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Android Application for Smart Diagnosis of Children with Disabilities and Its Correlation to Neuroscience: Definition, Literature Review with Bibliometric Analysis, and Experiments

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ABSTRACT

This study aimed to develop a Smart Diagnosis Application for Children with Disabilities as a tool that can detect early developmental disorders in children with indications of special needs. The development of smart diagnostic applications for children with special needs represents a significant advancement in early childhood care and intervention. Developing a smart diagnostic application involves a structured design-based research (DBR) process to ensure the application effectively meets the needs of children. Smart diagnostic applications use advanced technologies like artificial intelligence and machine learning to provide personalized assessments for children's developmental milestones. The tools empower parents, caregivers, and healthcare professionals with accurate insights. The user-friendly design makes the diagnostic process more manageable, and the cost-effectiveness reduces specialist visits. The iterative nature of the software allows for continuous improvement, contributing to better health outcomes and quality of life.

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1. INTRODUCTION

Children with disabilities represent a particularly vulnerable group in the healthcare system (Maryanti *et al*., 2021). They often require specialized attention and services can be challenging to access, particularly in under-resourced areas (Sudarjat, 2022; Kurniawan, 2022; Rahmat, 2021). Early and accurate diagnosis is crucial for children to receive the appropriate interventions and support (Elder *et al*., 2017). However, traditional diagnostic methods can be time-consuming, expensive, and inaccessible to many families. This gap in healthcare services calls for innovative solutions, and mobile technology presents a promising opportunity to bridge this gap.

In the modern era, technological advancements have permeated nearly every aspect of our lives, revolutionizing how we approach problems and find solutions (Kamalov *et al*., 2023). Among the myriad applications of technology, one particularly impactful area is healthcare (Qadri *et al*., 2020). The development of mobile applications has opened up new avenues for providing health services, particularly for vulnerable populations (Satre *et al*., 2021). This article delves into the innovative use of an Android application aimed at the smart diagnosis of children with disabilities, illustrating how technology can be harnessed to improve lives and deliver critical health services more efficiently.

The advent of Android applications tailored for healthcare purposes has already demonstrated significant benefits in various contexts. From chronic disease management to mental health support, mobile apps have seen they enhance patient engagement, improve health outcomes, and reduce the burden on healthcare systems (Allegrante *et al*., 2019). Building on successes, an Android application designed for the smart diagnosis of children with disabilities could be a game-changer in pediatric care.

Smart diagnosis applications utilize advanced algorithms and machine learning techniques to analyze data and provide diagnostic recommendations. For children with disabilities, such applications can offer a more accessible, cost-effective, and timely solution compared to traditional methods (Bodkhe & Tanwar, 2021). By integrating various diagnostic tools and resources into a single platform, the applications can streamline the diagnostic process, making it easier for parents and caregivers to access the necessary support.

One of the key advantages of using an Android platform for this purpose is its widespread availability and user-friendly interface (Baig *et al*., 2015). Android devices are prevalent and affordable, making them an ideal choice for developing countries and low-income families (McCool *et al*., 2022). An application designed for this platform can reach a broad audience, ensuring more children receive the early diagnosis and intervention they need (Archangeli *et al*., 2017). Additionally, the flexibility and scalability of Android apps allow for continuous updates and improvements, ensuring the application remains relevant and effective over time (Liu *et al*., 2015). Moreover, an Android application for the smart diagnosis of children with disabilities can leverage various built-in features of smartphones, such as cameras, microphones, and sensors, to collect data. The features can be used to conduct assessments otherwise require specialized equipment. For instance, speech recognition software can analyze a child's speech patterns, while the camera can capture movements and facial expressions for behavioral analysis. Such capabilities make the diagnostic process more comprehensive and less invasive (Zein *et al*., 2016).

The development of a smart diagnosis application also involves collaboration among healthcare professionals, software developers, and researchers. By combining their expertise, they can create an application both scientifically robust and practically useful (Shen, 2018). The involvement of pediatricians, neurologists, psychologists, and other specialists ensures

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the diagnostic criteria and algorithms are based on the latest medical knowledge and best practices. Meanwhile, software developers focus on creating an intuitive and engaging user experience that encourages regular use and adherence.

Another critical aspect of developing such an application is ensuring data privacy and security. Given the sensitive nature of health information, it is imperative that the application adheres to stringent privacy regulations and employs robust security measures (Ismagilova *et al*., 2022). Parents and caregivers must feel confident that their children's data is protected and the application complies with all relevant legal and ethical standards (Leibson & Koren, 2015). This trust is essential for the widespread adoption and success of the application.

The potential impact of an Android application for the smart diagnosis of children with disabilities extends beyond individual families. On a larger scale, the data collected by such applications can contribute to broader research and public health initiatives. By aggregating anonymized data, researchers can gain insights into the prevalence and characteristics of various disabilities, leading to better-targeted interventions and policies. This feedback loop enhances the overall effectiveness of healthcare systems and contributes to the global effort to support children with disabilities. The development of an Android application for the smart diagnosis of children with disabilities represents a significant step forward in pediatric healthcare. By harnessing the power of mobile technology, we can provide more accessible, efficient, and accurate diagnostic services to children in need. This innovation not only benefits individual families but also contributes to broader public health goals, paving the way for a healthier and more inclusive future.

