# Developmental Assessment With Young Children
## A Systematic Review of Battelle Studies

*Ana C. B. Cunha, PhD; Michelle D. Berkovits, PhD;*
*Karolina A. Albuquerque, MD*

Developmental assessment scales are important tools for determining developmental delays and planning preventive interventions. One broad assessment scale used to evaluate child development is the Battelle Developmental Inventories (BDIs). The BDI-2 has a standardized version in English with good psychometric properties and a translated version in Spanish; however, despite widespread clinical use, there has been limited early childhood development research focused on this assessment tool in the past 10 years. The purpose of this systematic review was to evaluate the literature about the BDIs and their screening test and analyze their use for child assessment. Seven databases were used to retrieve articles in English, Portuguese, and Spanish. Overall, 34 articles were evaluated for general features, salient findings, and key methodological issues, such as target population, objectives, research design, and main results. Authors' considerations about the psychometric properties and utility of the BDIs were also examined. Results indicated that 41.17% of studies with the BDIs were from the United States, and the most common target population was children with autism spectrum disorders. Generally, the articles highlighted the broad applications of this measure and robust psychometric properties cited in the BDIs examiner's manual as reasons for their use. This review suggests that it is important to conduct independent analyses of the psychometric properties of the BDIs as well as validation studies to ensure appropriate applications of the BDI, including for use with non-American populations. **Key words:** *child behavior, developmental disabilities, psychometric assessments, risk factors, systematic review*

*Author Affiliations: Department of Clinical Psychology, Institute of Psychology, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (Dr Cunha); Department of Pediatrics, University of Miami, Miller School of Medicine, Miami, Florida (Dr Berkovits); and Programa de Pós-graduação em Psicologia, Universidade Federal do Espirito Santo, Espirito Santo, Brazil (Dr Albuquerque).*

*Correspondence: Ana C. B. Cunha, PhD, Department of Clinical Psychology, Universidade Federal do Rio de Janeiro, Av Pasteur, 250, Pavilhão Nilton Campos, Campus da Praia Vermelha, Urca, Rio de Janeiro, RJ, Brazil, 22290-240 (acbcunha@yahoo.com.br).*

**D**EVELOPMENTAL assessment scales are a useful tool for early childhood researchers, clinical professionals, and policy researchers who may use these scales to identify risk factors, plan interventions, and implement programs for young children at risk for developmental difficulties. These scales have been used for early detection of developmental difficulties and to monitor children's developmental progress and outcomes (Barreno, López, & Menéndez, 2011; Barreno, López, & Menendez, 2013; Goldin, Matson, Beighley, & Jang, 2014). These tools can also facilitate therapeutic interventions to reduce risk of severe disabilities for children with specific diagnoses, such as autism spectrum disorders (ASDs; Turygin, Matson, Beighley, & Adams, 2013a). Also, developmental assessment

scales provide a useful indicator used to compare child development across a variety of domains as well as providing information about skill levels in specific areas, such as current cognitive abilities (Turygin et al., 2013a).

In general, conventional tests, which are standardized and norm-referenced, are used to meet the early intervention eligibility standards of the Individuals with Disabilities Education Act (IDEA, 2004; Macy, Bagnato, Macy, & Salaway, 2016). One commonly used conventional test is the Battelle Developmental Inventory (BDI), originally published in 1984 (Newborg, Stock, Wnek, Guidubaldi, & Svinicki, 1984) and revised as the Battelle Developmental Inventory, 2nd Edition (BDI-2) in 2005 (Newborg, 2005a). To ensure clarity, the original BDI will be referred to as BDI-1 throughout this article. For both editions of the BDI, this is a normed and standardized measure with a Spanish translation version available (Newborg, Stock, & Wnek, 1996; Newborg, 2005b). When all versions of the BDI are referred to collectively within this article, they will be referred to as "Battelle Developmental Inventories" or "BDIs," which includes the Screening versions.

Comparing conventional tests used to meet the IDEA standards (2004), the BDIs, as well as the Bayley Scales of Infant and Toddler Development (BSID) and other cognitive measures, such as the Stanford-Binet Intelligence Scales and the Wechsler Preschool and Primary Scales of Intelligence, have current editions developed to facilitate meeting of IDEA standards by including parent participation in the evaluation process (Macy et al., 2016). Domains assessed within current versions of the BDI and BSID correspond with areas of comprehensive assessment required by IDEA. Macy et al. (2016) affirm that the manuals of the BDI-2 and BSID-3 emphasize the importance of cultural diversity, include children with disability within the normative sample, and allow examiners to make careful, minor changes on test items when assessing children with disabilities. However, these modifications should not alter scoring criteria. Although the BDI-2 requires standardized administration, compared with other conventional measures, the BDI-2 has greater flexibility in its inclusion of a choice of administration methods for individual items and graduated scoring criteria.

The BDIs measure developmental skills for children from birth to 8 years of age across the following domains: personal–social, adaptive, motor, communication, and cognition. However, the number of subtests has been reduced from 22 to 13 from the BDI-1 to the BDI-2. The Standard Scores for each domain are referred to as developmental quotient scores, with a mean of 100 and *SD* of 15. Each domain comprised subdomains, with mean scaled scores of 10 and *SD* of 3. Lower scores indicate greater impairments. There is also a screening version of the BDI-2 that includes a subset of test items from the full test item pool. The BDI-2 Screening Test has similar procedures for item scoring, and the cutoff scores aid in identifying children who may need additional follow up (Newborg, 2005a).

Each BDI item offers from one to three modes of administration: structured, observation, and/or interview. For all modes, the administrator rates the child's developmental skills on the basis of a 3-point Likert scale: 0 means "milestone not yet evident"; 1 means "milestone emerging"; and 2 means "milestone achieved." The BDI-2 has been shown by the test developers to have robust psychometric properties, with acceptable content and criterion validity, as well as acceptable test–retest reliability (above 0.80), and excellent internal consistency (ranged from 0.98 to 0.99; Newborg, 2005a). In a systematic review on validation studies of neurodevelopmental screening tests for children 5 years of age or younger in the United States and Latin American from 1980 to 2012, the Battelle Development Inventory Screening Test was considered the best sensitivity screening inventory (Roma-Pardo, Liendo-Vallejos, Vargas-Lopez, Rizzoli-Cordoba, & Buenrostro-Marquez, 2012).

Recent research to provide social validity evidence for specific early childhood measures compared the qualities and patterns of

using authentic assessments and conventional tests among professionals in the early childhood intervention field (Lee, Bagnato, Pretti-Frontczak, 2015). Social validity of assessment measures is a recent paradigm in the early childhood assessment area in the United States, which refers to the acceptability of and satisfaction with an intervention or assessment procedure based on the judgments of individual consumers, participants, and implementers of the procedures (e.g., parents, children, and professionals; Bagnato, Goins, Pretti-Frontczak, & Neisworth , 2014). According to a survey by Lee et al. (2015), the BDI-2 was the most commonly used conventional test among interdisciplinary professionals in early childhood education settings because of its relatively short administration time and utility in determining eligibility for special education services. The validity and reliability of conventional tests, such as the BDI-II, were identified as a primary reason for interdisciplinary professionals' use of these tests (Lee et al., 2015). In addition, the BDI-2 was rated highly and identified as having several characteristics more commonly associated with authentic assessment tools because of the emphasis on ensuring developmentally appropriate assessment. Specifically, the BDI-2 includes functional content that follows a developmental sequence, relies on information from multiple sources, allows for testing adaptations, includes graduated scoring criteria, and has utility in natural settings.

