Measuring early child development across low and middle-income countries: A systematic review

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Abstract
The Sustainable Development Goals mandate that by 2030, all children should have access to quality early child development opportunities, healthcare and pre-primary education. Yet validated measures of ECD in low and middle income countries (LMICs) are rare. To address this gap, a Systematic Review (SR) of measures available to profile the development of children between the ages of 0–5 years in LMICs was undertaken. Drawing on education, psychology and health databases, we identified reliable, valid or measures adapted for use in LMICs for either assessments of children’s development or their learning environments. The inclusion criteria were (1) peer reviewed papers published between January 2009 and May 2019; (2) assessment tools used to measure cognitive/language development or the early years or home environment in at least one LMIC; (3) report of the psychometric properties (validity and reliability) of the tool, and/or description of the cultural adaptability/translation process undertaken before applying it to a LMIC. Two hundred and forty-nine available records published in the last decade in peer-review journals and nine relevant systematic literature reviews were identified. Fifty-seven records were qualitatively synthesised based on their psychometric properties and previous application in LMICs. A further seven dimensions outlined in

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Tables 4 and 5 identified specific characteristics of the tools from target age, administration method, domains, battery, accessibility, language and country/institution. We suggest these 12 key considerations for the selection of measurement tools that are applicable to effectively assess ECD in LMICs.

**Keywords**
child stunting, cognitive development, early childhood development, ECE setting, LMIC, home environment, systematic review

**Introduction: Opportunities and challenges of measuring child development and learning environments across LMICs**

Supporting, monitoring and measuring ECD outcomes is a global priority (McCoy et al., 2018a). In 2015, the United Nations adopted the 2030 agenda for the Sustainable Development Goals (SDGs) to end poverty and advance human development. The need to monitor and measure ECD underpins many of the goals. Identifying the kinds of environments that support young children’s learning are critical to address developmental challenges. One such challenge is childhood stunting.

Childhood stunting is the impaired growth and development that children experience as a result of poor nutrition, repeated infection and inadequate psychosocial stimulation. Stunting not only reduces linear growth but has major consequences for a child’s overall development, including poorer cognition and educational performance, with lifelong impacts on economic and social wellbeing (Williams and Suchdev, 2017). Stunting goes beyond the interaction between poor diets, nutrition, infectious disease and poor sanitation. Evidence suggests that interventions involving psychosocial stimulation provide much larger effect sizes for cognitive and language outcomes for children who are stunted, than interventions that focus on nutritional supplements alone (Aboud and Yousafzai, 2015). The data thus demonstrate the need to examine the wider sociocultural contexts in which children develop, highlighting the importance of capturing the child’s biodevelopmental niche, that is, the interaction between the child’s biological, physical and social environments (Super and Harkness, 2002).

Given the challenges raised by childhood stunting and the multifactorial drivers and impacts on development, interdisciplinarity is required to capture development. Crucially, achieving this objective requires reliable, valid and culturally sensitive assessments to profile both children’s development and their learning environments. Identifying the impact of different biodevelopmental niches also necessitates comparisons across countries and settings.

This SR aims to identify and evaluate potential measures for use as part of a large-scale interdisciplinary study UKRI GCRF Action Against Stunting Hub (2019–2024) working in India, Indonesia and Senegal. Key to the success of the study is providing comparative robust data about children’s development and learning contexts. Our ultimate aim is to provide a set of key considerations (outlined in Tables 2–5) which should inform decisions about which tool to use when carrying out studies in LMICs in general, and to inform specifically the education and cognition workstream of the Action Against Stunting Hub.

Reliable and valid measures provide the opportunity to track development, target needs, evaluate the efficacy of interventions and capture the impact of challenges to development both from within the child (Dockrell and Connelly, 2013) and the environment (Cabell et al., 2011). Without valid, reliable contextually sensitive tools, capturing the impacts of interventions and ECD at scale across different cultural contexts is likely to be misleading as neither baselines nor trajectories will be comparable. However, profiling early development raises substantial challenges. It is a period marked by significant growth in language, cognition, motor development and socioemotional behaviour, so markers of development are both quantitatively and qualitatively different across the period. This makes prediction over time challenging and often unreliable (Dockrell et al., 2015) particularly when some skills will be at floor at the earliest testing points. For example, 6-month
old infants will have no expressive language while other indicators of development such as some motor skills, can reach ceiling effects relatively quickly. These developmental patterns indicate the importance of using concurrent measures of development to identify patterns of need and to use developmental trajectories only when there is a population-based comparison as a benchmark. The ways in which a child’s developmental competencies can be measured, also varies. Profiling domains of development may be based on either criterion referenced measures or normative data; as we shall see normative data are often lacking in LMICs. Measures may involve direct assessment of the child’s skills through the use of standardised tests or observations, or be collected by using a proxy, such as a parent or teacher reports. Direct assessments of children’s skills provide more robust and valid measures of development.

The challenges for drawing comparisons across populations varies by type of measure and response format. For example, norm-referenced tests, which are reliable and valid, provide information about where an individual lies in comparison to peers of the same age. Norm-referenced tests can focus on hypothetical constructs such as non-verbal ability or specific abilities such as naming vocabulary. The basic principle of norm-referenced tests is to define a continuum of performance from lowest to highest and the measure assigned to a particular individual locates his/her position on that continuum relative to the standardisation sample. Tests can only provide appropriate norms if they are used for the population for which they were intended. Norms from high-income (often USA, UK and Australia) countries will not be appropriate for LMICs samples where children experience very different social contexts, languages and have access to different educational opportunities. By corollary, norms that are standardised on monolingual children may not be appropriate for bilingual or multilingual children. Norms must also be current as they become outdated by about three points a decade (Trahan et al., 2014).

To augment child-level data in the early years, it is also important to capture the child’s learning environment, profiling both the home and the early years settings (Fernald et al., 2009, 2017). Both environments have the potential to support and enhance ECD. The home learning environment includes the physical characteristics but also, importantly, the interactions which occur between the child and their families or primary caregivers within the home. These interactions offer both implicit and explicit learning opportunities for the child. The home environment is a key predictor of cognitive and socio-emotional development, and its effects are evident throughout formal education (Bradley and Caldwell, 1976; Olson et al., 1990). Home interactions, particularly maternal responsiveness, mediate the impact of social disadvantage on development (Evans et al., 2010; Foster et al., 2005). The impact of the home environment is complemented by the opportunities afforded by the early years environment.

The ‘quality’ of early years settings impacts on children’s development (Sylva et al., 2006). Assessments of quality typically consider both structural (e.g. child ratios, group size, caregiver’s qualifications and training) and process factors (e.g. caregiving practices, children’s experiences and caregiver–child interactions) that promote learning and development (World Health Organization, 2004). Whilst the nature of the environment varies across different types of settings, there is a strong relationship between structural and observed process characteristics. For example, as with the data from the home environment, process features such as caregivers’ warmth and responsiveness (Perlman et al., 2016), directly impact on positive children’s outcomes. Environments with high quality processes offer children rich opportunities to interact with adults, peers and materials (World Health Organization, 2004). Key factors for maintaining quality in preschool settings include child-adult pedagogical interactions, the curriculum, learning materials, teachers’ perceptions of learning and professional development opportunities (Mathers, 2021; Rao et al., 2019). Whether the same constructs generalise to LMICs is an important empirical question. Current understanding indicates that assessing learning environments need to consider the specific cultural context of what makes a positive learning environment (Raikes et al., 2019). There are therefore strong empirical and
theoretical reasons to profile children’s development, identifying strengths and needs, as well as capturing the learning environment. Even in countries in the global North—where a wide range of assessment tools have been developed and standardised—there remain significant debates about which measures to use for which children at which point of development and in which settings.

