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DIGITAL MEDIA IN CHILD DEVELOPMENTAL SCREENING: BENEFITS AND BARRIERS (SCOPING REVIEW)

Media Digital untuk Skrining Tumbuh Kembang Anak: Manfaat dan Hambatan (Scoping Review)

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ABSTRAK

Gangguan perkembangan pada anak masih banyak ditemukan dan berpotensi memengaruhi prestasi mereka di masa depan. Gangguan perkembangan di Indonesia juga tinggi. Studi di Jakarta menggunakan Battelle Developmental Inventory 2 menunjukkan bahwa 28,1 % anak di bawah 3 tahun mengalami keterlambatan kognitif, dan 17,4 % mengalami keterlambatan komunikasi. Data Survei Status Gizi Indonesia (SSGI) 2024 juga melaporkan 19,8 % balita mengalami stunting, meskipun menurun dari 21,5 % pada 2023. Skrining dini menjadi langkah krusial untuk deteksi dan intervensi tepat waktu. Saat ini, media digital menghadirkan pendekatan baru yang inovatif dan mudah diakses untuk skrining tumbuh kembang anak. Penelitian ini bertujuan mengeksplorasi manfaat dan hambatan penggunaan media digital dalam skrining perkembangan anak melalui metode scoping review dengan kerangka kerja PRISMA-ScR. Literatur dicari melalui tiga basis data, PubMed, Scopus, dan ScienceDirect pada Desember 2024. Dari 1.664 artikel yang ditemukan, sepuluh artikel memenuhi kriteria inklusi: diterbitkan antara 2019–2024, berbahasa Inggris, dan membahas penggunaan media digital untuk skrining tumbuh kembang anak. Artikel berasal dari berbagai negara, seperti India, Indonesia, Australia, AS, Spanyol, Yunani, dan Inggris. Hasil studi menunjukkan bahwa media digital, seperti aplikasi dan permainan edukatif, mampu meningkatkan deteksi dini, memperkuat keterlibatan orang tua dan tenaga kesehatan. Akses luas, efisiensi waktu, dan peningkatan keterlibatan pengguna menjadi nilai tambah yang mendorong potensi adopsi teknologi ini dalam layanan kesehatan anak. Namun, hambatan seperti keterbatasan infrastruktur, literasi digital rendah, dan belum terintegrasinya sistem digital dengan layanan kesehatan masih menjadi tantangan, terutama di negara berpenghasilan rendah dan menengah. Penyesuaian teknologi dengan konteks lokal menjadi kunci untuk efektivitas maksimal dalam skrining perkembangan anak.

***Kata kunci**: digital, media, tumbuh kembang anak, tes skrining*

ABSTRACT

Developmental disorders in children were still frequently found and had the potential to affect their future academic performance. In Indonesia, the prevalence remained high. A cross-sectional study in Jakarta using the Battelle Developmental Inventory 2 reported that 28.1% of children under the age of three experienced cognitive delays, while 17.4% had communication delays. Additionally, the 2024 Indonesian Nutritional Status Survey (SSGI) found that 19.8% of children under five were stunted, showing a decrease from 21.5% in 2023. Early screening was a critical step for timely detection and intervention. In recent years, digital media introduced new, accessible, and innovative approaches to developmental screening. This study aimed to explore the benefits and barriers of using digital media for developmental screening in children through a scoping review based on

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the PRISMA-ScR framework. Literature was searched through PubMed, Scopus, and ScienceDirect in December 2024. Of 1,664 articles identified, ten met the inclusion criteria: published between 2019 and 2024, written in English, and discussing digital media in developmental screening. The selected studies came from India, Indonesia, Australia, USA, Spain, Greece, and UK. Results indicated that digital tools, such as mobile applications and educational games, supported early detection and improved the involvement of both parents and healthcare professionals. Broad access, time efficiency, and greater user engagement were added values that encouraged adoption in child health services. However, challenges such as limited infrastructure, low digital literacy, and poor integration with health systems remained, particularly in low- and middle-income countries. Local context adaptation was essential to optimize effectiveness.

Keywords: child growth and development, digital, media, screening test

INTRODUCTION

Developmental disorders in children remain prevalent worldwide. In 2020, an estimated 149.2 million children under the age of five experienced developmental delays [1]. Studies by Osborn, White, and Bloom indicate that 50% of a child's intelligence is formed by age four, 80% by age eight, and reaches full potential by eighteen. This highlights the importance of the early years as a critical period for growth, learning, and long-term wellbeing [2].