In clinical settings, the BDI-2 has been used by qualified personnel who work with early childhood populations, like the Early Steps Program in Florida. Under the IDEA, Part C, this early intervention program provides services to infants and toddlers and their families from birth to 36 months. For children to enroll in the Early Steps Program, the child must have either a developmental delay or a diagnosed physical or mental condition that places him or her at high risk for a developmental delay. For Early Steps, the BDI-2 is one of the recommended tools to evaluate children's development for evaluation purposes (Florida Early Intervention System, 2015).

Moreover, researches have used the BDIs for a variety of purposes and concluded that the BDIs are a useful measure to identify and describe risk factors associated with developmental outcomes in specific populations, such as autism spectrum disorders (ASD) (Goldin et al., 2014; Sipes, Matson, & Turygin, 2011; Turygin et al., 2013a; Turygin, Matson, Konst, & Williams, 2013b). Moreover, these inventories are also useful to determine specific domains of developmental skills for children with specific diagnoses, like cerebral palsy (CP; Barreno et al., 2011; Barreno et al., 2013; Mancías-Guerra et al., 2014). In addition, the BDIs have been used for other research purposes, such as to test the efficacy of specific interventions or to screen for potential developmental delays. In summary, the proposal of this study was to review, synthesize, and evaluate the literature about BDI, BDI-2, and BDI Screening tests to analyze their use for early childhood developmental assessment.

## METHODS

This systematic review was written in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. To retrieve articles for this review, a search was done using the following databases: MEDLINE; SCOPUS, Cochrane, LILACS, IBECS, SciELO. The following two sets of key words were used for each search: (1) Children AND Assessment; (2) Children AND Assessment AND Battelle Inventory. The filters used for determining which studies found with these key words were selected from the electronic databases for this systematic review were as follows: (1) studies published in the past 10 years and (2) studies written in one of the following three languages: English, Portuguese, or Spanish. From the initial search, 120 articles were found, and after the filters were applied, 51 articles were included in the next phase. After duplicates were removed, 34 articles were screened by reading each title and abstract to confirm inclusion for the review.

All 34 articles were read extensively to extract pertinent data regarding outcomes from each study and identify key methodological issues. This following information was extracted from each article: (a) language and nationality of the study; (b) target population and characteristics; (c) research design; (d) objectives of the study related to the BDIs; and (e) main results related to the BDIs. The authors' considerations about the psychometric properties of the BDIs and reasons for using the BDIs for specific purposes were also examined. Observational studies (cross-sectional, case–control, and cohort), experimental studies (randomized controlled trials, randomized or quasi-randomized trials), and case reports were included.

## RESULTS

### Nationality, research design, and authors' considerations about the BDIs

Results from the total sample of articles retrieved for this review are summarized in Table 1.

The majority of the 34 articles (79.41%, 27 articles) were in English. The remaining seven articles were in Spanish. There were no articles found written in Portuguese, although there were three articles from Brazil. In regard to the nationality, 41.17% of the articles were from research conducted in the United States. Most of the other research was conducted in Spain or Latin America ($n = 15$), but two articles were found from Canada and one each from Israel, Pakistan, and Russia.

Regarding the research design, four validation studies were found using the BDIs as a secondary measure, and one case report study was found. The majority of articles (85.2%) were observational studies: 14 cohort studies; 6 group–control research studies; 6 cross-sectional studies; and 3 articles with secondary data analysis from prospective studies.

Related to the authors' descriptions about the psychometric properties and utility of the BDIs, the tools were identified as a "gold standard" measure for child development. Except

for three articles in which the authors did not identify any specific reasons for selecting the BDIs, 91.1% of articles considered the BDIs as good assessment tools with robust psychometric properties. In most of them, authors highlighted psychometric properties of the BDI-2 from the examiner's manual, including having acceptable test–retest reliability (0.80) as well as an excellent internal consistency (0.98-0.99).

Some authors also highlighted that the inventories cover a wide age range, facilitating longitudinal comparison using the same clinical measure to determine developmental trajectories and outcomes, as well as supporting the diagnosis of a specific disability condition, such as ASD. Also, the BDIs were used in distinct settings because of the administration time and different procedures available to gather information.

### Target population and main purposes of studies with the BDIs

The results for target population groups and the main purposes for using the BDIs are summarized in Tables 2 and 3, respectively.

Four groups of children were found as target populations in studies using the BDIs (see Table 2). More than half of those studies (58.8%) were conducted with children identified as at risk or diagnosed with developmental disorders for a variety of research objectives.

Variability was found in the use of different versions of the BDIs (see Table 3). The authors retrieved and reviewed articles published only from 2005 to 2015, after the BDI second edition was published; however, 44.12% of the total of articles used the original BDI-1. Almost half the studies (44.12%) used the BDIs as assessment tools to identify developmental outcomes in children with developmental disorders due to diagnosed conditions. The BDIs were also used to identify developmental outcomes in typically developing children and at-risk children. In four articles, the BDIs were used as a convergent and divergent validity measure in a mixed sample of children or in typically children sample. The BDIs were

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 1. Chmait, Baskin, Carson, Randolph, and Hamilton. (2015)/United States | Child with birth risks (diagnosed with severe fetal anemia due fetal alpha (0)-thalassemia); $N = 1$ (18 months) | To report a case of fetal alpha (0)-thalassemia treated with serial intrauterine transfusions and postnatal chronic transfusions | The DQ was 0.93 (32nd percentile) with all subdomains noted within normal limits, indicating overall intact neurodevelopment | The BDI-2 was considered useful for the study purposes |
| 2. Valenzuela, Montiel, and Mesa (2015)/Spain | Typically developing children; $N = 146$ (5 years) | To examine the influence of oxytocin administration during delivery on psychomotor development | Exposure to synthetic oxytocin during birth could have an effect on a child's subsequent motor development | No considerations mentioned about the BDI-1 |
| 3. Goldin et al. (2014)/United States | Toddlers with an ASD from the Louisiana EarlySteps Program; $N = 325$ (17–36 months) | To evaluate the relationship among the severity of ASD symptomology, DQ, and individual domain scores | Multilevel regression models found associations between higher autism severity scores and overall greater impairment (total DQ, and individual domains scores); the domains were found to be differentially affected by severity of ASD | The BDI-2 was considered as an assessment tool with robust psychometric properties, with acceptable test-retest reliability of (0.80), as well as excellent internal consistency (0.98-0.99) |
| 4. Mancías-Guerra et al. (2014)/Mexico | Children with CP; $N = 18$ (1 month to 8 years) | To evaluate short-term safety of a cell therapy procedure with a 6-month follow-up goal | An overall 4.7-month increase in developmental age after therapy procedure, according to the BDI-2 scores of all areas of evaluation | The BDI-2 was considered a good assessment tool because it covers a wide age range, facilitating longitudinal comparison with the same clinical measure to determine developmental trajectories and outcomes |

