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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.

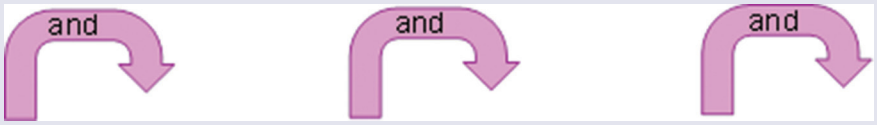
Literature search

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

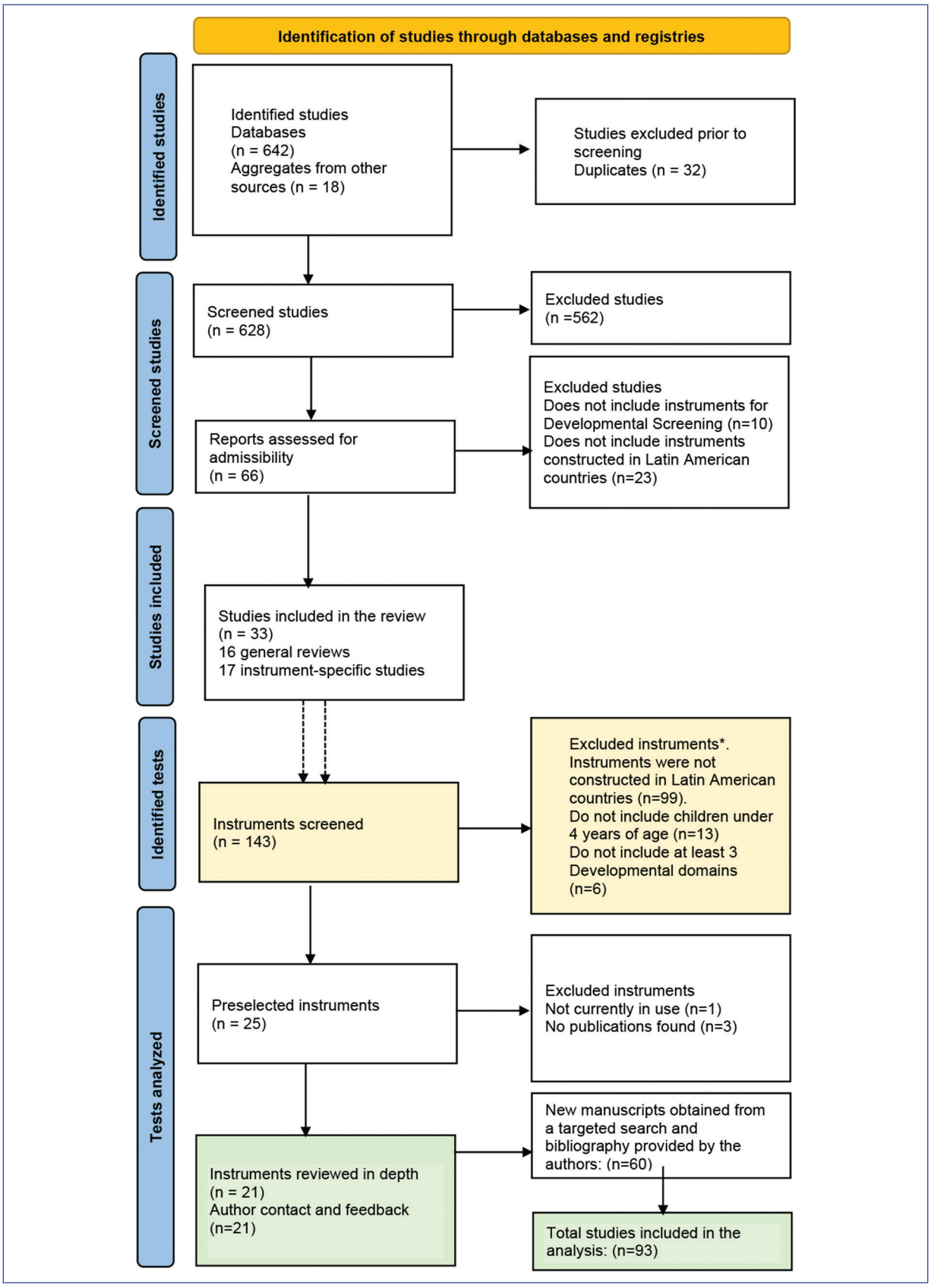


Figure 1. PRISMA flow chart with the instruments included in the bibliographic search[15].

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

(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	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).