Child growth and development is a dynamic, continuous process that begins at conception and extends through adolescence. Early childhood is often referred to as the "golden age" due to the rapid and sensitive developmental changes occurring during this stage [3]. Adequate stimulation during this period plays a vital role in shaping children's physical, cognitive, emotional, and social capacities [4]. Moreover, early life events significantly influence health outcomes in adulthood, including the risk of chronic diseases [5].

Children with developmental disorders face multiple disadvantages. They are 1.5 times more likely to require medical visits, 3.5 times more likely to be hospitalized, and twice as likely to miss school or repeat grades compared to their typically developing peers [6]. These children also face greater risks of long-term mental health issues, unemployment, and reliance on disability services in adulthood [7].

Early detection through developmental screening is essential for identifying delays and initiating timely interventions. In developed countries like the United States, regular developmental screening is already integrated into routine pediatric care and has proven effective [8] [9]. Experts recommend that screening should begin early in life and be conducted periodically to maximize early detection and intervention outcomes [10] [11].

Digital technology is increasingly being used in child development screening. Mobile applications, digital games, and online platforms offer practical and innovative tools to support early diagnosis, monitor developmental progress, and facilitate timely referrals. These tools can assist healthcare providers and parents in engaging with their child's developmental journey [12].

However, comprehensive reviews of the challenges in implementing digital media for child development screening remain limited. A better understanding of both the benefits and barriers is needed to guide policymakers and practitioners in adopting effective and context-appropriate digital solutions. Therefore, this scoping review aims to explore the use of digital media in child developmental screening across various countries, identifying key advantages and limitations to inform future implementation strategies.

METHODS

This study employed a scoping review method to map existing evidence on the benefits and barriers of using digital media in child growth and developmental screening. The review was conducted in accordance with the Preferred Reporting Items for

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Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) guidelines and followed the methodological framework recommended by the Joanna Briggs Institute (JBI).

Literature search was conducted in December 2024 using three academic databases: PubMed, Scopus, and ScienceDirect. The following Boolean search string was used: (("digital media") OR ("apps")) AND (("child") OR ("children")) AND (("growth") OR ("development")) AND (("screening test") OR ("detection") OR ("monitoring")). The search was limited to peer-reviewed original research articles published between 2019 and 2024, in the English language.

This scoping review adopted the PCC framework (Population, Concept, Context) to define the eligibility criteria. The Population included children aged 0–12 years, as this age range represents the key developmental period targeted for early screening. The Concept focused on the use of digital media, such as mobile apps, digital games, or online tools, for screening child growth and development. The Context involved original research conducted in healthcare or community settings, regardless of study design (quantitative, qualitative, or mixed methods).

Articles were included if they were published between 2019 and 2024, written in English, discussed the application of digital platforms or tools in child development screening, and were based on primary research. On the other hand, articles were excluded if they were reviews, commentaries, editorials, letters, book reviews, theses or dissertations, or if they focused on specific disease screening only (e.g., autism-only or vision-only studies). Irrelevant articles that did not address child development or digital media were also excluded.

The literature search initially identified 1,664 articles from three databases. Studies that addressed specific disease screening and did not focus on child development monitoring were excluded. Inclusion and exclusion criteria were consistently applied throughout the search and analysis phase [13]. All references were imported into Mendeley to manage citations and facilitate the removal of duplicates.

After eliminating 3 duplicate records, 1,661 articles remained for screening. The selection process was conducted in multiple stages. First, the titles and abstracts were screened to determine relevance and adherence to the inclusion criteria, resulting in 168 articles for full-text review. Following a more detailed assessment based on inclusion and exclusion criteria, 10 studies were deemed eligible for inclusion in the final analysis.

The charting process aims to provide a descriptive summary of the results of the articles that match the objectives and research questions of the scoping review. Three themes were identified during the analysis process that relevant to the research questions. The strategy for reporting these results follows the PRISMA ScR provided by the Joanna Briggs Institute for scoping reviews [14]. The data from the included studies were charted using Microsoft Excel to summarize key information such as study characteristics, digital media types, target population, outcomes, and identified barriers and facilitators. Thematic analysis was performed manually and categorized into three key themes relevant to the research objectives.

