involved in parenting, mothers remain the main caregivers and the ones most responsible for infants. According to figures from the "Instituto Nacional de Estadística y Geografía" (INEGI), between 2010 and 2015, the number of female heads of household increased by 1.4%, now representing 27% of Mexican families[24,25]. This indicates a change in the social paradigm; therefore, in future years, we will see a greater number of fathers involved in parenting activities. It is interesting to highlight that while a negative correlation has been found between maternal employment and development[26,27], the factors involved lie in the time that mothers spend with their children; however, additional research suggests that this effect can be counteracted if fathers invest additional time in parenting[28]. Moreover, paternal involvement in parenting benefits the neurocognitive development of children[29-34].

The study has important limitations. First, it uses a non-probability convenience sampling, which limits the ability to generalize the findings to other populations, especially in rural contexts or for individuals at higher socioeconomic levels.

Another limitation is the inherent subjectivity of self-reported responses, which may be influenced by cultural bias, social desirability, or misinterpretation of the questions. Finally, although the sample size was adequate for the descriptive analyses, it was insufficient to perform more complex analyses or to detect significant differences in subgroups. Another important limitation is that the survey was conducted some years ago, although there were no recent publications about these topics, and it could serve as a baseline or comparison for further studies.

Despite these limitations, the study provides a basis for future directions of research and intervention programs by specifying areas that require attention, such as raising awareness among parents concerning the importance of activities related to socioemotional and communicative development, as well as reviewing the quality of mass media information sources.

Conclusion

The findings of this study indicate that in the sample surveyed six of ten parents pay inadequate attention to their child's developmental progress during the initial 3 years of life in some ways. This observation indicates their potential oversight of this period as a stage of significant learning and child development, and the need for massive media campaigns focused on parents about the awareness of the crucial importance of the 1st years of life.

The socioemotional dimension is practiced spontaneously, especially by mothers, but it is not valued as a means of learning and knowledge. This notion extends to the domain of play, underscoring the significance of effective communication and the cultivation of awareness concerning the pivotal role of affective relationships and games in educational and learning contexts. This finding could help in the planning of ECD campaigns reinforcing the idea of the bonding, attachment and interaction to be crucial, where there is no need for expensive things to promote development because the most valuables activities to promote development are given naturally through the interaction with the child.

Considering the perceived lack of information that the most vulnerable families in our country have on ECD topics, it is necessary to establish public policy aimed at educating parents in addition to the policies already in place focused on detecting and handling developmental disorders.

Although fathers are increasingly involved in parenting, mothers are still clearly the main caregivers, underscoring the necessity for emphasizing the importance of co-parenting.

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REVIEW ARTICLE

Developmental and behavioral pediatrics service: comprehensive early childhood care in Mexico

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Abstract

Developmental pediatrics (DP) in Mexico has taken a crucial step forward in the creation of the Developmental and Behavioral Pediatrics Service (SPDC, for its acronym in Spanish) at Hospital Infantil de México Federico Gómez (HIMFG). The SPDC is a leading area in early detection and intervention in neurodevelopmental problems and contributes to children's well-being. Among its achievements are the development and implementation of the Child Development Evaluation Test, which has been validated for children under 6 years old, and of a free virtual training program for medical personnel that is supported by an interactive platform. Furthermore, the SPDC is the only center in Mexico to offer a postgraduate degree in DP. With a fair and evidence-based approach, the SPDC contributes to the strengthening of public policy, research, and comprehensive care to ensure children's development.

Keywords: *Developmental pediatrics. Child development. Screening test. Early interventions.*

Servicio de pediatría del desarrollo y la conducta: atención integral para la primera infancia en México

Resumen

La Pediatría del Desarrollo en México ha dado un paso crucial con la creación del Servicio de Pediatría del Desarrollo y la Conducta (SPDC) del Hospital Infantil de México Federico Gómez (HIMFG). Este servicio es líder en la detección temprana e intervención en problemas del neurodesarrollo, contribuyendo al bienestar de la infancia. Entre sus logros, destaca la implementación de la Prueba de Evaluación del Desarrollo Infantil, validada para menores de seis años; un programa de capacitación virtual gratuita para personal médico, apoyado en una plataforma interactiva y ser la única sede en México del posgrado de alta especialidad en Pediatría del Desarrollo. Con un enfoque equitativo y basado en evidencia científica, el SPDC contribuye al fortalecimiento de políticas públicas, investigación y atención integral para garantizar el desarrollo infantil.