While more than 80% of the global childhood population resides in LMICs, most ECD measures come from high income countries (Rao et al., 2019). Child Development Assessment tools (CDATs) in LMICs tend to follow one of four formats (Sabanathan et al., 2015):

1. a standard western CDAT with no adaptations;
2. a western CDAT translated (linguistic equivalence) and/or adapted for the local cultural environment (cultural equivalence);
3. an amalgamation of a number of translated and/or adapted items from several different western CDATs; or
4. a locally developed, culturally specific CDAT consisting of original items designed to be relevant to the population of interest.

Each of these approaches raises challenges for use and interpretation. Locally developed tools limit comparison across countries and settings, reducing our understanding of biodevelopmental niches. By contrast, measures designed and standardised in more affluent western settings with no appropriate adaptations will not be culturally appropriate. Norms are likely to be inaccurate and developmental criteria identified in criterion referenced assessments may not be culturally appropriate. There are thus a series of questions that need to be considered in any study aiming to profile the skills of children in LMICs (McCoy et al., 2018a, 2018b). In addition to the challenges with standardisation, measures which rely on self-completion by parents or professionals need to consider the literacy level of the respondents and the way in which items are interpreted within particular contexts. As McCoy et al. (2018b) argue ‘few valid and reliable tools exist for capturing ECD at scale across cultural contexts’ (p.58). What remains clear is that assessment tools developed in high-income countries (HICs) need to be modified before they are applied in LMICs. Cultural adaptation includes (a) establishing the appropriateness of target items, (b) translation/back translation of the measure and the underlying construct(s), (c) adaptation of the content and the procedure of administration, (d) piloting and iterative testing of the tool (Fernald et al., 2009). Without cultural adaptation, there is no guarantee that the same underlying abilities are being captured (Sabanathan et al., 2015). In sum, measuring ECD across LMICs poses significant challenges that need to be recognised when reporting child development profiles and profiling ECD environments.

Accordingly, the following research questions guided our work:

(1) What assessment tools have been used by peer-review published studies conducted in the last decade in LMICs to profile children aged 0–5 years old’s cognitive development and learning environment?

(2) What assessment tools have been recommended by relevant previous systematic reviews to measure children aged 0–5 years old’s cognitive development and learning environment?

**Methodology and methods**

To answer RQ1 the SR aimed to identify reliable and valid tools which can be used in LMICs to profile children’s cognition and their learning environment. To answer RQ2, we included previous relevant systematic literature reviews (see ** in References). The methods entailed a systematic searching and screening of published literature using a set of inclusion and exclusion criteria:
**Selection criteria**

The inclusion criteria were:

- peer reviewed papers published between January 2009 and May 2019
- assessment tools used to measure cognitive/language development or the early years or home environment used in at least one LMIC
- report of the psychometric properties (validity and reliability) of the tool, and/or description of the cultural adaptability/translation process undertaken before applying the tool to a LMIC.

We excluded studies that:

- Included assessments tools that were developed, standardised and used only on HIC
- Applied the tool to age groups different from our study
- Did not provide information about the tool’s psychometric properties (validity and reliability) and/or a description of the cultural adaptability/translation processes.

**Search terms**

Using the search terms provided in Table 1, 258 peer-review journal articles were retrieved through the authors’ university access system in relevant Education, Psychology and Health databases (ProQuest, PubMed, EconLit, PsychInfo, ERIC, Medline and Global Health). Two hundred and forty-six of these records were identified through database searching and 12 additional records were identified through hand search. Out of these, 68 duplicates were removed. From the 190 records screened, 68 were excluded based on their titles and abstracts following the inclusion and exclusion criteria described above. After assessing 122 full-text articles, 65 were excluded as they did not meet the inclusion criteria. The remaining 57 full text articles were included in our qualitative synthesis (see * in the Reference). In order to ensure the accuracy and reproducibility of the review, the fourth author replicated the screening and data extraction stages. The raw proportion of agreement between both coders was very high (97%). After providing further evidence to justify the inclusion/exclusion criteria of the nine studies where there was disagreement (3%), one study previously excluded was included. Figure 1 shows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines flowchart for article selection (Moher et al., 2015).

**Data extraction and coding**

Data from the 57 selected studies (43 reporting measures of child development, 14 environment) were entered into a spreadsheet. We extracted information from the studies using 25 criteria included in previous relevant SRs and agreed between the team: (a) Tool information (nine criteria); (b) Study information (four criteria), and (c) Tool application (12 criteria) (see Supplemental Appendix 1 for details). When information required for a full assessment of the feasibility of applying each tool was not provided, we imputed ‘not reported’ and interpreted it as an inconclusive area for future examination.

**Results: Qualitative synthesis**

Forty-two selected studies included in the SR reported 34 tools assessing children’s development at age 0–5 years old in 35 LMICs. Most of the tools reported validity ($n = 15$), but this was variably
Table 1. Search terms.

| TERMS | AND | AND | AND |
|-------|-----|-----|-----|
| ‘Assessment’, ‘questionnaire’, ‘checklist’, ‘tool’, ‘scale’, ‘measure’, ‘test’ | ‘Development’, ‘cognitive’, ‘cognitive development’, ‘cognition’ | ‘Child’, ‘infant’, ‘preschool’, ‘early childhood’, ‘early childhood education’, ‘early childhood education and care’ | ‘LMIC’, ‘Low-resourced setting’, ‘Global south’, ‘developing countries’, ‘low-income countries’, ‘low resource setting’ |

OR
‘Learning environment’, ‘environment’

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Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines flowchart for article selection (Moher et al., 2015).
described; some studies mentioned that the tool had ‘well established’, ‘satisfactory’ or ‘good’ validity without providing more details. Studies also varied in which type of validity was considered including concurrent, face, construct, content and convergent, without justifying these choices. When internal consistency was measured, Cronbach alpha varied between 0.23 (CREDI) and 0.95 (IDELA and CDSC). For most of the tools \( n = 16 \), reliability (inter-rater and test-retest) was also reported. Results varied greatly from poor (Kappa: 00 for some CREDI items) to very good reliability (BSID-I, STBAPD and MacArthur-Bates Communicative Development Inventory 0.99). Indeed, differential reliability (per domain as opposed to general) was reported, with lowest coefficients for social–emotional, and highest for motor, cognitive and language domains. For most of the tools, \( n = 15 \), cultural adaptation mentioned translation, backtranslation and adaptation of items to the new culture by the research team informed by local and international staff.

Nine environment tools were identified from the review. Ten studies reported five environment tools to measure the home environment at 0–5 years old in LMICs. These were applied in Bangladesh, Colombia, India, Indonesia, Mexico and Pakistan. Similarly to the developmental tools, there was marked heterogeneity in the way psychometric properties and cultural adaptation were reported. Again, there was variability in the type of validity reported including concurrent, face, construct, content and convergent, without justifying these choices. When internal consistency was measured, Cronbach alpha varied between adequate (Cronbach: 0.71 for FCI) to moderate (0.46 HSQ). Some studies simply referred back to previous research stating that the tool had good test-retest reliability or high inter-rater reliability without providing specific details. Cultural adaptation tended to mention that the instrument has been used worldwide previously, but with limited information regarding the process undertaken. Only the HOME included detailed information regarding its cultural adaptation.