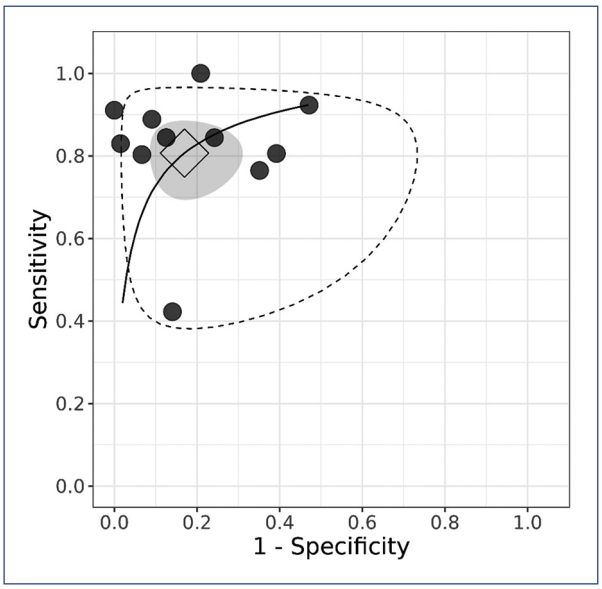


Figure 2. SROC curve for overall sensitivity and specificity of screening tests. Note: The dotted line represents the 95% prediction region of the bivariate model; the shaded area represents the 95% credible region of the bivariate model. Large heterogeneity among tests is observed[13,14].

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

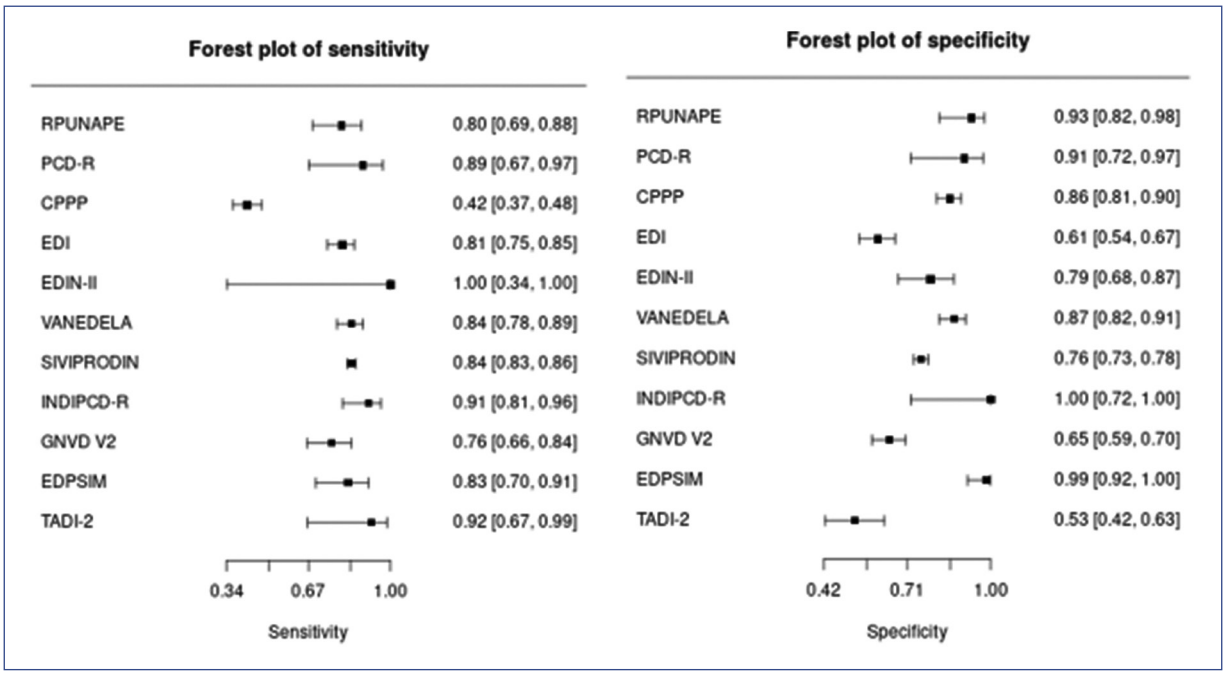


Figure 3. Forest plots of the estimated sensitivity and specificity of the developmental screening scales. Recalculated values in some tests with the data provided by the authors to construct the 2 × 2 table, explaining the difference between the published values of sensitivity and specificity and those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