Palabras clave: *Pediatría del Desarrollo. Desarrollo Infantil. Prueba de tamizaje. Intervenciones tempranas.*

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Introduction

In Mexico, attention to development in children under 5 years old is regulated by NOM-031-SSA2-1999, and section 9.6.1 of this regulation established the evaluation of psychomotor development during well-child visits, based on the behaviors defined in Appendix F[1]. However, this standard lacks validated parameters in terms of sensitivity and specificity, which limits its diagnostic utility and generates discrepancies in the comprehensive assessment of children's physical, cognitive, social, and emotional development. Proxy indicators, such as enrollment in childcare or preschool education programs, were often used instead of standardized and validated tools[2]. In 2011, a research group at the HIMFG was invited to validate a child development screening and the subsequent development of the modified version of the instrument, known since 2012 as Child Development Evaluation (CDE) Test (or Prueba EDI in Spanish).

In response to the limitations in the early detection and intervention of alterations in child development across the primary care in the Country, on October 15, 2012, the HIMFG, a National Institute of Health, created the Neurodevelopmental Research Unit (UIN for its acronym in Spanish). Although without a physical area inside the institution, the UIN in 2013 was iresponsible for the development of the Model of Promotion and Care of Child Development (PRADI, for its acronym in Spanish). This model was designed to strengthen the Rules of Operation of the PROSPERA program (conditional cash transfer program for families in poverty across the country). Its implementation included two fundamental components: (a) the timely detection of and attention to child development problems and (b) community education that was intended to promote the active participation of the beneficiary families of the Social Inclusion Program[3].

For the operation of the early detection of developmental problems, based on the CDE test, the UIN was committed to develop a series of manuals validated by a panel of experts, representing a key tool for the early detection of neurodevelopmental disorders ranging from the manual of application, facilitator manual, and a manual for the actions required when a child were identified at risk of delay in his or her development[4-6], together with close collaborations with each of the 32 states from the Country, helping them with training in CDE test application, meetings for the reference, and implementation of the path of attention in primary care. This standardized approach facilitated the timely identification of children at risk, providing a critical window for the early intervention and personalized counseling[7].

Due to its flexibility, efficiency, low cost, and minimal susceptibility to bias, the CDE test is considered the most appropriate instrument for assessing the Mexican child population aged 0-5 years old, becoming a central element of the Child Development Public Strategy since 2012[5].

First neurodevelopmental research unit in Mexico

May 14, 2014, marked a milestone in child development care in Mexico, with the inauguration of the Neurodevelopmental Research Unit (UIN) facilities at HIMFG. This project, carried out in collaboration with the Ministry of Health and organizations in the private sector, was conceived as the first unit of its kind in the country, with a comprehensive approach to the detection, care, and study of neurodevelopmental disorders.

UIN's facilities were provided with high-quality furniture and electronic equipment, optimized for the evaluation and stimulation of children's neurodevelopment. The unit initially had four offices that were equipped for the application of specialized tests, and it currently has seven evaluation areas. In addition, a specific space is included for timely stimulation activities and the evaluation of motor skills and physiotherapy.

Originally, the main objective of the UIN was the early detection of problems related to neurodevelopment through the implementation of scientific evaluation protocols and the design of timely interventions that benefit the child and adolescent population in vulnerable situations, focused on the first level of care and support for implementation in the 32 states.