The purpose of this study was to develop a Smart Diagnosis Application for Children with Disabilities as a tool that can detect early developmental disorders in children with indications of special needs. The novelties of the research are (i) increasing the sensitivity of early detection, measuring and increasing the level of sensitivity of Smart Diagnosis for Children with Disabilities in detecting potential indications of special needs in children through evaluation and improvement of prototypes, (ii) user interface optimization, investigate and improve the Smart Diagnosis for Children with Disabilities user interface, it can be used efficiently by parents, educators, and health workers in conducting child development assessments, (iii) assess user satisfaction, evaluate user satisfaction through prototype testing, and identify aspects that require improvement or improvement, and (iv) supporting innovation-based early detection, implementing smart diagnosis of children with disabilities as an innovative solution can support the early detection system for developmental disorders in children with indications of special needs. Also, to complete this study, we add the previous research about digital diagnostics for children. We hereby give a comprehensive collection of articles from the Scopus database, as indicated in **Table 1**, with references to earlier studies and our analysis investigations.

Table 1. Previous studies on bibliometric.

Title	Result	Ref
Droplet Digital PCR (ddPCR) Does Not Enhance the Sensitivity of Detection of Cytomegalovirus (CMV) DNA in Newborn Dried Blood Spots Evaluated in the Context of Newborn Congenital CMV (cCMV) Screening	Newborn bloodspot screening (NBS) was introduced in Buffalo, New York, in the 1960s by Dr. Robert Guthrie. It expanded to various asymptomatic congenital disorders, but political policymakers might disagree on its effectiveness as a public health prevention tool. A global NBS update in 2015 acknowledged the importance of national reports and included data from early 2024, including Caribbean and sub-Saharan Africa reports. Regional tables were updated with harmonized comparisons and recommended specimen collection times.	Hernandez-Alvarado (2024)

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Table 1. (Continue). Previous studies on bibliometric.

Title	Result	Ref
Is Our Newborn Screening Working Well? A Literature Review of Quality Requirements for Newborn Blood Spot Screening (NBS) Infrastructure and Procedures	Newborn screening with dried blood spots (NBS) was an effective secondary preventive technique for preventing severe congenital diseases. A comprehensive literature review in Germany focuses on the NBS pathway's components, including parental education, coverage, timeliness, laboratory quality assurance, follow-up of abnormal results, confirmatory diagnostics, documentation, and evaluation. The study emphasized the importance of NBS as a well-planned public health initiative with ongoing quality control, considering the perspectives of families and considering international cooperation or digital tools.	Odenwald *et al*. (2023)
Serum neurofilament light-chain levels in children with monophasic myelin oligodendrocyte glycoprotein-associated disease, multiple sclerosis, and other acquired demyelinating syndrome	Serum neurofilament light chain (sNfL) levels were significantly higher in children with initial acquired demyelinating syndrome (ADS), particularly those with longitudinally widespread myelitis or MRI patterns resembling acute disseminated encephalomyelitis. These elevated sNfL levels were correlated with higher cerebral and spinal MRI lesions and predicted relapses in juvenile MS patients.	Wendel *et al*. (2022)
Aspiration pneumonia in children with neurological disorders: a new indication for lung ultrasound? A case series	Aspiration pneumonia is a common cause of morbidity and mortality in adults and children. There were no published studies on lung ultrasonography's application in pediatric aspiration pneumonia diagnosis and follow-up. This case series provides clinical, biochemical, radiographic, and comprehensive findings.	Buonsenso *et al*. (2020)
Functional results after carpal tunnel release in mucopolysaccharidosis	Mucopolysaccharidosis is a condition causing hand disabilities due to the accumulation of glycosaminoglycan in the carpal tunnel. A study aimed to demonstrate the functional outcomes of carpal tunnel release in individuals with mucopolysaccharidosis. Seven patients, six boys with a mean age of 9.5, underwent bilateral carpal tunnel surgery. After a 12-month follow-up, all children with median nerve decompression improved their ability to handle small and large objects. However, the study found that surgery alone did not cause the improvement, and more studies are needed to confirm the cause.	Giostri *et al*. (2021)
Biallelic mutation of FBXL7 suggests a novel form of Hennekam syndrome	Hennekam lymphangiectasia-lymphedema syndrome, an autosomal recessive disorder characterized by intestinal lymphangiectasia, congenital lymphedema, facial dysmorphism, and intellectual disability, has been linked to a homozygous single-exon deletion of FBXL7 in a patient with the disorder. The deletion, which removes exon 3, suggested FBXL7 could be the fourth gene for Hennekam syndrome.	Boone *et al*. (2020)
Utilization of Fluorescence Microangiography in Pediatric Acute Compartment Syndrome: A Case Report	Acute compartment syndrome, a dangerous illness caused by crush injuries, fractures, and high-energy trauma, is rare in children. Diagnosing is challenging due to their inability to articulate symptoms. A 5-year-old girl developed compartment syndrome after an isolated crush injury. After hyperbaric oxygen therapy and an emergent fasciotomy, it improved hypofluorescence and was able to amputate distal digits. The patient resumed pre-injury activities and did not experience pain or functional impairment at a 12-month follow-up visit.	Bauerly *et al*. (2020)

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Table 1. (Continue). Previous studies on bibliometric.