From the five studies reporting four environmental tools to measure ECE settings, these were applied in four LMICs: China, Indonesia, Tanzania and South-Africa. Only the Chinese Early Childhood Environment Rating Scale (CECERS) mentioned good content, concurrent and criterion-related validity and the Early Childhood Environment Rating Scale-Revised (ECERS-R) referred to demonstrated predictive validity. The reliability of the three tools was reported to be good, ranging from 0.95 for ITERS-R to 0.97 for ECERS-R. Cultural adaptation tended to mention that the instrument has been used worldwide previously, but with limited detailed information regarding the process undertaken, except for Measuring Early Learning Quality and Outcomes (MELQO) (MELE module) where the process undergone was outlined.

Focusing on the 34 tools to assess children’s development at age 0–5 years old in LMICs, their target age was (1) 18–24 months \( n = 9 \); (2) 25–60 months \( n = 21 \) and 0–60 months \( n = 4 \). Focusing on the administration method, the majority of assessments were direct assessments of the child (23) and 11 were completed by caregivers. Developmental domains included language, cognition, motor skills and social-emotional development. However, the operationalisation of the domains varied by test and developmental phase. Overall, language \( n = 22 \) and cognition \( n = 17 \) were assessed in the majority of measures while motor skills \( n = 16 \) and socio-emotional development \( n = 14 \) were less common. More than a third of the studies did not include information about accessibility \( n = 11 \). From those that did, 14 required payment and nine were free to use. The tools were primarily produced in English \( n = 24 \), with five tools developed in local languages, such as French, Kigirima and Chinese. Five tools did not report the language of use. Most of the tools were developed in USA \( n = 13 \), while others were globally developed by international organisations such as World Bank, UNICEF and UNESCO \( n = 6 \). A few were developed in the UK \( n = 5 \) and countries such as India, Malawi, Kenya, Hong Kong and South Africa.

Focusing on the ten studies reporting five environment tools to measure the home environment at 0–5 years old in LMICs, all were suitable for 0–60 months \( n = 5 \). Regarding the administration
method, the majority of the tools were completed by caregivers \((n = 4)\), and one was a direct assessment. Three tools focused on cognitive and socioemotional caregiving with no information provided for the remaining two. Information about accessibility was often not provided \((n = 3)\), while two required payment. The dominant language of the tools was English \((n = 4)\), with one tool with missing information. Most of the tools were developed by international organisations such as UNICEF \((n = 3)\), with the remaining two, developed in USA and India, respectively.

Five studies reported four tools to measure the early learning environments at age 0–5 in LMICs. Regarding the target age, one was suitable for 0–60 months \((n = 1)\), and three, for 25–60 months \((n = 3)\). Three of the tools were direct assessments \((n = 3)\), one parent reported, and one was not reported. The environment tools also vary in terms of the domains assessed. All assessed the space and physical setting as well as the quality of interactions, curriculum planning and implementation and personnel \((n = 4)\), but varied in terms of the other included dimensions, such as personal care routines \((n = 2)\), inclusiveness \((n = 1)\) and play \((n = 1)\). Scales which examined the environment and physical setting were more common in the ECE settings measures than the home environment, whereas the key feature included in every tool was the quality of interaction with the child. Regarding accessibility, two studies did not include this information, one required payment and one was free to use. Two tools were in English \((n = 2)\), one in Chinese, and one was not reported. Two of the tools were global \((n = 1)\), one developed in USA \((n = 1)\), and one was Chinese \((n = 1)\).

**Discussion: 12 considerations for selecting suitable measurements to effectively assess ECD in LMICs**

The SR was undertaken to identify tools available to profile the development of children and their learning environments between the ages of 0–5 years. It reviews forty-three tools (34 focusing on child development and 9 on the environment) that have been used previously to assess early development in LMICs. The ongoing debate about which measure to use for which children in which setting remains a pressing one. This is of particular importance for childhood stunting and, as such, for the UKRI GCRF Action Against Stunting Hub.

Drawing on the synthesis of 57 records included in this SR, we compared the tools’ application identifying five critical markers (the study, population tested, validity, reliability and cultural adaptability/translation) outlined in Tables 2 and 3. Focusing on the psychometric properties, studies varied greatly in the way validity and reliability were reported, ranging from no reporting to a variation in the way these characteristics were addressed. Studies also varied in which type of validity was considered including concurrent, face, construct, content and convergent, without justifying these choices. Without valid and reliable tools, measuring the impacts of developmental challenges, such as stunting, interventions and ECD across different cultural contexts will not yield equivalent conclusions making it harder to identify barriers, drivers of development, and effective interventions. Here we used as a benchmark validity >.7, but a close attention of how reliability is reported is important. Regarding the cultural and contextual appropriateness/potential to adapt, and in line with Sabanathan et al. (2015), we found that researchers typically translated tools from HIC (linguistic equivalence) with a minority adapting them in a systematic way for the local cultural environment (cultural equivalence). In some cases, an amalgamation of a number of translated and/or adapted items from several different HIC tools were used but the validity of this approach was rarely examined. Researchers need to actively engage in developing robust measures which include cultural adaptations and translation/back translation. These procedures and any changes should be reported for the measures.

We also compared 43 tools (34 for assessing children’s development, 5 to measure the home environment and 4 to measure ECE settings) on key markers outlined in Tables 4 and 5. We suggest
Table 2. Development assessment tools by name, study, population tested, validity, reliability and cultural adaptability/translation.