In addition, this space was proposed and consolidated as a center of excellence for the training of specialists in neurodevelopment, as well as a national reference for the generation of scientific knowledge, promoting applied research concerning the design of public policy and evidence-based intervention strategies. Among the main lines of research developed by the UIN were the following:

– The CDE test, which was designed and validated in Mexico, and today, is a fundamental screening tool for the early detection of developmental disorders in children between 1 month and 6 years of age. Its application provides for the evaluation of the impact of interventions intended to enhance neurodevelopment. In 2023, the National Health and Nutrition Survey (ENSANUT, for its acronym in Spanish) incorporated the percentage of children that had any CDE, strengthening the importance of CDE in primary care, where

in the majority of cases, CDE test is used, marking a significant advance in the population-based assessment of child development by facilitating the timely identification of risks of neurodevelopmental delay in children under 5 years of age[8,9].

– Development of strategies for the training of health personnel in the application of the CDE test was performed using a free access virtual platform. This component took advantage of advances in information and communication technologies to overcome geographic and logistical barriers, allowing for the remote and massive training of health professionals in the management and application of this key tool[10]. The virtual platform offered interactive modules, audiovisual resources, and support materials based on scientific evidence, which facilitated the standardization of evaluation procedures at a national level. It also contributed significantly to the promotion of equity in access to diagnostic tools in marginalized communities, where health infrastructure and specialized human resources are limited.

These lines of research, clinical interventions, and educational strategies have been implemented in collaboration with international and national organizations, such as the United Nations Children's Fund in Mexico and the Fundación Gonzalo Río Arronte, among others. These strategic alliances have strengthened the impact of the model proposed by the UIN, contributing to its sustainability and outreach to highly vulnerable populations.

Developments in comprehensive early childhood care approach

Due to its increased medical assistance activity, on October 1st of 2019, under the management of the Medical Division, the Neurodevelopmental Research Unit changed its name to the "Developmental and Behavioral Pediatrics Service" (Table 1)[11]. It currently acts as a referral center for the care of neurodevelopmental disorders in children and adolescents from Mexico City, the Mexico City metropolitan area, and neighboring states, in addition to inter-hospital consultations from neurology, neurosurgery, internal medicine, rehabilitation, oncology, and genetics departments, among others.

Within HIMFG, as of 2024, together with psychiatry and neurology, the following diagnoses treated in the outpatient department were established:

– Autism spectrum disorder.
– Attention-deficit/hyperactivity disorder.
– Learning disorders.
– Intellectual developmental disorders.
– Sensory processing disorder in children with developmental problems.
– Behavioral disorders.
– Food selectivity.
– Parenting in neurological diseases.
– Loving and sensitive nurturing and care.

Creation of the first postgraduate medical course in developmental pediatrics (DP) in Mexico

The "High Specialty Course" or Fellowship in DP, a medical postgraduate course that has been recognized by the National Autonomous University of Mexico, was launched in 2017, with the HIMFG as its unique venue[12]. This program is comparable in standards and scope to those offered in the United States, Canada, and countries of the Indo-Pacific region, becoming a reference in the training of specialists in this area.

DP, conceived at BPDS is: "*a transdisciplinary branch of pediatrics that is centered on children and adolescents from a comprehensive and rights-based approach to promote their overall development, focusing on them and empowering families*." This specialty through a transdisciplinary approach promotes nurturing care, intend to maximize the individual potential of each patient, including the physical, social, and emotional dimensions. Professionals trained in this area foster the comprehensive development of children and adolescents, promoting their well-being and helping them to achieve the best version of themselves.

The main objective of the postgraduate program in DP is: "*to plan and execute preventive actions related to environmental, social, ecological, and psychosocial factors that contribute to the comprehensive development of children and adolescents. In addition, it seeks to detect prenatal and postnatal risk factors that directly affect neurodevelopment to facilitate the design of intervention and treatment strategies based on scientific evidence*.[13]"

In this program, specialists acquire skills to evaluate and accompany patients from an ethical and humanistic perspective, thus strengthening the quality and warmth of the care they receive. This includes the establishment of an effective rapport with patients and families, promoting an inclusive approach considering each individual's social, cultural, and family environment. In this training, we seek to generate a positive impact not only on health but also on the living conditions of children and adolescents from a comprehensive and transformational perspective.