This review conducted a basic methodological quality screening using an adapted version of the Mixed Methods Appraisal Tool (MMAT) to assess clarity of research questions, relevance of methodology, and transparency of results reporting. To minimize potential risks of bias, several strategies were implemented throughout the review process. Only peer-reviewed articles were included to ensure scientific rigor, while non-original works such as grey literature, reviews, and commentaries were excluded to maintain the focus on empirical evidence. Additionally, a transparent and replicable selection process was applied consistently, including independent screening by two reviewers and the use of predefined inclusion and exclusion criteria.

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The PRISMA-ScR flowchart summarizing the article selection process is presented in Figure 1 and the process detail is presented in Table 1. The review's findings are organized thematically to provide a narrative synthesis of the benefits and barriers of digital media use in child developmental screening.

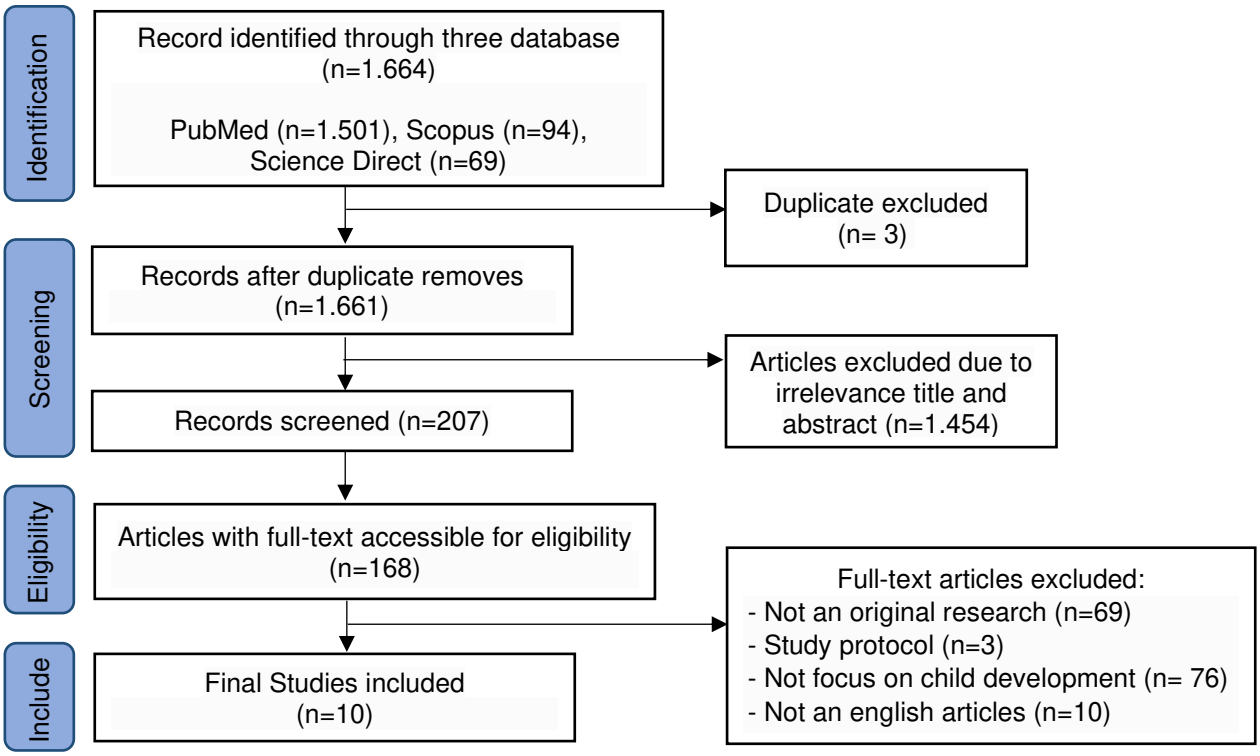

Figure 1. PRISMA Flowchart

Table 1. Summary of Article Selection Process

Stage	Description	n
Identification	Records identified through database searching: PubMed = 1,501, Scopus = 94, ScienceDirect = 69	1,664
	Duplicates removed	3
Screening	Records after duplicates removed	1,661
	Titles and abstracts screened	1,661
	Records excluded due to irrelevance of title and abstract	1,454
	Records included after screening	207
Eligibility	Full-text articles assessed for eligibility	168
	Full-text articles excluded: Not original research = 69, Study protocol = 3, Not focused on child development = 76, Not in English = 10	158
Included	Final studies included in the review	10

RESULT

A total of 10 studies were included in this scoping review, conducted across both developed (e.g., UK, US, Australia, Spain, Greece) and developing countries (e.g., India, Indonesia). The selected studies were published between 2021 and 2024, with a majority in 2024 (n = 5), reflecting recent research interest in this field.