| N | Tools                                           | Study                                      | Population and sample               | Validity                          | Reliability                        | Cultural adaptability/translation |
|---|------------------------------------------------|--------------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|----------------------------------|
| 1 | Caregiver-reported early child development (CREDI) | McCoy et al. (2017)                        | Peri-urban and rural Tanzania       | Internal consistency: 0.68–0.90    | Inter-rater reliability: 0.00–0.40  | Back/translated to/from Swahili by bilingual Tanzanian and American staff. Discrepancies resolved on consensus of a committee formed by CREDI local staff and bilingual Tanzanian community members |
|   |                                                |                                            | 2481 children                       |                                   |                                     |                                  |
|   |                                                |                                            | LMICs including India               | Criterion validity: 0.34–0.92      | Test retest reliability: 0.60       | Back/translated all CREDI items and materials into local language(s). Teams referenced to CREDI item descriptions and used colloquial language. Local teams made minor adaptations to the item examples |
|   |                                                |                                            | 8022 children                       | Age-normalised correlations: 0.23–0.47  |                                      |                                  |
|   |                                                |                                            |                                    | Internal consistency: 0.70–0.88     | Inter-rater reliability: 0.85–0.93  | Flexible administration procedure to allow observations and caregiver interviews. Modified form and manual were translated into French by two bilingual French and English speakers |
|   |                                                |                                            |                                    | Sensitive to age and group differences | Test retest reliability: 0.77–0.96  | Back/translated into English and Hindi. Full survey piloted on children from Bihar and adapted. The order of questions in the personal-social subscale was adapted |
|   |                                                |                                            |                                    | Internal consistency: 0.67–0.94     | Inter-rater reliability: 0.96       | Site team compiled, discussed and solved item-based culture-specific issues. Amendment of phrases to more culturally appropriate conceptual equivalents. For maternally reported items on attention and emotional reactivity, local language versions (Brazilian Portuguese, Hindi, Italian, Kiswahili and Marathi) from validated CBCL translations were made available to site staff |
|   | Developmental milestones checklist (DMC)       | Boggs et al. (2019)                        | LMICs including India (SLR)         | Rated excellent. Exact values not reported | Rated highly. Exact values not reported |                                  |
|   |                                                |                                            |                                    |                                    |                                     | Not reported in SLR |
| 2 | Developmental milestones checklist (DMC II)    | Larson et al. (2017)                       | Rural India                         | Internal consistency: 0.70–0.88     | Inter-rater reliability: 0.85–0.93  | Back/translated into English and Hindi. Full survey piloted on children from Bihar and adapted. The order of questions in the personal-social subscale was adapted |
|   |                                                |                                            | 4360 children                       | Sensitive to age and group differences | Test retest reliability: 0.77–0.96  | Site team compiled, discussed and solved item-based culture-specific issues. Amendment of phrases to more culturally appropriate conceptual equivalents. For maternally reported items on attention and emotional reactivity, local language versions (Brazilian Portuguese, Hindi, Italian, Kiswahili and Marathi) from validated CBCL translations were made available to site staff |
|   | Intergrowth-21st (inter-NDA)                   | Fernandes et al. (2014)                    | Brazil, India, Italy, Kenya and UK   | Not reported                       | Inter-rater reliability: 0.70       | Not reported in SLR |
|   |                                                |                                            | 4607 children                       |                                    | Test-retest reliability: 0.79       |                                  |
|   |                                                | Semrud-Clikeman et al. (2017)              | LMICs including India and Indonesia (SLR) | Not reported in SLR | Inter-rater reliability: 95% | Not reported in SLR |
|   |                                                |                                            |                                    |                                    | Test retest reliability: 95%        |                                  |
| 5 | Bayley MDI                                     | Fernald et al. (2017)                      | LMICs including Indonesia (SLR)     | Not reported                       | Not reported                       | Not reported |
| 6 | Bayley scales of infant development I (BSID-I) | Luo et al. (2015)                          | Rural China                         | Not reported                       | Inter-rater reliability: 0.99       | The test was adapted to Chinese language and environment in 1992 in an urban Chinese sample |
|   |                                                |                                            | 1808 children                       |                                    | Test retest reliability: 0.82–0.88  |                                  |
|   |                                                |                                            |                                    |                                    | Parallel forms reliability: 0.85–0.87 |                                  |
| N | Tools Study | Population and sample | Validity | Reliability | Cultural adaptability/translation |
|---|-------------|-----------------------|----------|-------------|----------------------------------|
| 7 | Bayley scales of infant development II (BSID-II) Carlo et al. (2013) | India, Pakistan and Zambia 371 children | Pilot-testing at each site to verify validity in the local context. Exact values not reported | Not reported | Few items were slightly modified to make it more culturally appropriate (i.e. image of a sandal instead of a shoe) |
| 7 | | Fernald et al. (2009) | LMICs including Indonesia (SLR) | Not reported in SLR | Not reported in SLR |
| 7 | | Wallander et al. (2014) | India, Pakistan and Zambia 145 children | Pilot-testing at each site to verify validity in the local context. Exact values not reported | Not reported | Few items were slightly modified to make it more culturally appropriate (i.e. image of a sandal instead of a shoe) |
| 8 | Bayley scales of infant development III (BSID-III) Bhopal et al. (2019) | Rural India 1726 children | Not reported | Inter-rater reliability: 97% | Systematic cultural adaptation process: (1) translation into Hindi independently by two trained research associates, (2) comparing translations and assessing technical equivalences, then producing final translations by consensus, (3) field research with project staff and mothers of young children to test understanding of translations and to improve them, (4) finalisation of tool for pretesting and (5) pretesting in the community |
| Luo et al. (2019) | China 448 caregiver–child dyad | Not reported | Not reported | No adaptations made |
| Wallander et al. (2010) | India, Pakistan and Zambia 431 children | Not reported | Not reported | Extensive testing and cultural adaptation through training on three occasions and ongoing evaluators’ monitoring |
| Kirsten et al. (2018) | South Africa 1143 children | Not reported | Not reported | Translated measures into Afrikaans and isiXhosa using standard forwards and backwards-translation method |
| Nores et al. (2019) | Colombia 459 children | Not reported | Not reported | Translation provided under a licence by the publisher (Pearson) done for another study on a similar population in Colombia with a test-retest reliability 0.95–0.98 (Attanasio et al., 2014) |
| Semrud-Clikeman et al. (2017) | LMICs including Indonesia (SLR) | Criterion validity with McCarthy scales and WPPSI: 0.73–0.79 Internal consistency: 0.89 | Test retest reliability: 0.83 | Not reported in SLR |
| 9 | Kilifi developmental checklist (KDC) Sabanathan et al. (2015) | LMICs including Senegal (SLR) | Rated excellent. Exact values not reported | Rated excellent. Exact values not reported | Items chosen based on ease of observing item success, ability to differentiate within study population, and ease to describe in local language |
| N  | Tools                                                                 | Study                                      | Population and sample                                                                 | Validity                                                                 | Reliability                  | Cultural adaptability/translation |
|----|----------------------------------------------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------|----------------------------------|
| 10 | Lucknow development screen for Indian children                        | Fischer et al. (2014)                      | LMICs including India (SLR)                                                           | Sensitivity: 95.9% Specificity: 73.1% Criterion validity with developmental assessment scale for Indian infants, and the Vineland social maturity scale; exact values not reported | Not reported in SLR          | Not reported in SLR               |
| 11 | WHO indicators of infant and young child development (IYCD)           | Lancaster et al. (2018)                    | LMICs including India and Indonesia 21,083 children                                    | Rated excellent. Exact values not reported                                | Not reported                 | Not reported                      |
| 12 | East Asia-pacific early child development scales (EAP-ECDS)          | Rao et al. (2019)                          | Cambodia, China, Mongolia and Vanuatu 4712 ethnic majority children                    | Rated excellent. Exact values not reported                                | Inter-rater reliability: 85% | Culturally developed              |
|    |                                                                      | Sun et al. (2018)                          | Cambodia, China, Mongolia, Papua New Guinea, Timor-Leste and Vanuatu 7583 children    | Rated excellent. Exact values not reported                                | Inter-rater reliability: 85% | Culturally developed              |
| 13 | International development and early learning assessment (IDELA)       | Pisani et al. (2018)                       | LMICs including India and Indonesia                                                    | Convergent validity: 0.33–0.61 Internal consistency: 0.66–0.95          | Inter-rater reliability: 0.79–0.97 | Not applicable                   |
|    |                                                                      | Yousafzai et al. (2018)                    | Rural Pakistan 340 children                                                            | Not reported                                                              | Inter-observer reliability: 0.99 | Questionnaires and child assessments administered in Sindhi. Language and sociocultural adaptation protocols ensured original items conceptual integrity in adaptation |
|    |                                                                      | Halpin et al. (2019)                       | Afghanistan, Bolivia, Ethiopia, Uganda and Vietnam 4970 children                      | Measurement invariance analysis revealed that most items do not provide a basis for comparing children’s development over the five countries | Not reported                 | Translated into Vietnamese, Luganda, Oromiffa, Spanish, Usnek and Dari |
|    |                                                                      | Wolf et al. (2018)                         | 108 public schools and 132 private schools, Ghana                                     | Internal consistency: 0.69–0.83                                          | Inter-rater reliability: 71.1% | The current protocol was piloted and adapted to the Ghanaian context. Specific details not included |