*(continues)*

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 5. Vanderbilt et al. (2014)/United States | Children with birth risks (utero-selective laser for twin–twin transfusion syndrome); $N = 100$ (2 years old) | To determine risk factors for poor infant cognitive performance | Overall cognitive performance DQs were in the normal range; associations among BDI-2 scores and risk factors (e.g., lower maternal education) | The BDI-2 was selected because of its normative data, age range, and the availability of English and Spanish versions |
| 6. Barreno et al. (2013)/Spain | Children with CP; $N = 41$ (1–6 years old) | To study 1 year of development for children with CP | BDI-2 Screening test scores improved significantly from the pretest to posttest scores in all areas after 1 year | The BDI-2 Screening test was selected because the screening version is more feasible in clinical settings due to administration time |
| 7. González, Pacheco-Sánchez-Lafuente, Roca-Ruíz, Hurtado-Suazo, and Díaz-López. (2013)/Spain | Children with SA who were born at term and did not have apparent neurological impairment at age 5 years; $N = 76$ children (38 with SA, and 38 non-SA; 5 years) | To investigate relationships between the markers of SA and the developmental, verbal, and behavioral characteristics of these children | There were no differences between the SA and non-SA groups in the motor, personal-social, or cognitive DQs on the BDI-2 | The BDI-2 individual domain scores represent the child's overall abilities in each of these areas and can be compared with others to determine relative developmental strengths and weaknesses |
| 8. McCall et al. (2013)/Russia | Children from orphanages at risk for developmental delay; $N = 357$ (birth to 4 years) | To investigate the efficacy of an intervention project in two orphanages, based on the associations between the BDI-1 DQ scores after intervention and after a follow-up period of approximately 6 years | The overall multivariate results indicated that the three intervention conditions maintained their differences across these three follow-up times (BDI-1 scores tended to increase between these periods) | The BDI-1 was selected because (a) the items were relevant ("authentic") to the orphanages' context, (b) it is better suited to mild disabilities children than other general behavioral/development tests, (c) it is appropriate for children from birth to 95 months, and (d) provides a total score plus subscales |

(*continues*)

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 9. Rizzoli-Córdoba et al. (2013)/Mexico | Mixed sample; $N = 438$ children (at risk, $n = 344$; typically developing, $n = 104$; <5 years of age) | To evaluate the psychometric properties of the "Evaluación del Desarrollo Infantil" (EDI) as a screening tool for childhood developmental problems | The modified version of EDI showed a sensitivity, specificity, and concordance compared with BDI-2 as a convergent validity measure | The BDI-2 was considered a gold standard measure for child developmental assessment |
| 10. Turygin et al. (2013a)/United States | Toddlers with ASD and those at risk for developmental delay from the Louisiana Early Steps Program; $N = 2054$ (ASD $n = 559$; atypical development (AD), $n = 1495$; 17–36 months) | To investigate whether the use of *DSM-5* criteria for ASDs would result in more developmentally delayed or cognitively impaired population as compared with those diagnosed with ASDs according to *DSM-IV-TR* criteria | Overall BDI-2 DQ were lower in all domains for children who qualified for the ASD diagnosis according to *DSM-5* criteria compared with those who met criteria according to the *DSM-IV-TR* | The BDI-2 was considered as an assessment tool with robust psychometric properties, and its validity has been established for high-risk groups such as those with ASD and other developmental delays |
| 11. Turygin et al. (2013b)/United States | Toddlers at risk for developmental delay, from the Louisiana EarlySteps Program; $N = 3173$ (17–36 months) | To investigate variables most related to the presence of parental concern of early communication deficits and its relationship with symptoms of ASD | Significant results were observed related to early communication first concerns, gender, and DQs (overall and individual domain scores) | The BDI-2 was considered as an assessment tool with robust psychometric properties |

*(continues)*

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 12. Bassan et al. (2012)/Israel | Children with birth risks (preterm infants with posthemorrhagic hydrocephalus; following intraventricular hemorrhage; $N = 32$ (3 months) | To delineate the impact of early ($\sim$25 days of life) vs late ($>$25 days) EVD on the neurodevelopmental outcome of preterm infants | Multiple regression analysis showed that the early EVD was associated with better scores than late EVD in adaptive, personal social, communication, and cognitive domains | No considerations about the BDI-2 or testing language listed |
| 13. Bowen et al. (2012)/Pakistan | Typically developing children who were enrolled in a trial of household-level handwashing promotion; $N = 461$ (5–7 years) | To evaluate associations between handwashing promotion and child growth and development | Total BDI-2 DQ among children enrolled in the intervention group averaged 6.1 points (0.4 $SD$) higher than children in the control group | The BDI-2 version was not validated for a Pakistani population; the attempts to translate and adapt the instrument was careful, but it is not a guarantee for accurate DQs among that population |
| 14. Gòmez-Arriaga et al. (2012)/Spain | Children with congenital malformation (mild ventriculomegaly - VM); $N = 18$ (1–8 years) | To analyze midterm neurodevelopment outcome in children | The BDI-1 Screening Test showed that the neurodevelopmental delay was worse in some domains (social–personal, gross motor, adaptive behavior, and fine motor) than others (communicative and cognitive). General trend toward worse outcomes were observed in the group of $\geq$4 years, although significant differences were found only for gross motor skills | The authors adapted the BDI-1 Screening test to conduct the assessment by telephone interview with parents in Spanish. The authors did not report any psychometric considerations of this adaptation |

(*continues*)

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 15. Jones, McEwen, and Neas (2012)/United States | Children with severe motor impairments; *N* = 28 (14–30 months) | To identify any effects of power wheelchairs on the development and function of young children with motor impairments | The BDI-2 scores and others assessment scores (e.g., mobility, functional skills, mobility caregiver assistance, and caregiver assistance for child self-care) were improved significantly more for the experimental groups than for the control group. Other findings showed an additional difference between the groups' BDI-2 total score | The BDI-2 was considered as an assessment tool with robust psychometric properties and value for measuring developmental change in longitudinal studies with young children |
| 16. Medeiros, Kozlowski, Beighley, Rojahn, and Matson (2012)/United States | Children with ASD and children with developmental delays but no ASD from the Louisiana EarlySteps Program; *N* = 1509 (17–36 months) | To examine the effect of DQ (total DQ and DQ domains) on challenging behavior presentation in toddlers with varying levels of ASD symptomatology, according to diagnosis | The BDI-2 DQ domains that were most influential on challenging behaviors varied by diagnosis, with communication and motor domains playing greater roles for toddlers with ASD, and personal–social and cognitive domains playing greater roles for atypically developing toddlers with no ASD diagnosis | The BDI-2 was considered as an assessment tool with robust psychometric properties; also, the BDI-2 author established acceptable levels of content and criterion validity through expert review and correlational comparisons |
| 17. Seguel et al. (2012)/Chile | Typically developing children; *N* = 611 at the beginning; *n* = 311 after 4 years of study (3 months to 4 years of age) | To analyze the effect of nursery school attendance on the learning and development of children in a longitudinal design | Nearly 80% of children showed learning and development performance according to their age, regardless whether they were attending a nursery school or staying at home | No considerations about the BDI-1 |

(*continues*)

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 18. Barreno et al. (2011)/Spain | Children with CP, and typically developing children; $N = 100$ (CP, $n = 50$; typical, $n = 50$; 4–70 months) | To demonstrate that developmental deficits can be detected at an early age using the BDI, as a brief development scale | The BDI-1 detected differences between the clinical and control groups. These differences were significant at all age levels and between tetraplegia and other motor disorders. There were no differences by gender | The BDI-1 was considered a good assessment tool because it covers a wide age range, it is easy to administer, and offers important information about developmental problems |
| 19. Devesa et al. (2011)/Spain | Children with CP with growth hormone deficiency; $N = 11$ (4.12 months to 1.31 years) | To assess the effects of growth hormone treatment combined with psychomotor and cognitive stimulation in the neurodevelopment of children | Psychomotor and cognitive status did not change during cognitive stimulation period; however, significant improvements in BDI-2 Screening Test scores were observed after the combined treatment period | The BDI-2 Screening Test was considered as an assessment tool with robust psychometric properties |
| 20. Iverson and Braddock (2011)/United States | Children with language impairment (LD), and typically developing children (TC); $N = 37$ (LI = 11; TC = 16 (2 years, 7 months to 6 years, 1 month) | To examine gesture and motor abilities in relation to language in children with LI | The children with LI performed more poorly on the BDI-1 Screening Test measures of fine and gross motor abilities. Regression analyses indicated that the poorer expressive language of the LI group was related to more frequent gesture production | The BDI-1 Screening Test was considered interesting for clinical settings because of the short time for administration and the easy evaluation tasks and scoring |