Title	Result	Ref
Epidemiology of ruptured brain arteriovenous malformation: A national cohort study in Korea	The study investigated the epidemiology of brain arteriovenous malformation (BAVM) in Korea, revealing a crude incidence of 3.5 per 100,000 person-years. Ruptured BAVMs were identified in 308 patients, with 12.7% of patients dying within a month. The standard occurrence was 3.6 ruptured BAVMs per 100,000 person-years with high rates of disability and mortality.	Kim *et al.* (2018)
Encephaloduroarteriosynangiosis for pediatric moyamoya disease: long-term follow-up of 100 cases at a single center	The study investigated the clinical outcomes of encephaloduroarteriosynangiosis (EDAS) in pediatric moyamoya disease (MMD). EDAS is safe and effective and can reduce neurological episodes and improve quality of life. Younger children faced higher ischemia risks, while older children benefitted.	Zhang *et al.* (2018)
Vision Diagnostics and Treatment System for Children with Disabilities	The VisDaT system was a computer-based tool designed to assist therapists in accurately diagnosing and treating children with visual abnormalities. It used a digital camera to monitor responses online and an eye tracker to record movements. The system's capabilities enabled the stimulation of children's eyesight and the decision-making process for future therapy.	Kasprowski and Harezlak (2018)
Brain morphometry in Pontocerebellar Hypoplasia type 2	A study on children with Pontocerebellar Hypoplasia Type 2 (PCH2) found slower growth rates, smaller brain volumes, and severe microcephaly, suggesting intrinsic cerebellar dysfunction rather than postnatal neurodegeneration disrupts cerebellar-cerebral networks.	Ekert *et al.* (2016)
Imaging in Pediatric Demyelinating and Inflammatory Diseases of Brain- Part 2	Imaging was crucial for diagnosing, treating, and monitoring pediatric demyelinating and inflammatory brain illnesses. Aquaporinopathies and CNS vasculitis spectrums were reviewed, with current criteria discussed using clinical vignettes.	Sudhakar *et al.* (2016)

2. LITERATURE REVIEW

2.1. Neuroscience in Children with Special Needs

Neuroscience, the scientific study of the nervous system, has significantly advanced our understanding of how the brain develops and functions in children. This field is particularly important when examining children with special needs, as it provides insights into the underlying neural mechanisms that contribute to various developmental and cognitive differences (Uddin, 2021). By exploring the mechanisms, researchers and clinicians can better diagnose, treat, and support children with special needs, ultimately improving their quality of life (Feiler & Stabio, 2018). Children with special needs often face a range of challenges, including learning disabilities, autism spectrum disorders, attention deficit hyperactivity disorder (ADHD), and sensory processing issues (Rosello *et al.*, 2022). Neuroscience plays a crucial role in identifying the brain structures and functions associated with the conditions. Understanding the differences is key to developing targeted interventions (Woo *et al.*, 2017). Early intervention is critical for children with special needs, as the brain is highly plastic during early childhood (Ritterband-Rosenbaum *et al.*, 2019). Neuroplasticity, the brain's ability to reorganize itself by forming new neural connections, is at its peak during this period. Neuroscience research has shown early, intensive interventions can lead to significant

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improvements in cognitive, social, and behavioral outcomes for children. **Figure 1** explains about correlation between neuroscience and children with special needs.

Techniques such as applied behavior analysis (ABA) for autism and cognitive-behavioral therapy (CBT) for ADHD are grounded in our understanding of neuroplasticity and brain function (Zhang *et al*., 2022). Advances in neuroimaging technologies, such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG), have allowed scientists to observe brain activity in real time (Baillet, 2017). The tools have been instrumental in uncovering how children with special needs process information differently (Heunis *et al*., 2020). For instance, fMRI studies have revealed children with dyslexia may use different neural pathways for reading compared to typically developing children (Vandermosten *et al*., 2016). This knowledge helps educators and therapists tailor their approaches to suit the unique needs of each child.

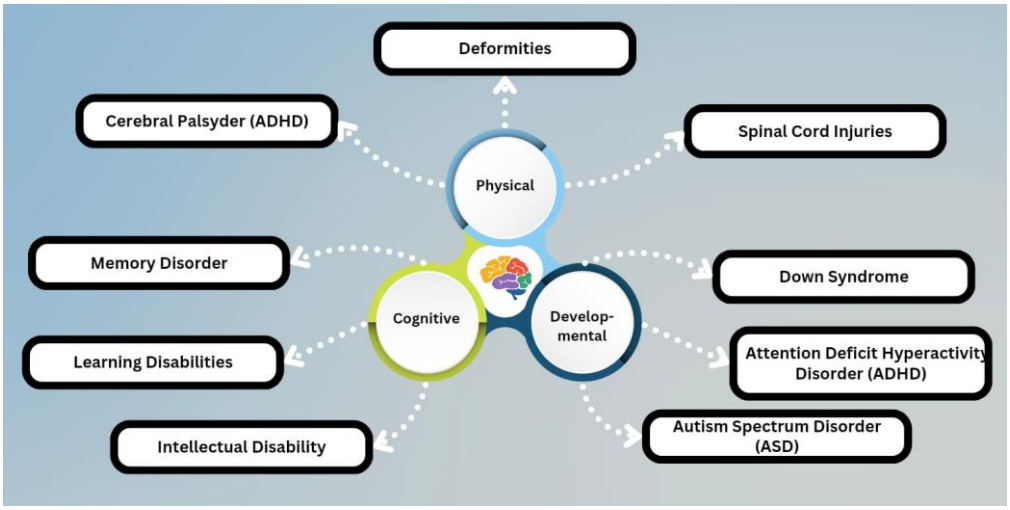

Figure 1. Correlation of neuroscience and children with special needs.