(Continued)
| No. | Tools | Study | Population and sample | Validity | Reliability | Cultural adaptability/translation |
|-----|-------|-------|------------------------|----------|-------------|----------------------------------|
| 14  | Early childhood development index (UNICEF) | Urke et al. (2018) | Honduras 2,729 children | Internal consistency: 0.41 | Not reported | Not reported |
| 15  | Child developmental scale of China (CDSC) | Li et al. (2019) | 9 Chinese provinces 2,111 children | Internal consistency: 0.71–0.95 | Test retest reliability: 0.89 | Tool developed in China |
| 16  | Hong Kong early child development scale (HKECDS) | Rao et al. (2013) | Hong Kong Central district and Tin Shui Wai 240 Chinese children | Internal consistency: 0.61–0.95 | Inter-rater reliability: 90% | Characters used instead of letters in the language scale. Items developed in English and translated into bilingual Cantonese research assistants. Accuracy of translation evaluated by members of the research team who were very proficient in both languages |
| 17  | Early development instrument (EDI) | Brinkman et al. (2015) | Indonesia Sample size varies | Not reported | Not reported | Response options changed from five-point Likert scale to binary responses. Omitted questions that asked for the subjective evaluation of a child’s abilities. wording of 11 questions altered to make their meaning clearer in the Indonesian language |
| 18  | Wechsler intelligence scales for children (WISC) | Fernald et al. (2017) | LMICs including India (SLR) | Not reported in SLR | Not reported in SLR | Not reported in SLR |
|     | Semrud-Clikeman et al. (2017) | LMICs including India and Indonesia (SLR) | Not reported in SLR | Not reported in SLR | Not reported in SLR |
| 19  | Wechsler preschool and primary scale of intelligence-III (WPPSI-III) | Tarullo et al. (2017) | Rural Pakistan 105 children | Internal consistency: 0.69–0.88 | Not reported | Cultural adaptation reported elsewhere (Rasheed et al., 2016) |
|     | Semrud-Clikeman et al. (2017) | LMICs including India and Indonesia (SLR) | Not reported in SLR | Not reported in SLR | Not reported in SLR |
|     | Jeong et al. (2018) | Rural Pakistan 1,302 children | Internal consistency: 0.74 | Not reported | Cultural adaptation reported elsewhere (Rasheed et al., 2018) |
| 20  | Measuring early learning quality and outcomes (MELQO) (MELE module) | Raikes et al. (2019) | Tanzania 684 children | Internal consistency: 0.32–0.91 | Rated highly. Exact values not reported | Adaptation of direct assessment and the teacher report items previously used in LMICs |
| N | Tools                                     | Study                                      | Population and sample       | Validity                        | Reliability                      | Cultural adaptability/translation |
|---|-------------------------------------------|--------------------------------------------|------------------------------|---------------------------------|----------------------------------|----------------------------------|
| 21| Peabody picture vocabulary test (PPVT)    | Tomlinson et al. (2016)                    | South Africa 644 mother-child dyads | Not reported                    | Not reported                     | Cultural adaptation reported elsewhere (Pakendorf and Alant, 1996) |
| 22| MacArthur-Bates communicative development inventory | Hamadani et al. (2010)                    | Rural Bangladesh 801 children | Not reported                    | test-retest reliability: 0.67–0.99 | The inventory was developed after extensive piloting with mothers of young children and in consultation with experts |
| 23| McCarthy scales for children's abilities general cognitive index (MSCA) | Knauer et al. (2019)                      | Poor, rural Mexico 603 children | Not reported                    | Not reported                     | The MSCA were translated and adapted for use in Mexico by researchers at Instituto Nacional de Perinatología in Mexico City |
| 24| British ability scales (BAS)              | Fernald et al. (2009)                     | LMICs including India (SLR) | Not reported in SLR             | Not reported in SLR              | Not reported in SLR              |
| 25| Standford binet                           | Fernald et al. (2009)                     | LMICs including India (SLR) | Not reported in SLR             | Not reported in SLR              | Not reported in SLR              |
| 26| Kaufman assessment battery for children (KABC) | Fernald et al. (2017)                    | LMICs including Senegal (SLR) | Not reported in SLR             | Not reported in SLR              | Not reported in SLR              |
| 27| Kaufman assessment battery for children – second edition (KABC-II) | Semrud-Clikeman et al. (2017)           | LMICs including Senegal (SLR) | Not reported in SLR             | Internal reliability = 0.70–0.96 | Not reported in SLR              |
| 28| Baroda development screening test (BDST)  | Fischer et al. (2014)                     | LMICs including India (SLR) | Specificity: 65% Sensitivity: 95% | Not reported in SLR              | Not reported in SLR              |
| 29| Developmental Neuropsychological Assessment (NEPSY-II) | Semrud-Clikeman et al. (2017)           | LMICs including Indonesia (SLR) | Internal consistency = 0.88–0.94 | Reliability = 0.28–0.88          | Not reported in SLR              |
| 30| Malawi developmental assessment tool (MDAT) | Gladstone et al. (2010)                  | Malawi 426 children          | Rated satisfactory. Exact values not reported | Inter-rater reliability: >0.4 | Consistency and clarity of items was ensured by back translating the tool with help of language expert from the University of Malawi. Items illustrated by a Malawian artist |
|   |                                           | Boggs et al. (2019)                      | LMICs including India (SLR)  | Rated excellent. Exact values not reported | Rated highly. Exact values not reported | Not applicable |
|   |                                           | van den Heuvel et al. (2017)             | Malawi 150 children          | Internal consistency: 0.76–0.84 | Inter-rater reliability: 0.98    | Translation not needed           |

(Continued)
| N  | Tools                                      | Study                                | Population and sample | Validity                          | Reliability                  | Cultural adaptability/translation |
|----|-------------------------------------------|--------------------------------------|-----------------------|-----------------------------------|------------------------------|----------------------------------|
| 31 | Ages and stages questionnaire 3rd ed.     | Bernal et al. (2019) Colombia         | 2767 children         | Internal consistency: 0.87        | Not reported                 | The ASQ has been used for early development assessments in LMICs (Rubio-Codina et al., 2015, in Bernal et al., 2019: 422) |
|    | (ASQ-3)                                   |                                      |                       |                                   |                              | Version translated into Bangla and adapted to the local context by a team leading expert in child development. Adaptations made reflected relevant examples for the Bangladeshi context during the assessment while preserving the original questions from the ASQ |
|    |                                           | Nair et al. (2017) Rural Bangladesh   | 1018 children         | Not reported                      | Inter-observer reliability: 0.93–1.0 | Not reported                     |
|    |                                           |                                       |                       |                                   |                              |                                  |
|    |                                           | Scherer et al. (2017) Pakistan        | 868 mother-child dyads| Not reported                      | Not reported                 | Not reported                     |
|    |                                           | Knauer et al. (2018a) Poor, rural Mexico 1893 children | Not reported                      | Not reported                      | Not reported                 | The EASQ was adapted for use in Mexico by researchers at the Instituto Nacional de Perinatología, Mexico City |
|    |                                           | Kvestad et al. (2015) North India     | 422 children          | Rated excellent. Exact values not reported | Rated highly. Exact values not reported | Forms translated to Hindi following official recommendations. Items not appropriate for the cultural setting were identified and adjusted. Exact items adjusted not identified |
|    |                                           | Knauer et al. (2018b) Poor, rural Mexico 603 children | Not reported                      | Not reported                      | Not reported                 | Not reported                     |
| 32 | ICMR (Indian Council Medical Research)    | Fernald et al. (2009) India (SLR)     | Not reported in SLR    | Not reported in SLR               | Not reported in SLR           | Not reported in SLR             |
|    | psychosocial developmental screening test | Semrud-Clikeman et al. (2017) LMICs including Indonesia, and India (SLR) | Not reported in SLR    | Not reported in SLR               | Not reported in SLR           | Not reported in SLR             |
| 33 | Screening test battery assessment psychosocial development (STBAPD) | Fischer et al. (2014) LMICs including India (SLR) | Not reported in SLR    | Inter-tester reliability: 95%–98% | Retest reliability: 95%–99% | Not reported in SLR. Developed by Vazir et al. (1994) |
| 34 | TDSC (Trivandrum developmental screening chart) | Chattopadhyay et al. (2015) Rural India 427 children | TDSC based on Bailey Developmental Screening Tool validated in India | Not reported                 | Developed in India             |                                  |
Table 3. Environment (Home and ECE setting) assessment tools by name, study, population tested, validity, reliability and cultural adaptability/translation.