(*continues*)

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 21. Matson, Wilkins, and Fodstad (2011)/United States | Mixed sample children (autistic disorder-ASD; and non-ASD) from the Louisiana EarlySteps Program; $N = 1007$ (ASD, $n = 330$; Non-ASD, $n = 677$; 17–37 months) | To investigate the psychometric properties of the Baby and Infant Screen for Children with aUtIsm Traits (BISCUIT) battery, using the BDI-2 as a convergent and divergent measure | The BISCUIT-Part 1 demonstrated good convergent validity with the BDI-2 Personal Social domain; additionally, divergent validity was demonstrated by its small correlation with the Adaptive and Motor domains from the BDI-2 | The BDI-2 was considered as an assessment tool with robust psychometric properties, as well as acceptable test–retest reliability |
| 22. Nip, Green, and Marx (2011)/United States | Typically developing children; $N = 23$ (3–21 months) | To determine the association between orofacial movement speed and standardized measures of cognitive and language development during the early stages of communication development | Significant associations were identified between orofacial kinematic and the BDI-2 language and cognitive skills scores, even when age served as covariate | The BDI-2 was considered as a tool that is meant to provide a global snapshot of a child's development |
| 23. Sipes et al. (2011)/United States | Infants and toddlers with ASDs and AD from Louisiana Early Steps Program; $N = 1668$ (ASD, $n = 604$; AD, $n = 1064$; birth to 36 months) | To develop cutoff scores for the BDI-2, which could be used as a screening tool to differentiate young children with possible ASD | Based on the 1 SD from the mean of the ASD group, the cutoff score of 89 was found (with 0.84 of sensitivity and 0.55 of specificity); when the 1.5 SD was chosen, the cutoff score of 96 was determined with high sensitivity of 0.94 and a specificity of 0.31. The last cutoff score has high sensitivity and can be used for the screening measure | The BDI-2 was considered as an assessment tool with robust psychometric properties, as well as acceptable test–retest reliability |

(*continues*)

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 24. Ternera (2011)/Colombia | Typically developing children; *N* = 312 (3–7 years) | To describe infant adaptive development characteristics related to the self-help skills and the tasks required by these skills | The BDI-1 results related to adaptive behavior revealed that the girls and boys are different in performing some tasks effectively by themselves. Correlations were found between adaptive behavior skills (dressing, feeding, and self-care) and cognitive domains | The BDI-1 was considered as an assessment tool with robust psychometric properties that is easy to administer |
| 25. Barros, Matijasevich Santos, and Halpern (2010)/Brazil | Typically developing children; *N* = 3869 (24 months) | To investigate psychosocial determinants of child development within a birth cohort and its interactions with maternal schooling and economic position | Child development scores evaluated by the BDI-1 Screening Test was strongly associated with socioeconomic position, maternal schooling, and stimulation (e.g., low performance was associated with low mother's schooling, employment, and stimulation) | The BDI-1 Screening Test was considered as assessment tool with robust psychometric properties; however, it does not have validation for a Brazilian population |
| 26. Matson, Hess, Sipes, and Horovitz (2010a)/United States | Children with birth risk (premature) and developmental disabilities (Down syndrome, or diagnosed with Global Developmental Delay) from the Louisiana EarlySteps Program; *N* = 28 (17–34 months) | To compare infant developmental profiles of children at developmental risk | The children with Global Developmental Delay or Down syndrome scored significantly lower on the BDI-2 than premature children, specifically on the personal-social and motor domains | The BDI-2 was considered as an assessment tool with robust psychometric properties |

(*continues*)

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 27. Matson, Neal, Fodstad, and Hess (2010b)/United States | Children with an ASD from the Louisiana EarlySteps Program; *N* = 153 (22–36 months) | To analyze the relationship between socialization and challenging behaviors in toddlers with ASD | Lower levels of adult interaction and peer interaction were associated with higher levels of stereotypic behavior, aggressive/destructive behavior, and to a lesser extent self-injury | The BDI-2 Screening Test was considered as an assessment tool with robust psychometric properties |
| 28. Moura et al. (2010a)/Brazil | Typically developing children; *N* = 3907 (12 and 24 months) | To describe the incidence and persistence of suspected developmental delay (SDD) and associated risk factors | Incidence of SDD between 12 and 24 months was 1.8%. Multiple analyses showed that the SDD incidence was associated with some risk factors (e.g., low Apgar, preterm delivery), and some factors were associated with the persistence of SDD (e.g., low Apgar, low socioeconomic level, intergestational interval, breastfeeding duration <6 months) | The BDI-1 Screening Test was considered as an easy assessment tool with robust psychometric properties; and the administration format offers opportunity to get the best child performance. However, it does not have validation for Brazilian population |
| 29. Moura et al. (2010b)/Brazil | Typically developing children; *N* = 3869 (24 months) | To identify risk factors for SDD at age 2 years | 3.3% children screened positive for SDD. Regression analysis showed that some risk factors were more related to SDD at age 12 months, like maternal sociodemographic variables (few years of schooling), reproductive and gestational characteristics (e.g., gestational diabetes), or child and environmental characteristics (low birth weight, antenatal care appointments), etc. | The BDI-1 Screening Test was considered as an assessment tool with robust psychometric properties; however, it does not have validation for a Brazilian population |

(*continues*)

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\ Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 30. Ternera (2010)/ Colombia | Typically developing children; *N* = 312 (3–7 years) | To determine the relationship between motor development and the evolutionary process of language and cognition | Age-appropriate developmental levels were found for the majority of children; although some of them showed results lower than the normative sample. Positive correlations among motor, cognition, and language development scores were found | The BDI-1 was considered as an adequate tool to evaluate essential childhood skills in different domains of development |
| 31. Snider, Majnemer, Mazer, Campbell, and Bos (2009)/ Canada | Mixed sample (at-term and preterm children), *N* = 100 (12 months, adjusted age) | To compare four different assessment approaches (Alberta Infant Motor Scales, Peabody Developmental Motor Scales-2, Vineland Adaptive Behavior Scales—Daily Living Skills, and Battelle Developmental Inventory) to predict motor and functional outcomes of at-term and preterm infants | Results from the three other measures presented a more moderate profile than BDI-1 results. Preterm survivors demonstrated developmental delays as measured by the different domains of the BDI (37%–89%). Clinical risk factors (e.g., duration of ventilation) rather than other infant tests explained 5%–16% of the variance of BDI scores | The BDI-1 allows for variability of responses among participants and is responsive to individual differences at that age |
| 32. Garcia-Filion et al. (2008)/ United States | Children with visual impairment; *N* = 73 (5 years) | To determine the developmental outcomes of children with optic nerve hypoplasia and the correlation of development with neuroradiographic, endocrinologic, and ophthalmic findings | BDI-1 results confirmed developmental delays in 71% of children at 5 years; greater than for child with bilateral optic nerve hypoplasia | The BDI-1 was selected due to the normative data available, targeted age range, and adaptations for and previous use with visually impaired populations |

(*continues*)