Neuroscience also contributes to our understanding of the genetic factors that influence developmental disorders (Muhle *et al*., 2018). Research has identified numerous genes associated with conditions such as autism and intellectual disabilities. By studying the genetic variations, scientists gain insights into the biological pathways that affect brain development (de la Torre-Ubieta *et al*., 2016). This genetic information informs early screening and personalized treatment plans, offering hope for more effective interventions (Parenti *et al*., 2020). One promising area of neuroscience research is the study of sensory processing in children with special needs. Many children experience heightened or diminished sensitivity to sensory stimuli, which impacts their daily functioning and learning (Lane, 2020). Neuroscientific investigations into sensory processing have led to the development of therapies that are aimed at normalizing sensory experiences (Thye *et al*., 2018).

Neuroscience research has also highlighted the importance of environmental factors in brain development (Tooley *et al*., 2021). Children with special needs may be more vulnerable to environmental influences, such as stress, nutrition, and exposure to toxins (Rauh & Margolis, 2016). Understanding how the factors impact the developing brain guides the creation of supportive environments to promote optimal neurodevelopment. In addition to clinical applications, neuroscience findings are informing educational practices for children with special needs. This includes using multisensory teaching methods, individualized learning plans, and assistive technologies to support different learning styles. Neuroscience-driven educational approaches help children with special needs achieve their full academic potential (Monk & Hardi, 2023).

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Neuroscience is paving the way for innovative therapies to harness the brain's inherent capacity for change. Techniques such as neurofeedback, which trains individuals to regulate their brain activity, and transcranial magnetic stimulation (TMS), which uses magnetic fields to stimulate specific brain regions, are being explored as potential treatments for various developmental disorders (Oberman *et al*., 2016). Therapies offer the promise of directly modifying brain function to improve cognitive and behavioral outcomes in children with special needs (Wojtalik *et al*., 2018). Neuroscience is a vital field that enhances our understanding of the brain and its development in children with special needs (Feiler & Stabio, 2018). As research continues to advance, the insights gained from neuroscience hold the potential to transform the lives of children with special needs, offering them better opportunities for growth, learning, and social integration.

2.2. Digital Diagnostic for Children with Special Needs

The advent of digital diagnostics is revolutionizing healthcare, particularly for children with special needs (Ahmad *et al*., 2023). The innovative tools leverage technology to provide more accurate, accessible, and timely diagnoses, addressing the unique challenges faced by this vulnerable population (Mbunge *et al*., 2021). Digital diagnostics offer a promising alternative, utilizing advanced technologies such as artificial intelligence (AI), machine learning, and mobile health applications to streamline the diagnostic process and make it more accessible to families (Yousaf *et al*., 2019). **Figure 2** explains the flow of digital diagnostics.

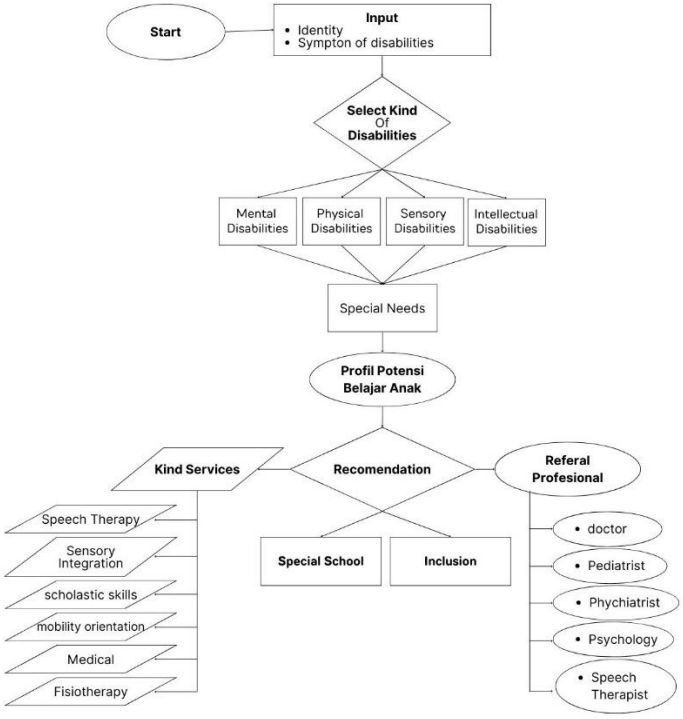

Figure 2. Flow of digital diagnostics.

One of the key advantages of digital diagnostics is the ability to conduct comprehensive assessments remotely. Mobile applications and online platforms enable parents and caregivers to collect data about their children's behavior, development, and health from the comfort of their homes. The tools include interactive questionnaires, video-based assessments, and real-time tracking of developmental milestones. The data can be analyzed using sophisticated algorithms to identify potential developmental delays or disorders (Bélanger & Caron, 2018).

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AI plays a crucial role in the effectiveness of digital diagnostic tools (Kumar *et al*., 2023). AI algorithms analyze vast amounts of data quickly and accurately, identifying patterns and anomalies that might be missed by human observers. AI-driven speech and language analysis tools detect early signs of speech and communication disorders by analyzing audio recordings of a child's speech. Machine learning algorithms evaluate a child's behavior in video recordings to identify symptoms of autism spectrum disorder (ASD) or ADHD (Thabtah, 2019).

Digital diagnostics are making the tools more accessible by integrating them with mobile and wearable devices (Heintzman, 2016). Another significant benefit of digital diagnostics is the ability to provide continuous monitoring and real-time feedback (Albahri *et al*., 2018). Traditional diagnostic assessments are often limited to specific points in time, which may not capture the full extent of a child's condition (Spence, 2018). Digital tools allow for ongoing data collection and analysis, providing a more comprehensive picture of a child's development. This continuous monitoring helps detect subtle changes and improvements over time, enabling more personalized and adaptive interventions (Perski *et al*., 2022).