The use of digital media in child growth and development screening spans various technologies such as mobile applications, educational games, IoT-based tools, and machine learning platforms. These studies employed a variety of methods, including Randomized Controlled Trials (RCTs), quasi-experimental, cross-sectional, and qualitative designs, illustrating the growing interdisciplinary interest in the field. The

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researcher provides detailed characteristics of the selected literature studies in Data Charting (Table 2).

Table 2. Data Charting

No	Author(s) & Year	Country	Objective & Digital Media Used	Method	Key Findings
1	Thaventhiran *et al.* (2023) [15]	UK	*GrowthMonitor* AR-based app to measure child height	A Randomized Controlled Trial (RCT) study conducted in 2019 using purposive sampling among 145 participants (75 boys) with a mean age of 8.7 years from the Children's Hospital at Barts Health Trust, in London, UK	Accurate measurement; limited to iOS devices and internet required
2	Serrano-Barroso *et al.* (2022) [16]	Spain	Game to detect impulsivity & attention issues in young children	A Randomized Controlled Trial (RCT) study conducted in 2022 using random sampling among 103 normal and 23 ADHD children aged 4-5 years in Seville, Spain	Effective early screener; not for clinical diagnosis
3	Deveau *et al.* (2022) [17]	USA	*GuessWhat?* game-based app using ML for autism screening	A Randomized Controlled Trial (RCT) study conducted in 2021 using non-probability sampling among 49 children between 3 and 12 years of age and diagnosed with ASD in USA	Distinguishes ASD vs. neurotypical; further validation needed
4	Toki *et al.* (2024) [18]	Greece	*SmartSpeech* game to detect neurodevelopmental disorders	A Randomized Controlled Trial (RCT) study conducted in 2021-2022 using convenience sampling among 229 typically developing children aged 4 to 12 years in Greece	Engaging multi-domain screener; needs broader validation
5	Barr *et al.* (2024) [19]	Australia	*Watch Me Grow–Electronic (WMG-E)* for multicultural screening & service navigation	A Semi-structured interviews were conducted in 2023 using convenience sampling among 17 family members, service navigators, and service providers in a multicultural community in South Western Sydney, Australia	Improves access & parental empowerment; faces language & tech barriers
6	Bhavnani *et al.* (2021) [20]	India	*DEEP* platform for cognitive assessment in preschoolers	A Cross-sectional study was conducted in 2018-2019 using random sampling among 1.359 children (3 years old) from from 120 villages in Rewari district in rural Haryana, India	Scalable, effective in rural settings; comparable to BSID-III
7	Dubey *et al.* (2024) [21]	India	*START* app for autism screening by non-specialists	A Cross-sectional case-control field study conducted in 2023 using purposive sampling among 131 children (2–7 years old; 48 autistic, 43 intellectually disabled and 40 non-autistic typically developing) from low resource settings in Delhi-NCR, India	Usable in low-resource areas; potential bias in parent reporting
8	Hasriani *et al.* (2023) [22]	Indonesia	Android app using DPQ for early stunting detection	A Quasi-experimental design study involving 30 cadres and 30 mothers with 15 children in each group selected by systematic random sampling in Soppeng regency, Indonesia	Enhances cadre and parental knowledge and skills

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9	Hutabarat, Wijaya and Wijaya (2024) [23]	Indonesia	IoT-enabled digital scale for stunting symptom detection	A Research and Development (RND) study conducted in 2023 using convenience sampling among three infants under two years of age in Indonesia	High accuracy (99.4%); effective for infants <2 years
10	Melinda *et al.* (2024) [24]	Indonesia	Mobile app using EEG & CNN to identify ASD	A Research and Development (RND) study conducted in 2023 using cross-validation from 17 subjects, including 4 with normal brain activity and 13 with ASD in Indonesia	High accuracy; limited dataset and EEG quality dependency

The reviewed studies highlighted key benefits of digital media in child developmental screening. These tools improved access, especially in low-resource settings, and encouraged parental involvement through intuitive mobile platforms. Many offered engaging, scalable assessments using games or sensors, with some using AI to improve accuracy. However, challenges included reliance on internet access, device compatibility, limited validation across populations, and low digital literacy among caregivers. The lack of integration with healthcare systems also limited long-term impact and sustainability. The thematic summary is presented in Table 3.