**Table 1.** Article Summaries Including Nationality, Research Design, Population, Objectives, Main Results, and Authors' Considerations About the Battelle Developmental Inventories' Psychometric Properties and Usage (*Continued*)

| Reference\Nationality | Research Design and Population (General Child Characteristics) | Objectives | Main Results | Authors' Considerations About the BDI-2 |
|---|---|---|---|---|
| 33. López, Granados, and Vázquez (2007)/Spain | Children with ASD; $N = 11$ (38–58 months) | To analyze the adequacy of the BDI-1 to assess ASD children | BDI-1 results confirmed data from other studies with ASD (low scores not only in DQ but also in specific domains (communication, motor and adaptive behavior) | The BDI-1 was considered a good assessment tool to help in the diagnosis of ASD |
| 34. Rydz et al. (2006)/Canada | Typically developing children; $N = 101$ (18 months) | To test the accuracy of two parent-completed screening measures (the ASQ and CDI) compared with the BDI-1 as a standardized measure | Compared with the BDI-1 results, neither questionnaire (CDI or ASQ) proved to be an ideal screening instrument (poor psychometric properties like sensitivity, specificity, positive and negative predictive value) | The BDI-1 was considered as a "gold standard" for the study purposes |

*Note.* ASD = autism spectrum disorder; ASQ = ages and stages questionnaire; BDI = Battelle Developmental Inventory; CDI = Child Developmental Inventory; CP = cerebral palsy; DQ = developmental quotient; *DSM-5* = Diagnostic and Statistical Manual; EVD = external ventricular drainage; SA = severe academia.

**Table 2.** Target Population of Studies Using the Battelle Developmental Inventories

| Population | Types | References |
|---|---|---|
| Typically developing children ($n = 10$) | – | Barros et al., 2010; Bowen et al., 2012; Moura et al., 2010a; Moura et al., 2010b; Nip et al., 2011; Rydz et al., 2006; Seguel et al., 2012; Ternera, 2010, 2011; Valenzuela et al., 2015. |
| At-risk children ($n = 5$) | Biological risk ($n = 4$) Social risk ($n = 1$) | Bassan et al., 2012; Chmait et al., 2015; González et al., 2013; McCall et al., 2013; Vanderbilt et al., 2014. |
| Children with developmental disorders ($n = 15$) | Autism spectrum disorders ($n = 6$) Cerebral palsy ($n = 4$) Down syndrome ($n = 1$) Congenital malformation ($n = 1$) Visual impairment ($n = 1$) Language impairment ($n = 1$) Severe motor impairments ($n = 1$) | Goldin et al., 2014; López et al., 2007; Matson et al., 2010b; Medeiros et al., 2012; Sipes et al., 2011; Turygin et al., 2013a. Barreno et al., 2011; Barreno et al., 2013; Devesa et al., 2011; Mancías-Guerra et al., 2014. Matson et al., 2010a. Gòmez-Arriaga et al., 2012. Garcia-Filion et al., 2008. Iverson & Braddock, 2011. Jones et al., 2012 |
| Mixed sample of children ($n = 4$) | Autism spectrum disorders and atypically developing children ($n = 2$) At-risk and Typically developing children ($n = 2$) | Matson et al., 2011; Turygin et al., 2013b. Rizzoli-Córdoba et al., 2013; Snider et al., 2009. |

used as assessment tools to analyze the influence of a specific medical procedure or the efficacy of a developmental intervention. The BDIs were used to measure intervention efficacy across studies focused on typically developing children, at-risk children, children with birth complications, and children with developmental disorders. Finally, the BDI-2 was used to investigate associations between risk factors and suspected developmental delays in three studies.

## DISCUSSION

Considering that developmental assessment scales are important tools to identify developmental delays and investigate associations between developmental risks and outcomes for young children, the purpose of this study was to conduct a systematic review of the literature about the BDIs. This inventory has been considered an important assessment tool with appropriate features for use in clinical settings and research studies. Overall, the BDIs have been used for a variety of purposes and objectives in the last 10 years, including differential diagnosis, longitudinal follow-up, program eligibility, treatment efficacy, examination of developmental trajectories, and investigation of the psychometric properties of other infant assessment measures. These studies provide support for the variety of potential research and clinical applications for the BDIs. It is interesting to note that despite the positive view of the psychometric properties of the BDIs established by the test developers, which were often highlighted in the reviewed studies, none of these studies focused on conducting independent examination of the psychometric properties of the BDIs

**Table 3.** Main Purpose for Using the BDIs, According to BDI Versions

| Purposes | BDI Versions | References |
|---|---|---|
| To identify developmental outcomes (*n* = 18) | BDI-1 | Garcia-Filion et al., 2008; López et al., 2007; Ternera, 2010, 2011. |
| | BDI-2 | Goldin et al., 2014; González et al., 2013; Matson et al., 2010a, 2010b; Medeiros et al., 2012; Nip et al., 2011; Sipes et al., 2011; Turygin et al., 2013a, 2013b. |
| | Screening | Barreno et al., 2011, 2013; Gòmez-Arriaga et al., 2012; Iverson & Braddock, 2011; Moura et al., 2010a. |
| As a convergent and divergent validity measure (*n* = 4) | BDI-1 | Rydz et al., 2006; Snider et al., 2009. |
| | BDI-2 | Matson et al., 2011; Rizzoli-Córdoba et al., 2013. |
| To analyze the influence of a specific medical procedure or to test efficacy intervention (*n* = 09) | BDI-1 | Jones et al., 2012; McCall et al., 2013; Seguel et al., 2012; Valenzuela et al., 2015 |
| | BDI-2 | Bassan et al., 2012; Bowen et al., 2012; Chmait et al., 2015; Mancías-Guerra et al., 2014. |
| | Screening | Devesa et al., 2011. |
| To investigate associations between risk factors and suspected developmental delay (*n* = 3) | BDI-2 | Vanderbilt et al., 2014. |
| | Screening | Barros et al., 2010; Moura et al., 2010b. |

*Note.* BDI = Battelle Developmental Inventory.

beyond citing information provided by the publishers within the instrument manuals. There is a clear need for this independent research on the psychometric properties of the BDIs.

Although the BDIs have had extensive use for general assessment and screening, it is important to emphasize that current research is not sufficient to validate their use for critical decision-making in early intervention in general, and especially for children with severe developmental disabilities. It was noted that in this review, 44% of the studies used the BDIs to identify developmental outcomes, highlighting the commonplace use of the BDIs for this purpose. However, the 6 cross-sectional studies that used the BDI-2 for specific purposes (compared the BDI-2 to another measure or to the accuracy for program eligibility by independent expert judgments) do not provide sufficient evidence that the BDI-2 is usefull to determine developmental outcomes or eligibility within the natural context of a US state or international territories. It will be crucial for more independent research to be conducted within the fields of Early Childhood Special Education (ECSE) and Early Intervention (EI) to determine the appropriateness and effectiveness of BDIs for specific purposes within these programs. Overall, there is a lack of robust psychometric studies about many standardized measures to support their validity in accomplishing each of the major purposes for assessments in EI/ECSE (Bagnato et al., 2014). Considering that the BDI-2 was recently identified as the most popular

instrument used for assessing early child development in the United States (Lee et al., 2015), it is important to conduct independent studies attesting to the BDIs' validity and reliability to meet all IDEA standards, especially for children with developmental disorders.