Digital diagnostic tools also enhance collaboration between parents, caregivers, and healthcare professionals (Donovan *et al*., 2020). Parents easily share their observations and concerns with clinicians, and then provide more informed guidance and support (Bradbury *et al*., 2018). Digital platforms connect families with support networks and resources, fostering a community of shared experiences and knowledge. Privacy and data security are critical considerations in the development and implementation of digital diagnostics (Adeniyi *et al*., 2024). Given the sensitive nature of health information, the tools adhere to stringent privacy regulations and employ robust security measures (Nowrozy *et al*., 2024). Ensuring data is encrypted and stored securely protects the privacy of children and their families, building trust and encouraging the widespread adoption of digital diagnostic technologies (Agrawal & Prabakaran, 2020).

The potential of digital diagnostics extends beyond individual assessments to broader public health and research initiatives (Coravos *et al*., 2019). Aggregated data from digital diagnostic tools provide valuable insights into the prevalence and characteristics of developmental disorders in different populations (Land *et al*., 2019). This information informs public health policies, early intervention programs, and educational strategies, ultimately contributing to better outcomes for children with special needs on a larger scale. Digital diagnostics play a pivotal role in addressing healthcare disparities (Saeed & Masters, 2021). Children in remote or underserved areas often lack access to specialized diagnostic services. Digital tools bridge this gap by providing remote assessments and connecting families with healthcare professionals regardless of geographical location. This increased accessibility leads to earlier diagnoses and interventions, improving long-term outcomes for children in the communities.

Digital diagnostics represent a transformative advancement in the care and support of children with special needs. By harnessing the power of technology, the tools offer more accurate, accessible, and timely diagnoses, paving the way for personalized and effective interventions. As digital diagnostics continue to evolve, they hold the potential to significantly improve the lives of children with special needs and their families, fostering a more inclusive and supportive society.

2.3. Algorithm for Smart Diagnostic Application

The integration of algorithms in applications designed for the diagnostic evaluation of children with special needs is a groundbreaking development in healthcare technology (Satpathy *et al*., 2024). The algorithms harness the power of AI and machine learning to

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analyze complex data sets, identify patterns, and provide accurate and timely diagnoses (Sahu *et al*., 2022). Algorithms are essentially sets of rules or procedures for solving problems or performing tasks (Ahn *et al*., 2021). In the context of digital diagnostics, algorithms are used to process and analyze various forms of data, such as behavioral observations, speech and language patterns, neuroimaging results, and other biometric data (Corcoran & Cecchi, 2020). By leveraging the algorithms, digital applications provide a more efficient and precise diagnosis than traditional methods. **Figure 3** explains how the algorithm runs in the Smart Diagnostic Application.

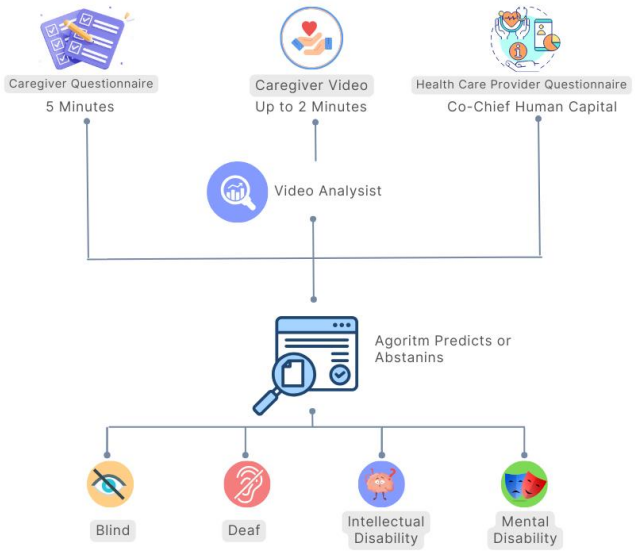

Figure 3. Algorithm for smart diagnostic application.

One of the most significant benefits of using algorithms in diagnostic applications is their ability to handle large volumes of data quickly and accurately (Mirbabaie *et al*., 2021). Traditional diagnostic methods often rely on manual observations and assessments, which can be time-consuming and subject to human error (MacAulay *et al*., 2022). In contrast, algorithms analyze vast amounts of data in real-time, identifying subtle patterns and correlations that might be overlooked by human observers (Smith & Pinter-Wollman, 2021). This capability is particularly valuable for diagnosing complex conditions such as ASD, ADHD, and learning disabilities (Muskens *et al*., 2017).

Machine learning, a subset of AI, is particularly powerful in the development of diagnostic algorithms (Nichols *et al*., 2019). Machine learning algorithms learn from data inputs, improving their accuracy and performance over time (Ofori *et al*., 2020). In digital diagnostic applications, the algorithms are trained on extensive datasets of children's developmental and health records, enabling them to recognize patterns associated with specific conditions (Xiao *et al*., 2018). One common application of algorithms in digital diagnostics is in the analysis of speech and language patterns. Speech recognition software captures and analyzes audio recordings of a child's speech, using algorithms to assess factors such as vocabulary usage, sentence structure, and pronunciation. The analyses help identify speech and language disorders early, facilitating timely interventions. Similarly, algorithms analyze video recordings of a child's behavior, tracking movements, facial expressions, and interactions to detect signs of developmental disorders.