| N  | Tools                                      | Study                                | Population and sample | Validity          | Reliability                   | Cultural adaptability/translation |
|----|--------------------------------------------|--------------------------------------|-----------------------|-------------------|-------------------------------|----------------------------------|
|    | Home environment                           |                                      |                       |                   |                               |                                   |
| 1  | Infant/toddler (IT) HOME, early childhood (EC) | Nores et al. (2019)                   | Colombia, 819 children | Not reported      | The inter-rater reliability was above 0.9 on the full scale | The assessment instruments chosen have been used extensively in evaluations of early care and education including studies in developing countries (Fernald et al., 2017) |
|    |                                            | Hamadani et al. (2010)                | Rural Bangladesh, 801 children | Validated instrument across countries | The intraclass correlation for each of the four interviewers with the trainer ranged from $r = 0.94–0.99$ ($n = 20$) | Although the HOME is a good measure of the home environment, the scale is not suitable for use in large-scale population surveys. The HOME takes 45–60 minutes to administer and requires skilled, well-trained interviewers and considerable adaptation when used in developing countries. Moreover, the HOME involves observations, which are more difficult to standardise for use in large population surveys |
|    |                                            | Knauer et al. (2018)                  | Poor, rural Mexico, 1893 children | The items that comprise the instrument were selected based on empirical evidence, and then validated through testing. The instrument has been well validated in the U.S. and used worldwide, including in several Latin American countries | The internal consistency of the scale was satisfactory (Cronbach $= 0.8227$) | Not reported |
|    |                                            | Knauer et al. (2018)                  | Poor, rural Mexico, 603 children | The HOME Inventory has been well validated and used worldwide | The internal consistency of the scale was satisfactory (Cronbach $= 0.8227$) | Not reported |
|    |                                            | Scherer et al. (2019)                 | Pakistan, 869 dyads (mother and child) | This tool, designed to assess home environment and stimulation quality, has been used frequently in LMIC | Not reported | Not reported |

(Continued)
| N | Tools | Study | Population and sample | Validity | Reliability | Cultural adaptability/translation |
|---|-------|-------|-----------------------|----------|-------------|----------------------------------|
| 2 | Family Care Indicator (FCI) questionnaire | Knauer et al. (2018) | Poor, rural Mexico, 603 children | Has been well validated, Cronbach = 0.7100 | Not reported | Has been used worldwide |
|    |       | Hamadani et al. (2010) | Bangladesh, 801 children | Determining the validity of the FCIs across cultures requires studies in a number of cultural settings and is beyond the scope of this study | To assess short-term test-retest reliability, the FCI questionnaire was repeated 7–14 days later among 40 mothers. The items that were observed (‘household books’, ‘magazines’, ‘varieties’ and ‘sources’ of play materials) were highly reliable (intraclass correlations $r > 0.85$, $p < 0.001$) whereas ‘play activities’ was only moderately reliable ($r = 0.64$, $p < 0.001$) | Not reported |
| 3 | Home Screening Questionnaire (HSQ) | Nair et al. (2009) | India | The likelihood ratio (LR) for positive test was .46 (95% CI, 3.3 to 6.9) | the sensitivity was 83%, specificity 82%, positive predictive value 83.3%, negative predictive value 81.6%, and accuracy 82.5% | Not reported |
| 4 | Multiple Indicator Cluster Survey (MICS) | McCoy et al. (2018) | Nationally representative data collected in 58 LMICs | The activities have been previously found to show acceptable predictive validity when relating to child outcomes | The activities have been previously found to show acceptable short-term reliability | All survey questions are translated and back translated into local languages by in-country teams |
| 5 | Multiple Indicator Cluster Survey (MICS 3) | Bornstein et al. (2012) | 28 developing countries, 127,000 families with under-5 years children | Not reported | Kuder-Richardson 20 reliabilities were satisfactory (DeVellis, 2003) at 0.68 for the cognitive caregiving scale | MICS3 covers a large array of topics and its significant flexibility allow countries to adapt the survey to their particular situations and needs but keeps comparability through standardised questions and administration |
| N  | Tools                                                                 | Study                                                                 | Population and sample                                                                 | Validity                                                                                       | Reliability                                                                                   | Cultural adaptability/translation |
|----|----------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|----------------------------------|
| 1  | ECE centre                                                          |                                                                      |                                                                                        |                                                                                                |                                                                                                |                                  |
|    | 1 Infant/toddler environment rating scale-revised (ITERS-R); early childhood environment rating scale-revised (ECERS-R) | Brinkman et al. (2016)                                               | Indonesia, 310 total villages sampled, with 4–16 students observed within each village | Many studies have demonstrated its predictive validity (Burchinal et al., 2008; Montes et al., 2005; Peisner-Feinberg et al., 2001) | Good test-retest reliability, high inter-rater reliability (Clifford et al., 2010)              | Not reported                     |
|    |                                                                      |                                                                      |                                                                                        |                                                                                                |                                                                                                |                                  |
|    | 2 Child Activities (CA) system                                      | Montie et al. (2006), in Fernald et al. (2009)                       | Indonesia                                                                              | Not reported                                                                                    | Not reported                                                                                   | Not reported                     |
|    |                                                                      |                                                                      |                                                                                        |                                                                                                |                                                                                                |                                  |
|    | 3 Chinese Early Childhood Environment Rating Scale (CECERS)         | Li et al. (2019)                                                     | 8 Chinese provinces, 2110 children                                                       | Good content validity, concurrent validity and criterion-related validity                     | Good reliability within each sub-scale and the total score. Internal consistency (Cronbach’s alpha) ranged from 0.83 to 0.93 for the subscales and was 0.96 for the total scale | Not reported                     |
|    |                                                                      |                                                                      |                                                                                        |                                                                                                |                                                                                                |                                  |
|    | 4 Measuring early learning quality & outcomes (MELQO) (MELE module) | Raikes et al. (2010)                                                 | Tanzania, 684 children                                                                    | Not reported                                                                                    | Enumerators were evaluated several times with accuracy checks and were judged to reach reliability standards based on participation in in-person training and two checks on reliability conducted at the end of the training period | Adaptation of direct assessment and the teacher report items previously used in LEMICs; items commonly-used in intelligence and school-readiness instruments (i.e. IDELA) (Wolf et al., 2017), head shoulders knees toes task (McClelland et al., 2014), and the Canadian National Longitudinal Study of Children and Youth and the EDI (Janus and Offord, 2007) |
Table 4. Development assessment tools by name, target age, administration method, domains, battery, accessibility, language and country/Institution.