There were a few studies identified that were conducted with children with developmental disorders that discuss the validity of BDIs for assessment in ECSE/EI for eligibility determination. López et al. (2007) affirmed that the BDI-1 is a good assessment tool to aide in the diagnosis of ASD supported by data from other studies of children with ASD. Another Spanish study demonstrates the validity of the screening version of the BDI to identify children with developmental delay, even before 12 months (Barreno et al., 2011). Finally, two studies were conducted in an IDEA Part C early intervention program that supported the validity of the BDI-2 as a tool for screening, eligibility, and monitoring children with ASD (Goldin et al., 2014; Sipes et al., 2011). Sipes and colleagues conducted research with infants and toddlers with ASD and atypical development to develop cutoff scores for the BDI-2 in order to use this measure as a screening tool to differentiate young children with possible ASD. Based on a psychometric study, those authors found a cutoff score with high sensitivity that can be used for screening children with developmental disorders, such as ASD. We can conclude that those studies are an initial attempt to investigate the validity and reliability of using the BDIs to meet IDEA standards for at-risk and children with developmental disorders, but further research is still needed.

Results also revealed that relatively few studies have been published focused on use of the BDI-2 in the last 10 years, despite frequent use of this test in clinical practice. Of the 34 articles found, 44.12% of them used the first version of BDI, even though the BDI-2 has been published since 2005 (Newborg, 2005a, 2005b). Considering that this review focused on articles from 2005 to 2015, after the publication of the BDI-2, it was expected to find primarily articles that had used the new version of this test, but this has not occurred. This may be partially due to lag times between research studies being conducted and studies being published or decisions to keep an original version of a measure in a longitudinal study. However, it is also noted that the majority of studies with continued use of the original BDI-1 were conducted outside of the United States. This suggests a gap between the revised measure being published in the United States and it being put into regular use in other countries, with the use of the outdated version of the BDI continuing long after the BDI-2 was published. Likewise, this highlights the fact that the 34 studies found in the last 10 years, mostly on the first edition of BDI, are not sufficient to assert the reliability, validity, and utility of the BDI-2 for ECSE/EI purposes and appropriateness of specific items for these populations. Therefore, it is important to conduct well-designed independent studies on the English and Spanish versions of the BDI-2 and BDI-2 screener to determine the appropriateness of this assessment instrument for their current usages in the ECSE/EI field.

Many of the reviewed studies were conducted with children with developmental disorders and those at risk for developmental delays. However, it is important to note that while the manual for the BDIs provides some guidance on allowable accommodations for children with specific impairments (e.g., hearing, vision, significant neuromotor impairments), the BDIs have shown limited involvement in the "universal design" movement to improve the appropriateness and adaptability of the scale for use with children with significant disabilities. It will be important to consider how the BDIs fit with state policies and procedures such as those of the California Department of Education to develop assessment measures that incorporate universal design, such as the Desired Results Developmental Assessment and Desired Results Access versions (California Department of Education, Early Education and Support Division, 2015). Bagnato et al. (2014) identify the BDI as a conventional

test that has relatively low consumer social validity for ECSE/EI purposes, despite being the most popular among interdisciplinary professionals and teachers (Lee et al., 2015). It will be important for further research to examine ways that conventional tests such as the BDIs can better incorporate the need for enhanced social validity and universal design to be used effectively for ECSE/EI purposes while maintaining the practical and psychometric benefits that make the measures popular for use in these settings.

A number of articles that focused on individuals with developmental delays and disabilities were from studies conducted in the Louisiana Early Steps Program (IDEA Part C Program) using the BDI-2, with the objective to investigate relationships between ASD symptoms and developmental variables (Goldin et al., 2014; Matson et al., 2010a, Matson et al., 2010b; Medeiros et al., 2012; Sipes et al., 2011; Turygin et al., 2013a, 2013b). These recent studies are of particular importance to examine because they target a population of children in the United States with whom the BDI-2 has widespread clinical use, namely, those children seeking eligibility for and receiving services through IDEA Part C. In these studies from Louisiana, the BDI-2 standardization sample included a small number of children with disabilities. Despite the fact that the BDI manual allows examiners to make minor modifications on the test items for assessing children with disabilities (Newborg, 2005a), none of those studies from Louisiana Early Steps Program cited any adaptation or modification to adjust the test for their specific population. According to the Louisiana's Early Intervention System (2014), the BDI-2 is commonly used to evaluate the development of children from birth to 3 years to determine eligibility for services in IDEA Part C Early Intervention Systems, such as is done in Louisiana. However, the articles reviewed in this paper showed how the BDI-2 evaluations conducted in that program could be used for research purposes. These research findings from the Louisiana Early Steps Program provide scientific evidence about the utility of the BDI-2 for infants and toddlers with developmental delays. On the contrary, it is important to discuss that the articles from the Louisiana Early Steps Program are not independent studies, because they were conducted with a population from the same database.

In addition, we found that 41.17% of the studies were being conducted in the United States, whereas 35.29% were studies with Hispanic populations in other countries (Spain, Colombia, Chile, and Mexico). This is not surprising given that both versions of the BDI are normed using an English-speaking American population, and the publishers developed translated versions, but without validation standards, of the BDIs in Spanish (Newborg et al., 1996; Newborg, 2005b). In several articles, the authors highlighted the availability of a Spanish version of the test as a reason to choose the BDIs (Gòmez-Arriaga et al., 2012; Ternera, 2010, 2011; Valenzuela et al., 2015; Vanderbilt et al., 2014). Although there is not a standardized version or translation of the BDI-1 or BDI-2 for a Brazilian population, we found three articles from Brazil (Barros et al., 2010; Moura et al., 2010a, 2010b). Articles with research conducted in Israel, Pakistan, and Russia were also found (Bassan et al., 2012; Bowen et al., 2012; McCall et al., 2013). Except for the Israeli study, where the authors did not mention any considerations about the BDI (Bassan et al., 2012), the authors of the other articles discussed the need for validation studies for the BDI using non-American populations. The validity of using the BDI in other languages and cultures, while only English norms are currently available is an important area for further research. One of the critical first steps in this process will be research focused on standardization of the Spanish translation of the BDI-2 with a normative sample of Spanish speakers.

In several articles reviewed (Barros et al., 2010; Bassan et al., 2012; Moura et al., 2010a, 2010b), the authors highlighted the need to interpret results of the BDIs carefully when the scales were used with a nonnormed population, such as the Pakistani and Brazilian population studies. In spite of

the fact that all of those articles reported careful attempts to translate and adapt the BDIs (Bowen et al., 2012; Moura et al., 2010a, 2010b), this is not a guarantee for accurate developmental quotients among those population. Psychometric validation studies with non-American, non-English–speaking populations are needed to ensure the reliability and validity of data obtained from BDI assessments and their applicability in these settings for identifying developmental status and planning future interventions with diverse populations. It was interesting to note that the strong psychometric properties of the BDIs were identified as a reason for selecting this tool in studies outside the United States, despite the lack of norms for non-American, non–English-speaking populations.

This review found that published research including the BDI, BDI-2, and Screening test of both versions of the BDI in the past 10 years has focused on using these tools to screen for developmental delays and to identify developmental outcomes in typically developing children, those deemed to be at risk, and children with established developmental delays and disabilities. Overall, according to this review, the BDIs are considered important and reliable assessment tools with good psychometric properties and sensitivity to evaluate general child development and specific domains. However, much additional independent research is needed to validate these assertions about the BDIs. Finally, it is important to point to the necessity of more validation studies to improve the use of BDI-2 in non-American and non–English-speaking populations, in order to ensure accurate results from development assessment in those populations for future studies and clinical purposes.