Table 3. Thematic Summary of Benefits and Barriers

Theme	Number of Studies (n = 10)	Countries Mentioned
Accessibility improvement	7	India, Indonesia, Australia
Parental/caregiver engagement	5	UK, Australia, Indonesia
AI/machine learning accuracy	3	US, Indonesia
Cultural/language barriers	3	Australia, India
Technical/device limitations	4	UK, Indonesia, India
System integration gaps	3	Australia, Greece

DISCUSSION

Use of Digital Media in Implementing Child Growth and Development Screening

The application of digital media, ranging from mobile apps to AI-based games, has gained traction as a valuable approach to bridge gaps in traditional screening systems that are often limited by geographic, economic, and professional barriers [25], [26], [27]. In high-income nations, digital media applications for child developmental screening have evolved to integrate state-of-the-art technologies.

The "GrowthMonitor" app developed in the United Kingdom utilizes augmented reality (AR) technology through smartphone cameras to measure a child's height with clinical accuracy. This tool can identify deviations in growth patterns early, enabling timely medical intervention. The app's integration with cloud storage also supports longitudinal tracking and data analysis, although its utility is currently constrained by compatibility issues with Android devices and a need for stable internet connectivity [28].

In the United States, the "GuessWhat?" app leverages machine learning algorithms and interactive gameplay to screen children for autism spectrum disorder (ASD). It evaluates facial expressions, vocalizations, and behavioral responses during a virtual charades game. This non-invasive and child-friendly approach improves engagement while reducing screening anxiety often associated with clinical visits. Initial findings suggest high sensitivity in identifying early ASD markers, though further validation is required across diverse populations [17].

Similarly, Spain has introduced an Android-based serious game designed to evaluate attention and impulsivity behaviors among preschool children. This digital tool, grounded in the principles of psychometric analysis, provides preliminary risk assessments for attention-deficit/hyperactivity disorder (ADHD) through reaction time and pattern

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recognition tasks embedded in a gaming environment. While it cannot be used for diagnostic purposes, its function as a triage tool for early referral to specialists [29].

Greece's "SmartSpeech" project represents another innovation, a mobile-based serious game employing principal component analysis to measure a child's language development, cognitive functioning, and social-emotional behavior. The game's embedded analytics generate real-time developmental profiles and flag potential delays, assisting both parents and educators in initiating support strategies early on [18].

In Australia, the "Watch Me Grow – Electronic" (WMG-E) initiative is a comprehensive eHealth program designed to streamline developmental surveillance and service navigation. It provides culturally responsive tools, especially for Australia's multicultural communities, enabling caregivers to complete milestone checklists online, receive tailored feedback, and access local services directly through the platform. The program has been particularly effective in engaging parents from linguistically diverse backgrounds who may otherwise face barriers in accessing child health services [30].

In India, the "Developmental Assessment on an E-Platform (DEEP)" is a game-based cognitive assessment tool aimed at preschool-aged children. It is designed for use by non-specialist health workers in community settings and does not require continuous internet access. The platform incorporates locally relevant content and intuitive visuals, and its outcomes have shown significant correlation with the gold-standard Bayley Scales of Infant and Toddler Development (BSID-III). DEEP is particularly notable for democratizing access to quality developmental assessments, previously restricted to urban clinics [31], [32].

Another Indian initiative, the "START" app (Screening Tools for Autism Risk using Technology), allows minimally trained health workers to conduct autism screening using a combination of video-based child behavior tasks and caregiver questionnaires. The app's design prioritizes simplicity and functions well in field settings without consistent network coverage. Its early trials have demonstrated high usability, acceptability, and preliminary diagnostic utility [21].

In Indonesia, the adoption of Android-based mobile apps to detect stunting and developmental delays in children has gained policy support at the community level. These applications serve as interactive platforms for health cadres and parents to record anthropometric data, monitor feeding practices, and access educational content. The integration of digital reminders and visualizations enhances caregiver compliance and comprehension. Importantly, these tools have significantly improved knowledge, skills, and early detection practices among village health workers (kader), particularly in remote regions [33].