| N  | Tool's name                                                                 | Tool's target age | Administration method | Domains                                                                 | Battery | Accessibility | Language of the tool | Country/Institution |
|----|----------------------------------------------------------------------------|-------------------|-----------------------|------------------------------------------------------------------------|---------|---------------|---------------------|---------------------|
| 1  | Caregiver Reported Early Childhood Development Instruments (CREDI)          | 1                 | Caregiver report      | Motor, cognitive, language, social-emotional and mental health development | No      | Free to use   | English             | USA                 |
| 2  | Developmental Milestones Checklist (DMC)                                  | 1                 | Caregiver report      | Motor, language and personal-social development                        | No      | Free to use   | English             | Kenya               |
| 3  | Developmental Milestones Checklist II (DMC II)                            | 2                 | Caregiver report      | Social/emotional; cognitive (learning, thinking, problem-solving); language/communication; movement/physical development | Yes     | Free to use   | French              | USA                 |
| 4  | Intergrowth-21st (inter-NDA)                                              | 1                 | Direct assessment     | Cognition, language skills, behaviour, motor skills and attention       | Yes     | Free to use   | English             | UK                  |
| 5  | Bayley MDI                                                                 | 2                 | Direct assessment     | Achievement, simultaneous processing and sequential processing          | Not reported | Not reported | Not reported         | World Bank          |
| 6  | Bayley scales of infant development I (BSID-I)                            | 1                 | Direct assessment     | Motor, cognitive and language scales                                     | Yes     | Payment required | English             | USA                 |
| 7  | Bayley scales of infant development II (BSID-II)                          | 1                 | Direct assessment     | Motor, cognitive and language scales                                     | Yes     | Payment required | English             | USA                 |
| 8  | Bayley scales of infant development III (BSID-III)                        | 1                 | Direct assessment     | Motor, cognitive and language scales                                     | Yes     | Payment required | English             | USA                 |
| 9  | Kilifi Developmental Checklist (KDC)                                      | 1                 | Caregiver report      | Developmental, locomotor, eye–hand co-ordination, hearing, speech and social–emotional development | No      | Payment required | Kigiriama            | Kenya               |
| 10 | Lucknow Development Screen for Indian Children                            | 1                 | Caregiver report      | 27 milestones: gross motor, fine motor, language and social domains which cover motor, language and social domains which cover each month of age and beyond | Not reported | Not reported | Not reported         | Not reported        |
| 11 | WHO Indicators of Infant and Young Child Development (IYCD)               | 1                 | Caregiver report      | 120 items (23 fine motor, 23 gross motor, 20 receptive language, 24 expressive, language, 30 socioemotional) | Not reported | Not reported | English             | Global              |
| 12 | East Asia-Pacific Early Child Development Scales (EAP-ECDS)                | 2                 | Direct assessment     | Cognitive development; socio-emotional development; motor development; language and emergent literacy; health, hygiene and safety; cultural knowledge and participation; and approaches to learning | Yes     | Free to use   | Local language      | UNICEF              |

(Continued)
| N  | Tool's name                                      | Tool's target age | Administration method | Domains                                                                 | Battery | Accessibility | Language of the tool | Country/Institution |
|----|-------------------------------------------------|-------------------|-----------------------|-------------------------------------------------------------------------|---------|---------------|----------------------|---------------------|
| 13 | International Development and Early Learning Assessment (IDELA) | 2                  | Direct assessment     | Language/literacy, numeracy/cognitive development, physical development and social-emotional development | No      | Free to use   | English              | Save the children   |
| 14 | Early Childhood Development Index (UNICEF)      | 2                  | Caregiver report      | (1) language/cognitive (2) physical, (3) socio-emotional and (4) approaches to learning | No      | Free to use   | English              | UNICEF              |
| 15 | Child Developmental Scale of China (CDSC)      | 2                  | Direct assessment     | Language, Early Math, Social Cognition and Physical Movement            | No      | Not reported  | Chinese              | China               |
| 16 | Hong Kong early child development scale (HKECDS) | 2                  | Direct assessment     | Personal, social and self-care; language development; pre-academic learning; cognitive development; gross motor; fine motor; physical fitness, health and safety; and self and society | No      | Not reported  | Chinese              | China (Hong Kong)   |
| 17 | Early development instrument (EDI)             | 2                  | Direct assessment     | Five domains: physical health and well-being, social competence, emotional maturity, language and cognitive development and communication skills and general knowledge | No      | Not reported  | English              | Telethon kids institute Australia |
| 18 | Wechsler intelligence scales for children (WISC) | 2                  | Direct assessment     | Intelligence (receptive vocabulary, block design, information, object assembly and picture naming) | No      | Payment required | English              | English             |
| 19 | Wechsler preschool and primary scale of intelligence-III (WPPSI-III) | 2                  | Direct assessment     | Intelligence (receptive vocabulary, block design, information, object assembly and picture naming) | No      | Payment required | English              | USA                 |
| 20 | Measuring early learning quality and outcomes (MELQO) (MODEL module) | 2                  | Direct assessment and teacher report | (1) Executive function; (2) Social–emotional development and (3) Pre-academic skills (literacy and mathematics) | No      | Free to use   | English              | Global              |
| 21 | Peabody picture vocabulary test (PPVT)         | 2                  | Direct assessment     | Language/literacy; receptive and expressive vocabulary                  | Yes     | Payment required | English              | South Africa        |
| 22 | MacArthur-Bates communicative development inventory | 2                  | Caregiver report      | Language. Subscales oral language: vocabulary comprehension, production, gesture use and early grammar | No      | Payment required | English              | Brookes Publishing  |
| 23 | McCarthy scales for children's abilities general cognitive index (MSCA) | 2                  | Caregiver report      | General cognitive index (CGI): verbal scale (perceptual-performance, quantitative), memory scale and motor scale | No      | Payment required | English              | USA                 |
| 24 | British ability scales (BAS)                   | 2                  | Direct assessment     | Cognitive ability and educational achievement                          | Yes     | Payment required | English              | UK                  |

(Continued)
| N  | Tool’s name                                                                 | Tool’s target age | Administration method | Domains                                                                 | Battery | Accessibility | Language of the tool | Country/Institution |
|----|------------------------------------------------------------------------------|-------------------|-----------------------|-------------------------------------------------------------------------|---------|----------------|----------------------|---------------------|
| 25 | Sanford Binet                                                               | 2                 | Direct assessment     | Fluid reasoning, knowledge, quantitative reasoning, visual-spatial processing and working memory | Yes     | Payment required | English              | France              |
| 26 | Kaufman assessment battery for children (KABC)                               | 2                 | Direct assessment     | Achievement, simultaneous processing and sequential processing           | Not reported | Not reported | English              | Not reported        |
| 27 | Kaufman assessment battery for children – second edition (KABC-II)            | 2                 | Direct assessment     | Individual’s strengths and weaknesses in cognitive ability and mental processing | Yes     | Payment required | English              | Not reported        |
| 28 | Baroda Development Screening Test (BDST)                                     | 2                 | Direct assessment     | motor and mental development of infants                                  | Yes     | Payment required | English              | not reported        |
| 29 | Developmental neuropsychological assessment (NEPSY-II)                        | 2                 | Direct assessment     | Measure of executive functions, memory, language and reasoning            | Not reported | Not reported | English              | Not reported        |
| 30 | Malawi developmental assessment tool (MDAT)                                  | 3                 | Direct assessment     | Gross motor, fine motor, social development and language                  | Yes     | Free to use     | English              | Malawi and England  |
| 31 | Ages and stages questionnaires 3rd ed. (ASQ-3)                               | 3                 | Caregiver report      | Cognitive and socio-emotional                                             | No      | Payment required | English              | Brookes Publishing  |
| 32 | ICMR (Indian Council Medical Research) Psychosocial Developmental Screening Test | 3                 | Direct assessment     | Gross motor, vision and fine motor, hearing, language and concept development and personal | No      | Not reported    | Not reported         | Indian Council of Medical Research |
| 33 | Screening Test Battery for Assessment of Psychosocial Development (STBAPD)    | 2                 | Direct assessment     | 5 areas: (1) gross motor, (2) vision and fine motor, (3) hearing language and concept development, (4) self-help skills and (5) social skills | Not reported | Not reported | Not reported         | Not reported        |
| 34 | TDSC (Trivandrum developmental screening chart)                              | 3                 | Direct assessment     | (1) Motor, cognitive and language and (2) gross motor, fine motor-adaptive, personal social and language domains of development | Not reported | Not reported | Not reported         | India               |
### Table 5. Environmental (Home and ECE centre) assessment tools by name, target age, administration method, domains, battery, accessibility, language and country/Institution.