## REFERENCES

Bagnato, S. J., Goins, D., Pretti-Frontczak, K., & Neisworth, J. T. (2014). Authentic assessment as "best practice" for early childhood intervention: National consumer social validity research, *Topics in Early Childhood Special Education*, *34*(2), 116–127.

Barreno, E. M., López, M. J. R., & Menendez, M. J. C. (2011). La prueba de cribado del inventario de desarrollo de Battelle para la detección precoz de alteraciones del desarrollo en parálisis cerebral. *Anales de Pediatría*, 75(6), 372–379. Retrieved from http://dx.doi.org/10.1016/j.anpedi.2011.06.004

Barreno, E. M., López, M. J. R., & Menendez, M. J. C. (2013). La parálisis cerebral como una condición dinámica del cerebro: Un estudio secuencial del desarrollo de niños hasta los 6 años de edad. *Universitas Psychologica*, *12*(1), 119–127. Retrieved from http://revistas.javeriana.edu.co/index.php/revPsycho/article/viewFile/840/3968

Barros, A. J. D., Matijasevich, A., Santos, I. S., & Halpern, R. (2010). Child development in a birth cohort: Effect of child stimulation is stronger in less educated mothers. *International Journal of Epidemiology*, *39*, 294–296. Retrieved from http://dx.doi.org/10.1093/ije/dyp316

Bassan, H., Eshel, R., Golan, I., Kohelet, D., Sira, L. B., Mandel, D., . . . External Ventricular Drainage Study Investigators, (2012). Timing of external ventricular drainage and neurodevelopmental outcome in preterm infants with posthemorrhagic hydrocephalus. *European Journal of Paediatric Neurology*, *16*, 662–670. Retrieved from http://dx.doi.org/10.1016/j.ejpn.2012.04.002

Bowen, A., Agboatwalla, M., Luby, S., Tobery, T., Ayers, T.,, & Hoekstra, R. M. (2012) Association between intensive handwashing promotion and child development in Karachi, Pakistan. *Archives of Pediatrics & Adolescent Medicine*, *166*(11), 1037–1044. Retrieved from http://dx.doi.org/10.1001/archpediatrics.2012.1181

California Department of Education, Early Education and Support Division (2015). *DRDP (2015): A developmental continuum from early infancy up to kindergarten entry*. Retrieved from https://www.desiredresults.us/

Chmait, R. H., Baskin, J. L., Carson, S., Randolph, L. M., & Hamilton, A. (2015). Treatment of alpha(0)-thalassemia (–SEA/–SEA) via serial fetal and post-natal transfusions: Can early fetal intervention improve outcomes? *Hematology*, *20*(4), 2017–222. Retrieved from http://dx.doi.org/10.1179/1607845414Y.0000000187

Devesa, J., Alonso, B., Casteleiro, N., Couto, P., Castañón, B., Zas, E., . . . Reimunde, P. (2011). Effects of recombinant growth hormone (GH) replacement and psychomotor and cognitive stimulation in the neurodevelopment of GH deficient (GHD) children with cerebral palsy: A pilot study. *Therapeutics and Clinical Risk Management*, 7, 199–206. Retrieved from http://dx.doi.org/10.2147/TCRM.S21403

Florida's Early Intervention System. (2015). *Early steps operations guide*. Retrieved from http://www.floridahealth.gov/AlternateSites/CMS-kids/home/resources/es_policy/es_Policy.html

Garcia-Filion, P., Epport, K., Nelson, M., Azen, C., Geffner, M. E., Fink, C., . . . Borchert, M. (2008). Neuroradiographic, endocrinologic, and ophthalmic correlates of adverse developmental outcomes in children with optic nerve hypoplasia: A prospective study. *Pediatrics*, *121*(3), 653–659. Retrieved from http://dx.doi.org/10.1542/peds.2007-1825

Goldin, R. L., Matson, J. L., Beighley, J. S., & Jang, J. (2014). Autism spectrum disorder severity as a predictor of inventory—second edition (BDI-2) scores in toddlers. *Developmental Neurorehabilitation*, *17*(1), 39–43. Retrieved from http://dx.doi.org/10.3109/17518423.2013.839585

Gòmez-Arriaga, P., Herraiz, I., Puente, J. M., Zamora-Crespo, B., Nunez-Enamorado, N., & Galindo, A. (2012). Mid-term neurodevelopmental outcome in isolated mild ventriculomegaly diagnosed in fetal life. *Fetal Diagnosis and Therapy*, *31*, 12–18. Retrieved from http://dx.doi.org/10.1159/000331408

González, M. B., Pacheco-Sánchez-Lafuente, F. J., Roca-Ruíz, C., Hurtado-Suazo, J. A., & Díaz-López, M. A. (2013). Relationship between severe acidemia, verbal abilities, and behavior in a Spanish cohort of 5-year-old children born at term. *Journal of Developmental & Behavioral Pediatrics*, *34*, 102–110. Retrieved from http://dx.doi.org/10.1097/DBP.0b013e31827d582a

Individuals with Disabilities Education Act (IDEA). (2004). 20 U.S.C.§1414(1)-(3), 1412(a)(6)(B) Retrieved from http://www.wrightslaw.com/idea/law/section1414.pdf

Iverson, J. M., & Braddock, B. A. (2011). Gesture and motor skill in relation to language in children with language impairment. *Journal of Speech, Language, and Hearing Research*, *54*, 72–86. Retrieved from http://dx.doi.org/10.1044/1092-4388(2010/08-0197)

Jones, M. A., McEwen, I. R., & Neas, B. R. (2012). Effects of power wheelchairs on the development and function of young children with severe motor impairments. *Pediatric Physical Therapy*, *24*(2), 131–140. Retrieved from http://dx.doi.org/10.1097/PEP.0b013e31824c5fdc

Lee, D., Bagnato, S. J., & Pretti-Frontczak, K. (2015). Utility and validity of authentic assessments and conventional tests for international early childhood intervention purposes: Evidence from U.S. national social validity research. *Journal of Intellectual Disability Diagnosis and Treatment*, *3*, 164–176.

López, Y. S., Granados, T. G., & Vázquez, V. S. (2007). Inventario de Desarrollo Battelle como instrumento de ayuda diagnóstica em el autismo. *Revista de laAsociaciónEspañola de Neuropsiquiatría*, *XXVII*(100),

303–317. Retrieved from http://www.redalyc.org/articulo.oa?id=265019653004

Louisiana's Early Intervention System. (2014). *Early steps program policy*. Retrieved from http://www.dhh.state.la.us/assets/docs/OCDD/EarlySteps/FinalPolicyOctober2014OSEPJan2015.pdf

Macy, M., Bagnato, S. J, Macy, R., & Salaway, J. (2016). Conventional tests and testing for early intervention eligibility: Is there an evidence base? *Infants and Young Children*, *28*(2), 182–204.