Implementation High-, Low-, and Middle-Income Countries

In high-income settings, digital tools tend to emphasize precision, automation, and user-centered design. The UK-developed GrowthMonitor uses augmented reality (AR) and smartphone cameras to detect abnormal growth trajectories, offering cloud-based tracking for longitudinal analysis, though limited by compatibility and internet requirements. Similarly, in the United States, the GuessWhat? App gamifies ASD screening through facial recognition and behavioral analysis, engaging children while leveraging machine learning for early risk detection.

Spain's use of video games for attention screening and Greece's SmartSpeech initiative reflect a growing trend toward gamified and automated multi-domain screening, integrating cognitive, linguistic, and behavioral metrics. Australia's Watch Me Grow–Electronic (WMG-E) illustrates how digital service navigation can be culturally tailored for diverse populations, helping bridge service gaps for multilingual families. These tools are typically supported by robust healthcare infrastructure, allowing seamless integration with electronic health records, professional oversight, and real-time clinical referrals. As such, they represent advanced models of digital developmental surveillance.

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In contrast, digital innovation in LMICs like India and Indonesia emphasizes accessibility, affordability, and offline functionality. India's DEEP platform provides cognitive assessments via game-based tasks that can be administered by non-specialists, without needing constant internet access. The START app enables community health workers to screen for autism using video-based tasks and caregiver questionnaires, supporting autism detection in underserved regions.

Indonesia's Android-based apps for stunting detection (e.g., DPQ and IoT-integrated scales) empower local health cadres (kader) and parents through visual tracking, reminders, and educational content. These innovations support early identification of developmental concerns in settings with limited pediatricians and long distances to care facilities. Unlike high-income countries, the technology complexity is simpler, but the community engagement and local relevance are strong. These tools often function independently of national systems but make a substantial impact on early detection rates and public awareness.

Benefits of Using Digital Media in Child Growth and Development Screening

The integration of digital media into the field of child growth and development screening marks a transformative shift in how developmental milestones, delays, and disorders are identified and managed. The advantages provided by digital media range from increased accessibility and real-time data collection to enhanced engagement and parental empowerment [34].

One of the most significant benefits is the enhancement of early detection accuracy. The "GrowthMonitor" application utilizes augmented reality (AR) to enable parents to measure their children's height at home with near-clinical accuracy. This approach allows for continuous growth monitoring outside clinical settings and facilitates early identification of deviations from standard growth trajectories, such as stunting or growth hormone deficiency [28].

Similarly, "GuessWhat?" app transforms routine developmental screenings into interactive games, wherein children are prompted to act out different emotions, animals, or activities. The application then analyzes behavioral patterns, facial expressions, and response times to detect atypical behaviors consistent with autism spectrum disorder (ASD) [17]. Spain's video game-based screening tool engages users through intuitive game tasks while simultaneously collecting data on reaction time, error frequency, and behavioral consistency. These data points are automatically analyzed to produce risk profiles for conditions such as ADHD, allowing educators and clinicians to prioritize follow-up assessments [29].

The "SmartSpeech" project provides an innovative example of how digital media can be used for automated and multidomain developmental screening. The mobile platform integrates gameplay elements with speech and language assessment protocols, enabling the detection of neurodevelopmental disorders such as speech delays, cognitive impairments, and social-emotional dysfunctions [18].

Australia's "Watch Me Grow – Electronic" (WMG-E) platform enables caregivers to complete developmental screening questionnaires online and receive real-time feedback and referrals to relevant services. WMG-E is especially effective in reaching multilingual and marginalized communities, thereby bridging health access gaps in diverse populations [30].

In low- and middle-income countries (LMICs), the benefits of digital media in child developmental screening are no less impactful, though they tend to emphasize accessibility, cost-effectiveness, and scalability. These regions often face systemic challenges such as shortages of pediatric specialists, geographic barriers to healthcare, and limited diagnostic infrastructure.

India's "DEvelopmental assessment on an E-Platform (DEEP)" and START (Screening Tools for Autism Risk using Technology) application, which enables autism

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screening in resource-constrained environments exemplifies how digital tools can democratize access to developmental assessments. DEEP is designed for use in community settings and is operable by non-specialists, making it ideal for outreach in rural or underserved areas, while START tool combines computer-based visual tasks with structured caregiver interviews, and is designed to be administered by community health workers with minimal training. The result is an inclusive screening system that bypasses the need for specialist availability and can reach large populations through mobile health (mHealth) strategies [21], [31], [32].