Predictive modeling is another crucial aspect of algorithm-based diagnostics (Cosma *et al*., 2017). Predictive algorithms use historical data to forecast future outcomes, helping clinicians anticipate a child's developmental trajectory and potential challenges (Kaur *et al*., 2022). This

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information guides early intervention strategies, improving long-term outcomes for the child. The development and refinement of diagnostic algorithms involve close collaboration between data scientists, healthcare professionals, and software developers (Stanfill & Marc, 2019). Data scientists design and train the algorithms, while healthcare professionals provide the clinical expertise to ensure the algorithms are accurate and clinically relevant. Software developers then integrate the algorithms into user-friendly applications that parents, caregivers, and clinicians use effectively. **Figure 4** explains the flow of using the smart diagnosis application which is easy and user friendly.

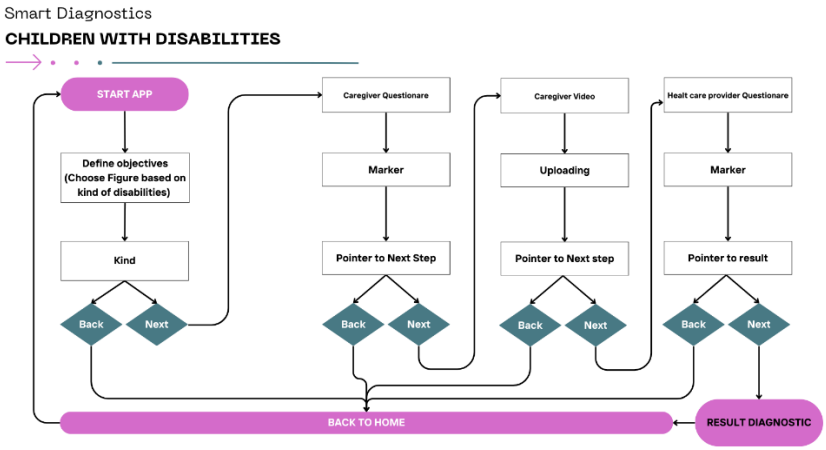

Figure 4. The flow of using the smart diagnostic application.

One of the key challenges in developing the algorithms is ensuring they are trained on diverse and representative datasets (Liang *et al*., 2022). Algorithms trained on biased or limited data may not perform accurately across different populations (Mhasawade *et al*., 2021). Therefore, it is essential to include data from children of various ages, ethnicities, and socioeconomic backgrounds to create algorithms that are generalizable and equitable. Privacy and data security are critical considerations in the use of diagnostic algorithms (Pillai, 2021). Given the sensitive nature of health data, applications must adhere to stringent privacy regulations and employ robust security measures. Algorithms must be designed to ensure data is anonymized and encrypted, protecting the privacy of children and their families (Martín-Ruíz *et al*., 2018). This trust is essential for the widespread adoption of digital diagnostic tools. The impact of algorithm-based diagnostics extends beyond individual assessments to broader healthcare and research initiatives (Jones *et al*., 2022). Aggregated data from digital diagnostic applications provide valuable insights into the prevalence and characteristics of developmental disorders, informing public health policies and research (Huckvale *et al*., 2019). Additionally, continuous data collection and analysis enable ongoing refinement of the algorithms, improving their accuracy and effectiveness over time.

In educational settings, algorithm-based diagnostic tools play a pivotal role in supporting children with special needs. Teachers and educators use the tools to identify students who may require additional support and tailor their teaching strategies accordingly. Algorithms are transforming the field of diagnostics for children with special needs by providing more accurate, accessible, and timely evaluations. By leveraging AI and machine learning, the algorithms analyze complex data sets, identify patterns, and offer valuable insights into a child's developmental and cognitive health. As technology continues to advance, the integration of algorithms into diagnostic applications holds the promise of significantly improving the early detection and management of developmental disorders, ultimately enhancing the lives of children with special needs and their families.

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3. METHODS

3.1. Bibliometric Analysis

Bibliometric analysis is a quantitative method used to evaluate the academic literature in a specific field by analyzing the characteristics of research publications. Detailed information regarding bibliometric analysis is explained elsewhere (Al Husaeni & Nandiyanto, 2022). In the context of developing a smart Android application for diagnosing children with special needs, a bibliometric analysis provides insights into the research trends, key authors, influential publications, and prevalent themes in this domain. This article outlines the steps involved in conducting a bibliometric analysis for this topic and discusses the findings and their implications for future research and development. Data for bibliometric analysis was typically collected from academic databases such as Web of Science, Scopus, PubMed, and Google Scholar. The search strategy should include relevant keywords and phrases, such as "smart application," "android," "diagnosis," "children with special needs," and "machine learning." The search can be refined by using Boolean operators, filters for publication dates, and specific subject areas. Bibliometric analysis provided valuable insights into the research landscape of smart diagnostic applications for children with special needs. By examining publication trends, influential authors, collaboration networks, and thematic areas, this analysis helps identify key developments and future directions in the field. As technology continues to evolve, ongoing bibliometric analysis is crucial in tracking progress and guiding innovation in the development of effective diagnostic tools.

3.2. Design Process

Design-Based Research (DBR) is a robust methodology that combines empirical educational research with the theory-driven design of learning environments. In the context of developing a smart Android application for diagnosing children with special needs, DBR provides a systematic framework to iteratively design, test, and refine the application. This approach ensures the resulting product is both scientifically sound and practically useful. This article outlines the application of DBR in creating a smart diagnostic tool, detailing each phase of the process and the benefits it offers. **Figure 5** explains the flow of how to make the Smart Diagnostic Application.