Table 1. Medical-Healthcare activities in the developmental and behavioral pediatrics department in the 2019-2024 period

Activity	Year						
	2019	2020	2021	2022	2023	2024*	Projection for 2025
Total pediatric visits	2,377	1,266	2,604	3,524	3,556	3,105	3,747
Comprehensive developmental assessments (screening, diagnostic and intelligence evaluations)		377	537	1,736	1,373	1,456	1,547
Resident rotations at HIMFG and other institutes	140	42	58	86	86	68	86

Developmental and Behavioral Pediatrics Department (2024). Prepared by the authors, using reports provided by the Developmental and Behavioral Pediatrics Service: Data collected from January-to September 2024. HIMFG: Hospital Infantil de México Federico Gómez.

As of 2023, the DP Department has trained 24 highly qualified DP specialists in this area. Among them, two have stood out for their significant contributions in the field of research, earning recognition.

In 2019 and 2023, their research projects received honorific mentions for their impact and scientific rigor. In addition, one of these specialists, Dr. Melissa Cañete, out of more than 1200 students in highly specialized courses nationwide, was awarded first place at the 25th Research Conference in 2023, consolidating the prestige of the BDPS as a leader in scientific production in DP, across all specialties in Mexico.

The first project to receive an honorable mention focused on the validation of group 15 (60-71 months old) of the CDE test, which was specifically designed by Dr. Maria Salud-Trejo for the early detection of neurodevelopmental problems in children under 6 years of age in Mexico. This advance represents a fundamental step toward the expansion of the use of CDE test in older populations and strengthening early detection in the national context.

These awards highlight the quality of the graduates and the impact of the DBPS in the generation of scientific knowledge. The progress achieved by the specialists has made it possible to strengthen the use of standardized tools such as CDE test and to promote innovative strategies for the early detection, consolidating the Service's commitment to the continuous improvement of child health care in Mexico, which is an area that, according to studies carried out by the National Institute of Public Health, is highly relevant[14].

At the same time, to share and promote the knowledge generated concerning Developmental and Behavioral Pediatrics, the DP Annual Meeting was created, which is targeted at medical, healthcare, and education personnel. The first Meeting was held in July of 2017 and featured the participation of national and international experts from different governmental and civil society sectors, including topics related to the attention and care of children and adolescents, as well as comprehensive care for neurodevelopmental disorders.

Table 2. Number of users who passed the EDI test course completed by means of the virtual training platform in the 2020-2024 period

Year	Staff who passed the test with the minimum passing grade (9.0)
Pilot test 2020-2021	1316
2022	767
2023	580
2024	605

Developmental and Behavioral Pediatrics Department (2024). Prepared by the authors, using reports provided by the National Center for Child and Adolescent Health: Data collected from January to September 2024.

To date, the scientific production of the department includes more than 21 scientific articles published in indexed medical journals and several book chapters. In recognition of the work and effort carried out in favor of early childhood, "Fondo Unido México" granted the BDPS two awards:

1. The "Al Aliado Vive Unido 2017" Award for the evaluation of girls and boys from the Nacer Aprendiendo Centers in 2016, which measures the effectiveness of Fondo Unido's educational program, and for its contribution to the prioritization of child development in Mexico[15].
2. The "Articulación Intersectorial para Cambios Sistémicos" (Intersectoral Articulation for Systemic Change) Award, for being the first public advocacy effort for Fondo Unido-United Way Mexico and incorporating the first standardized measurement of child development, together with that of the weight and height of children under 6 years of age who attend

Table 3. Number of CDE tests applied to child population nationwide in the 2018-2024 period

Year	Total CDE test applied	Total initial CDE tests	Total subsequent CDE tests	Remarks
2018	864,009	518,059	345,950	< 1 year old and 1-4 year old groups were included.
2019	653,413	406,716	246,697	
2020	346,109	221,489	124,620	
2021	463,546	291,746	171,800	As from 2021, the age group was expanded (1-5 year old children)
2022	608,180	368,675	239,505	
2023	496,972	294,685	202,287	
2024*	407,345	233,194	174,151	
Total	3,839,574	2,334,564	1,505,010	

Data from: Health Information System (SIS Consolidated SINBA) (2024). Care provided to children under 5 years old in preventive health appointments: Data collected up to September 2024. https://sinba.salud.gob.mx/CubosDinamicos.