Digital media transforms traditional child developmental screening by enabling real-time data collection, interactive user engagement, and parental empowerment. In both country groups, tools like GuessWhat?, SmartSpeech, and WMG-E have improved detection and increased screening coverage. In LMICs, tools such as DEEP and START expand service access to rural communities where developmental screening was previously infeasible. These tools reduce reliance on clinical visits, allow at-home monitoring, and support early referrals, making developmental care more equitable and proactive.

Barriers of Using Digital Media in Child Growth and Development Screening

The barriers to digital media implementation in child developmental screening are more pronounced in developing countries, where challenges intersect with resource scarcity, infrastructural weaknesses, low digital literacy, systemic health inequities [35]. One of the most critical issues is limited access to digital infrastructure. Many rural and remote areas lack reliable electricity, mobile data coverage, and internet bandwidth, severely limiting the feasibility of using internet-dependent applications for real-time developmental screening [36]. This digital divide not only undermines app functionality but also creates geographic disparities in the reach and impact of digital interventions.

An overarching barrier in developing countries is the lack of integration between digital tools and national healthcare systems [37]. Unlike in developed countries where digital screening tools are often embedded within electronic health records or linked to government programs, many LMICs still lack standardized health information systems. This disconnect hinders the continuity of care and limits the ability of digital tools to influence health policy, funding allocation, or long-term child health tracking.

Those technological and systemic barriers are becoming challenges towards broader adoption. In developing countries, infrastructural deficits such as poor internet, electricity shortages, and low digital literacy restrict implementation. Cultural-linguistic diversity further hampers adoption when tools are not contextually adapted. A single nation like India may have dozens of spoken languages and cultural beliefs regarding child development. Without contextual customization, digital tools risk being perceived as foreign or irrelevant, leading to low adoption rates. Similarly, in Indonesia, social norms may discourage open discussion of developmental delays, leading to under-utilization of digital screening platforms even when technically available.

Moreover, lack of integration with national health systems results in data silos and fragmented care pathways. In high-income countries, despite advanced features, some tools still face issues of device exclusivity, data privacy concerns, and need for professional oversight during use. Across all contexts, sustainability is a concern if tools are not supported by policy frameworks or national funding.

Novelty and Literature Gaps

While various studies have examined digital innovations in child development monitoring, there remains a limited body of work that synthesizes these findings across different country contexts, particularly comparing low- and middle-income countries (LMICs) with high-income settings. This scoping review contributes novelty by mapping the global landscape of digital tools used in growth and developmental screening, highlighting not only technological variety but also differences in implementation

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strategies, equity issues, and contextual adaptation. Furthermore, previous reviews often focus on specific disorders (e.g., autism or ADHD); in contrast, this study adopts a broader developmental lens, encompassing multiple domains such as cognitive, social-emotional, physical, and language development.

Methodological Limitations and Risk of Bias

This scoping review, while comprehensive, has several limitations. The inclusion of only English-language, peer-reviewed articles introduces language and publication bias, potentially excluding relevant evidence from non-English sources or grey literature. In addition, most of the included studies employed non-randomized sampling, and many lacked longitudinal follow-up, which limits understanding of long-term outcomes.

Furthermore, while tools like GuessWhat? and START demonstrate promising diagnostic utility, their validation samples were small and geographically limited, raising questions about generalizability. The heterogeneity in study design and outcome reporting also constrained deeper comparison or meta-analysis.

CONCLUSION

The integration of digital media into child development screening marks a significant advancement in global child health. Tools such as mobile apps, serious games, and IoT-based systems have enhanced efficiency, accessibility, and engagement among parents and health workers. High-income countries often use precision-driven, automated systems, while low- and middle-income nations favor scalable, low-cost innovations. However, adoption remains uneven due to infrastructure gaps, limited digital literacy, and weak integration with healthcare systems. Addressing these issues requires context-sensitive design, strong implementation strategies, and inclusive policies. Future research should evaluate long-term impacts, scalability, cost-effectiveness, and sustainability. Co-design with caregivers, community health workers, and policymakers is also essential to ensure relevance and foster local ownership.

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