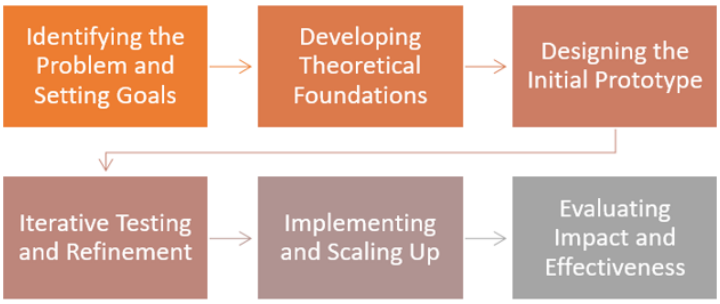

Figure 5. Step of design application.

The first step in DBR was identifying the specific problem that the application aims to address. In this case, the problem was the need for accurate, accessible, and timely diagnostic tools for children with special needs. Traditional diagnostic methods can be time-consuming, expensive, and often require visits to multiple specialists. A crucial aspect of DBR was grounding the design in existing theories and research. For this application, theories from developmental psychology, neuroscience, and educational technology inform the design. Understanding the neural and behavioral markers of conditions like ASD, ADHD, and learning

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disabilities guides the development of diagnostic algorithms. Additionally, principles of user-centered design and mobile health (mHealth) technologies insure the application is user-friendly and effective.

Based on the theoretical foundations, an initial prototype of the application is designed. This prototype includes key features such as interactive questionnaires, video-based assessments, and real-time tracking of developmental milestones. The design should leverage the capabilities of Android devices, such as cameras and microphones, to collect data unobtrusively. The prototype should also incorporate AI algorithms to analyze data and provide diagnostic feedback. DBR emphasizes iterative testing and refinement through cycles of design, implementation, analysis, and redesign. The initial prototype is tested in real-world settings with a small group of users, such as parents, caregivers, and healthcare professionals. Feedback from the users is collected through observations, interviews, and surveys. This feedback is used to identify strengths and weaknesses in the prototype, guiding subsequent refinements. The testing in this design is shown in **Figure 6**.

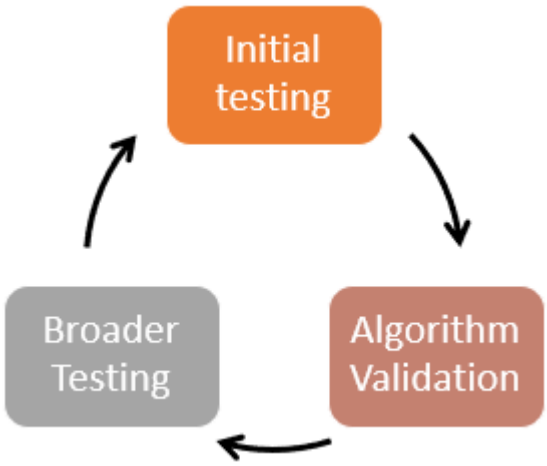

Figure 6. Cycle of testing phase.

The first testing cycle focuses on usability and functionality. Participants use the application to complete diagnostic tasks, and their interactions are monitored to identify any usability issues. Common challenges include navigating the interface, understanding instructions, and completing assessments accurately. The feedback gathered in this phase informs the first round of refinements, addressing any usability barriers and enhancing the user experience. In the second cycle, the focus shifts to validating the diagnostic algorithms. Data collected through the application is compared to established diagnostic criteria and assessments performed by healthcare professionals. The algorithms are accurately identifying developmental and cognitive differences. Any discrepancies are analyzed to improve the algorithms' accuracy and reliability. The third testing cycle involves a larger and more diverse group of users to ensure the application performs well across different populations. This phase tests the application's generalizability and robustness, ensuring it can be effectively used by families from various backgrounds. Additional refinements are made based on this broader feedback, aiming to create a universally accessible and reliable diagnostic tool.

Once the application has undergone thorough testing and refinement, it is ready for broader implementation. This phase involves scaling up the deployment of the application to a wider audience, including schools, clinics, and community health programs. Training sessions and support materials are provided to ensure that users can effectively utilize the

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application. Continuous monitoring and feedback mechanisms are established to gather ongoing data on the application's performance and impact. The final phase of DBR involves evaluating the impact and effectiveness of the application in real-world settings. This evaluation includes both qualitative and quantitative measures, such as user satisfaction, diagnostic accuracy, and improvements in early intervention outcomes. Longitudinal studies may be conducted to assess the long-term benefits of using the application for diagnosing and supporting children with special needs.

Design-Based Research provides a comprehensive and iterative approach to developing a smart Android application for diagnosing children with special needs. By combining theoretical foundations with empirical testing and refinement, DBR ensures the resulting application is both scientifically robust and practically useful. This methodology not only enhances the accuracy and accessibility of diagnostic tools but also fosters continuous improvement and adaptation to meet the evolving needs of users. As technology and research advance, the principles of DBR continue to guide the development of innovative solutions to improve the lives of children with special needs and their families.