Child Care Centers (CAI), awarded through the Strategy for the Accompaniment of Child Development and Nutritional Surveillance[16].

Virtual CDE test training

In collaboration with the National Center for Child and Adolescent Health (CeNSIA, for its acronym in Spanish) and thanks to the founding from Gonzalo Río Arronte IAP Foundation, a free virtual training program was developed and implemented to support the correct application of the CDE test, targeted at first level healthcare personnel. This training seek to promote the detection and timely intervention of neurodevelopmental delay in at-risk children from 1 to 59 months of age, through the acquisition of skills in a course that is structured in 15 interactive modules, equivalent to 40 h of theoretical and practical training, held on a web-based platform.

The design of this strategy ensures the standardization of screening at the national level, with the objective of reaching 4 million children, guaranteeing homogeneous and high-quality results. The virtual modality and 24-h availability facilitates access and optimizes the scope of the training, strengthening the capacities of health personnel and promoting an evidence-based approach to early childhood development in Mexico.

To consolidate the progress achieved in the early detection of child developmental disorders, it was necessary to evaluate the operational feasibility and effectiveness of the training strategies being implemented. For this, a pilot test for the virtual training on the CDE test was designed and implemented in 2020, with the objective of evaluating the effectiveness of the training program in the correct application of the CDE test, as well as its feasibility for real operational contexts.

This pilot involved a representative sample of 2139 participants who were recruited from health units distributed across different states of Mexico, including Aguascalientes, Campeche, Colima, Chihuahua, Guanajuato, Guerrero, Nayarit, Nuevo León, Puebla, Querétaro, Tabasco, Tamaulipas, Yucatán, Zacatecas, Oaxaca, Tlaxcala, Baja California Sur, State of Mexico, Mexico City, and Sonora. Out of the initial participants, 1316 people passed the course, representing 61.5% of the total sample (Table 2)[17].

According to reports provided by CeNSIA, from the analysis of the pilot group, a significant increase in the number of applications of the CDE test was observed at the national level following the training of primary care personnel (Table 3)[18].

This increase can be attributed to several key factors: (a) the easing of the social coexistence restrictions that were imposed during the COVID-19 pandemic, which facilitated access to health services; (b) the comprehensive updating of the virtual training course, drawing on feedback obtained from the first groups that used the interactive platform; (c) the revision and publication of the 2021 version of the manual for the application of the EDI test, which included the incorporation of group 15 (60 months to 71 months and 29 days), developed by Dr. María Salud Rodríguez Trejo in 2020[19]; and (d) the national distribution, both physical and digital, of 20,000 copies of the updated materials in conjunction with the CeNSIA, starting in 2022. These factors contributed to the standardization and massification of the screening, thus favoring the timely detection of child development problems.

A central current challenge is the optimization of the capacity of the server hosting the training platform to expand its scope and improve the user experience in terms of accessibility, interaction, and functionality.

Improvements in the technological infrastructure, together with pre-course updates and training materials, will not only consolidate the standardization of screening at the national level but also guarantee a more efficient and accessible training experience for health personnel, thus contributing to the strengthening of timely detection strategies in child development.

Conclusion

Developmental and behavioral pediatrics in Mexico is a crucial training field in pediatrics, and of high importance for the future of children, with significant advances in early detection, timely intervention, and professional training. However, its consolidation faces important challenges. It is essential to promote the greater dissemination and understanding of its relevance among health professionals and society at large, fostering a collective approach to comprehensive child development.

It is also important to reduce inequality in access to specialized services, in particular in rural and marginalized communities, where structural limitations continue to be an obstacle. Finally, ensuring the sustainability of the training and care efforts will require innovative strategies to overcome human and technological resource constraints. Addressing these challenges will be key to strengthening DP and guaranteeing an equitable and healthy future for Mexican children.

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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 study does not involve patient personal data nor requires ethical approval. The SAGER guidelines do not apply.

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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