Mancías-Guerra, C., Marroquín-Escamilla, A. R., González-Llano, O., Villarreal-Martínez, L., Jaime-Perez, J. C., García-Rodríguez, F., . . . Gómez-Almaguer, D. (2014). Safety and tolerability of intrathecal delivery of autologous bone marrow nucleated cells in children with cerebral palsy: An open-label phase I trial. *Cytotherapy*, *16*, 810–820. Retrieved from http://dx.doi.org/10.1016/j.jcyt.2014.01.008

Matson, J. L., Hess, J. A., Sipes, M., & Horovitz, M. (2010a). Developmental profiles from the Battelle developmental inventory: A comparison of toddlers diagnosed with Down syndrome, global developmental delay and premature birth. *Developmental Neurorehabilitation*, *13*(4), 234–238. Retrieved from http://dx.doi.org/10.3109/17518421003736032

Matson, J. L., Neal, D., Fodstad, J. C., & Hess, J. A. (2010b). The relation of social behaviours and challenging behaviours in infants and toddlers with autism spectrum disorders. *Developmental Neurorehabilitation*, *13*(3), 164–169. Retrieved from http://dx.doi.org/10.3109/17518420903270683

Matson, J. L., Wilkins, J., & Fodstad, J. C. (2011). The validity of the baby and infant screen for children with aUtIsm traits: Part 1 (BISCUIT: Part 1). *Journal of Autism and Developmental Disorders*, *41*, 1139–1146. Retrieved from http://dx.doi.org/10.1007/s10803-010-0973-3

McCall, R. B., Groark, C. J., Fish, L., Muhamedrahimov, R. J., Palmov, O. I., & Nikiforova, N. V. (2013). Maintaining a social-emotional intervention and its benefits for institutionalized children. *Child Development*, *84*(5), 1734–1749. Retrieved from http://dx.doi.org/10.1111/cdev.12098

Medeiros, K., Kozlowski, A. M, Beighley, J. S., Rojahn, J., & Matson, J. L. (2012). The effects of developmental quotient and diagnostic criteria on challenging behaviors in toddlers with developmental disabilities. *Research in Developmental Disabilities*, *33*, 1110–1116. Retrieved from http://dx.doi.org/10.1016/j.ridd.2012.02.005

Moura, D. R., Costa, J. C., Santos, I. S., Barros, A. J. D., Matijasevich, A., Halpern, R., . . . Barros, F. C. (2010a). Natural history of suspected developmental delay between 12 and 24 months of age in the 2004 Pelotas birth cohort. *Journal of Paediatrics and Child Health*, *46*, 329–336. Retrieved from http://dx.doi.org/10.1111/j.1440-1754.2010.01717.x

Moura, D. R., Costa, J. C., Santos, I. S., Barros, A. J. D., Matijasevich, A., Halpern, R., . . . Barros, F. C. (2010b). Risk factors for suspected developmental delay at age 2 years in a Brazilian birth cohort. *Paediatric and Perinatal Epidemiology*, *24*, 211–221. Retrieved from http://dx.doi.org/10.1111/j.1365-3016.2010.01115.x

Newborg, J., Stock, J. R., Wnek, L., Guidubaldi, J., & Svinicki, J. (1984). *Battelle Developmental Inventory: Examiner's Manual*. Allen, TX: DLM LINC Associates.

Newborg, J., Stock, J. R., & Wnek, L. (1996). *Inventario de desarrollobattelle*. Madrid, Spain: TEA.

Newborg, J. (2005a). *Battelle developmental inventory—second edition*. Itasca, IL: Riverside Publishing.

Newborg, J. (2005b). *Battelle developmental inventory, 2nd edition, Spanish, user's guide*. Itasca, IL: Riverside Publishing.

Nip, I. S. B., Green, J. R., & Marx, D. B. (2011). The co-emergence of cognition, language, and speech motor control in early development: A longitudinal correlation study. *Journal of Communication Disorders*, *44*(2), 149–160. Retrieved from http://dx.doi.org/10.1016/j.jcomdis.2010.08.002

Rizzoli-Córdoba, A., Schnaas-Arrieta, L., Liendo-Vallejos, S., Buenrostro-Márquez, G., Romo-Pardo, B., Carreón-García, J., . . . Onofre Muñoz-Hernández, O. (2013). Validación de un instrumento para la detección oportuna de problemas de desarrollo en menores de 5 años en México. *Boletín médico del Hospital Infantil de México*, *70*(3), 195–208. Retrieved from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1665-11462013000300003

Roma-Pardo, B., Liendo-Vallejos, S., Vargas-Lopez, G., Rizzoli-Cordoba, A., & Buenrostro-Marquez, G. (2012). Pruebas de tamizaje de neurodesarrollo global para niños menores de 5 años de edad validadas en Estados Unidos y Latinoamérica: Revision sistemática y análisis comparative. *Bol Med Hosp Infant Mex*, *69*(6):450–462. Retrieved from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1665-11462012000600006&lng=es&tlng=es

Rydz, D., Srour, M., Oskoui, M., Marget, N., Shiller, M., Birnbaum, R., . . . Shevell, M. I. (2006). Screening for developmental delay in the setting of a community pediatric clinic: A prospective assessment of parent-report questionnaires. *Pediatrics*, *118*(4), e1178–e1186. Retrieved from http://dx.doi.org/10.1542/peds.2006-0466

Seguel, X., Edwards, M., Hurtado, M., Bañados, J., Covarrubias, M., Wormald, A., . . . Héctor Galaz y Alejandra Sánchez, A.. (2012). ¿Quéefectotieneasistir a sala cuna y jardín infantil desde lostres meses hasta loscuatroaños de edad? Estudio longitudinal enla junta nacional de jardines infantiles. *Psykhe*, *21*(2), 87–104. Retrieved from http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-22282012000200008&lng=es&tlng=es

Sipes, M., Matson, J. L., & Turygin, N. (2011). The use of the Battelle Developmental Inventory–Second Edition (BDI-2) as an early screener for autism spectrum disorders. *Developmental Neurorehabilitation*, *14*(5), 310–314. Retrieved from http://dx.doi.org/10.3109/17518423.2011.598477

Snider, L., Majnemer, A., Mazer, B., Campbell, S., & Bos, A. F. (2009). Prediction of motor and functional outcomes in infants born preterm assessed at term. *Pediatric Physical Therapy*, *21*(1), 2–11. Retrieved from http://dx.doi.org/10.1097/PEP.0b013e3181957bdc

Ternera, L. A. C. (2010). Importancia del desarrollo motor en relación con los procesos evolutivos dellenguaje y la cognición en niños de 3 a 7 años de la ciudad de Barranquilla (Colombia). *Salud Uninorte*, *26*(1), 65–76. Retrieved from http://redalyc.org/articulo.oa?id=81715089008

Ternera, L. A. C. (2011). Características del desarrollo adaptativo en niños de 3 a 7 años de la ciudad de Barranquilla. *Psychologia: Avances de la disciplina*, *5*(2), 95–104. Retrieved from http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1900-23862011000200008&lng=en&tlng=es

Turygin, N., Matson, J. L., Beighley, J., & Adams, H. (2013a). The effect of DSM-5 criteria on the developmental quotient in toddlers diagnosed with autism spectrum disorder. *Developmental Neurorehabilitation*, *16*(1), 38–43. Retrieved from http://dx.doi.org/10.3109/17518423.2012.712065

Turygin, N., Matson, J. L., Konst, M., & Williams, L. (2013b). The relationship of early communication concerns to developmental delay and symptoms of autism spectrum disorders. *Developmental Neurorehabilitation*, *16*(4), 230–236. Retrieved from http://dx.doi.org/10.3109/17518423.2012.756950

Valenzuela, M. J. G., Montiel, D. L., & Mesa, E. S. G. (2015). Exposure to synthetic oxytocin during delivery and its effect on psychomotor development. *Developmental Psychobiology*, *57*(8), 908–920. Retrieved from http://dx.doi.org/10.1002/dev.21321

Vanderbilt, D. L., Schrager, S. M., Llanes, A., Hamilton, A., Seri, I., & Chmait, R. H. (2014). Predictors of 2-year cognitive performance after laser surgery for twin-twin transfusion syndrome. *American Journal of Obstetrics & Gynecology*, *211*, 388.e1–7. Retrieved from http://dx.doi.org/10.1016/j.ajog.2014.03.050