| N  | Tool’s name                        | Tool’s target age | Administration method | Domains                                                                 | Battery | Accessibility | Language of the tool | Country/Institution origin |
|----|------------------------------------|-------------------|-----------------------|--------------------------------------------------------------------------|---------|----------------|-----------------------|---------------------------|
|    |                                    |                   |                       |                                                                          |         |                |                       |                           |
| 1  | Infant/toddler (IT) home, early childhood (EC) HOME | 3 | Direct assessment | Quality of parenting and the home environment | No | Payment required | English | USA |
| 2  | Family Care Indicator (FCI) questionnaire | 3 | Caregiver report | Household books, magazines, varieties and sources of play materials, and play activities | No | Not reported | English | UNICEF |
| 3  | Home screening questionnaire (HSQ)  | 3 | Caregiver report | 30 items; multiple choice, fill in the blanks, yes/no questions plus a toy inventory checklist. Domains not reported | No | Payment required | English | India |
| 4  | Multiple indicator cluster survey (MICS) | 3 | Caregiver report | Two questionnaires: Household Questionnaire; Questionnaire for Individual Women. Domains not reported | No | Not reported | English | UNICEF |
| 5  | Multiple indicator cluster survey (MICS 3) | 3 | Caregiver report | Cognitive caregiving: reading books, telling stories, naming, counting and drawing; socioemotional caregiving: playing with the child, singing songs and taking the child outside | No | Not reported | Not reported | UNICEF |

(Continued)
| N | Tool’s name                                                                 | Tool’s target age | Administration method | Domains                                                                 | Battery | Accessibility | Language of the tool | Country/Institution origin |
|---|----------------------------------------------------------------------------|------------------|-----------------------|------------------------------------------------------------------------|---------|---------------|----------------------|---------------------------|
| 1 | Infant/toddler environment rating scale-revised (ITERS-R); early childhood environment rating scale-revised (ECERS-R) | 3                | Direct assessment     | ITERS-R: 39 items across seven dimensions: space and furnishings, personal care routines, listening and talking, activities, interaction, program structure and parents and staff; ECERS-R: 43 items across seven subscales: space and furnishings, personal care routines; language-reasoning; activities, interaction, program structure and parents and staff | No      | Payment required | English, but has many translations | USA                       |
| 2 | Child activities (CA) system                                               | 2                | Not reported          | Not reported in SLR (Fernand et al., 2009)                             | Not reported | Not reported | Not reported          | World Bank                |
| 3 | Chinese early childhood environment rating scale (CECERS)                  | 2                | Direct assessment     | Space and furnishings; personal care routines; curriculum planning and implementation; whole-group instruction; activities; language-reasoning; guidance and interactions; and parents and staff | No      | Not reported | Chinese               | China                     |
| 4 | Measuring early learning quality and outcomes (MELQO) (MELE module)        | 2                | Direct assessment and teacher report | (1) Environment and physical setting, (2) family and community engagement, (3) personnel; (4) interactions, (5) inclusiveness, (6) pedagogy and (7) play | No      | Free to use   | English               | Global                    |
that these seven markers (target age, administration method, domains, battery, accessibility, language and country/Institution) are also critical to address the implementation challenges that practitioners and researchers face when choosing tools. Crucially, information on the tool’s accessibility (including licences, training and other operational aspects) are required in order to successfully apply the tool to a new context. Moreover, measures which require high levels of professional training will be challenging in contexts where psychologists, speech and language therapists or occupational therapist are not commonplace.

Overall, our SR highlights a need for improvement in the way studies report a tool’s psychometric properties and the cultural adaptation. In line with McCoy et al. (2018b) we found few valid and reliable tools suitable for use in comparative studies across LMICs for cognition and the environment.

Finally, conducting the SR has raised important questions about how measures are selected. Reliability and validity are necessary dimensions in deciding appropriate measures but equally important are considerations of cultural appropriateness and suitability of the tool for intended use. Making an informed choice about which measure and why requires a nuanced understanding of the purpose and overarching objectives of the project and research focus. Why, what and how to measure children’s development at different ages are crucial decisions to choose suitable ECD measures (Fernald et al., 2009). Our SR has served as a foundation for identifying relevant opportunities and challenges when choosing ECD measures in LMICs. Over 30 years of child development, research has emphasised the ways in which children and contexts shape each other (Sameroff and MacKenzie, 2003) yet studies in LMICs have often been limited to child level measures alone. Any attempt to measure and model development must include both the child and the different contexts in which they develop. The SR confirmed that to capture the child’s biodevelopmental niches measures at child and environment level are needed.

Limitations

As all SR, the results were determined by our keywords and search parameters. The focus during the last decade meant that resources published before 2010 were excluded. Although we compensated for this focus on the last decade by including nine previous relevant SR, there are limitations derived from our choices. In addition the significant number of studies that did not report their psychometric properties or cultural adaptations limited our ability to synthesise the evidence from these sources.

Conclusion

Effective ECD measures are crucial for meeting the SDGs. Our SR illustrates a number of opportunities and challenges when identifying tools to measure ECD across LMICs. Selecting appropriate measures is a crucial step to tracking early development and learning to better understand a complex challenge such as childhood stunting. A poorly chosen measure can significantly compromise the best research design and study. Overall our SR put forwards 12 key considerations used to compare the tools. Five dimensions present in Tables 2 and 3 (study, population tested, validity, reliability and cultural adaptability/translation) bring attention to previous applications of the tools in LMICs. Seven dimensions outlined in Tables 4 and 5 (target age, administration method, domains, battery, accessibility, language and country/Institution) refer to the tools’ characteristics. Together they can illuminate the process of selecting assessment tools. These key considerations extend beyond evaluating basic psychometric properties to consider the wider social context in which children are developing to ensure their suitability and validity for the study’s purpose.
Finally, our contribution to the field of early childhood research is the revision of 43 up-to-date tools (34 for assessing children’s development, five to measure the home environment and four to measure ECE settings) for measuring ECD across LMICs. We suggest that the 12 key considerations used in our SR are critical as they offer future researchers and practitioners in the field a guide to pay attention to the implementation challenges, psychometric properties and cultural appropriateness of different tools to assess ECD in LMICs.

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Supplemental material

Supplemental material for this article is available online.

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