4. RESULTS AND DISCUSSION

4.1. Bibliometric about Digital Diagnostics for Children with Special Needs for the Last 10 Years

Bibliometric analysis is one of the effective methods for understanding research trends. Many reports regarding bibliometrics have been published (Nursaniah & Nandiyanto, 2023; Nurrahma *et al*., 2024, Firdaus *et al*., 2023; Al Husaeni & Wahyudin, 2023; Chano *et al*., 2023; Chano *et al*., 2024). **Table 2** shows the annual research report "digital diagnostics for children with special needs" which has been published in national and international journals. Based on the data, the total number of documents found over the last 10 years was 810 documents. The detailed number of research documents regarding "Digital diagnostics for children with special needs" namely 2014 as many as 137 documents, 2015 as many as 119 documents, 2016 as many as 110 documents, 2017 as many as 97 documents, 2018 as many as 82 documents, 2019 as many as 89 documents, 2020 as many as 89 documents, 2021 has 52 documents, 2022 has 24 documents, 2023 has 8 documents, and, 2024 has 3 documents.

Table 2. The annual research report on "Digital diagnostics for children with special needs".

Year	Document	Percentage
2014	137	16.91
2015	119	14.69
2016	110	13.58
2017	97	11.98
2018	82	10.12
2019	89	10.99
2020	89	10.99
2021	52	6.42
2022	24	2.96
2023	8	0.99
2024	3	0.37
Total	810	100

Based on the number of research documents each year, it is known research publications regarding "Digital diagnostics for children with special needs" have decreased from year to year. **Figure 7** shows a graph of the decline in the number of publications regarding "Digital

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diagnostics for children with special needs" more clearly. Over the past 10 years, the highest number of studies on this topic occurred in 2014 (137 documents) and the lowest number in 2024 (3 documents). The decrease in the number of documents occurs consistently every year, but there was a drastic decrease of around 37 documents from 2020 (89 documents) to 52 documents in 2021.

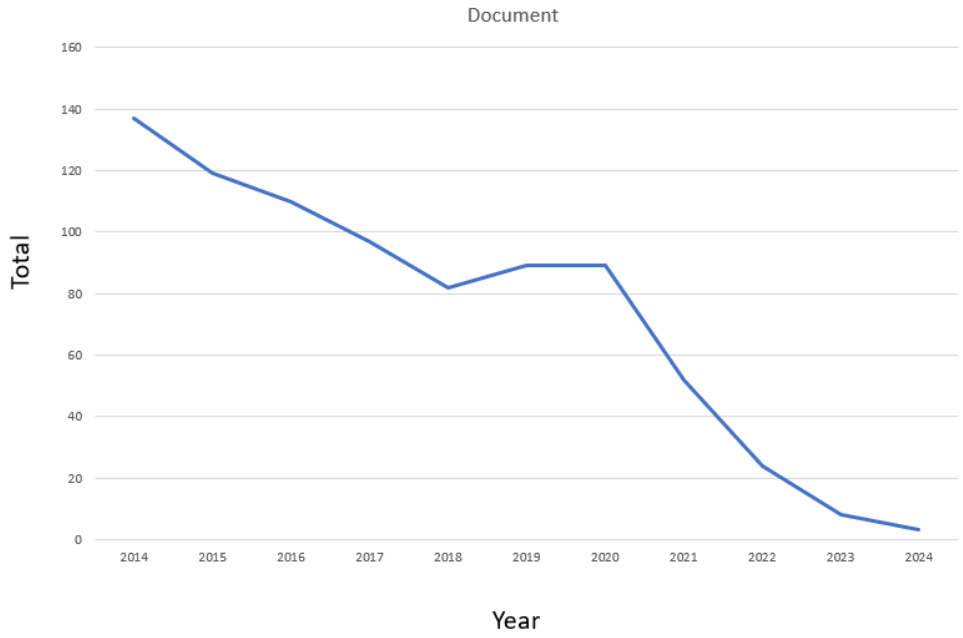

Figure 7. Annual report for publication based on scopus database, taken on June 2024 using the keyword “Digital diagnostics for children with special needs”.

The top ten papers on digital diagnostics received the most citations and were included in this study. A selection of metadata from publications with the most citations is presented in **Table 3** which shows the most frequently cited article in the field of Digital diagnostics for children with special needs is the article written by Chung *et al*. (2018), with the title "International ERS/ATS guidelines on definition, evaluation and treatment of severe asthma " with 4322 citations in total. The articles written have been cited 4303 since 2017, with an average number of citations per year of 221.38 times.

Table 3. Articles about digital diagnostics with the most citations.

No	Cited	Title	Ref
1	4322	International ERS/ATS guidelines on the definition, evaluation, and treatment of severe asthma	Chung *et al*. (2018)
2	4245	Annual research review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents	Polanczyk *et al*. (2015)
3	3456	Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your “house”	Grant & Osanloo (2014)
4	2172	ADHD prevalence estimates across three decades: an updated systematic review and meta-regression analysis	Polanczyk *et al*. (2014)
5	2065	KDOQI US commentary on the 2012 KDIGO clinical practice guideline for the evaluation and management of CKD	Inker *et al*. (2014)
6	1856	Evidence-based practices for children, youth, and young adults with autism spectrum disorder: A comprehensive review	Wong *et al*. (2015)
7	1809	Early social-emotional functioning and public health: The relationship between kindergarten social competence and future wellness.	Jones *et al*. (2015)

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Data mapped using VOSviewer produces 3 forms of visualization, namely network visualization (**Figure 8**), overlay visualization (**Figure 9**), and density visualization (**Figure 10**). The network visualization shows the terms generated from the abstract and keywords are considered appropriate to the keywords used during data collection divided into 6 clusters with a total of 70 items. Each item has a different link, total link strength, and occurrence. Overall, based on the network visualization, the total link strength is 2.778 while the number of links is 1.118.

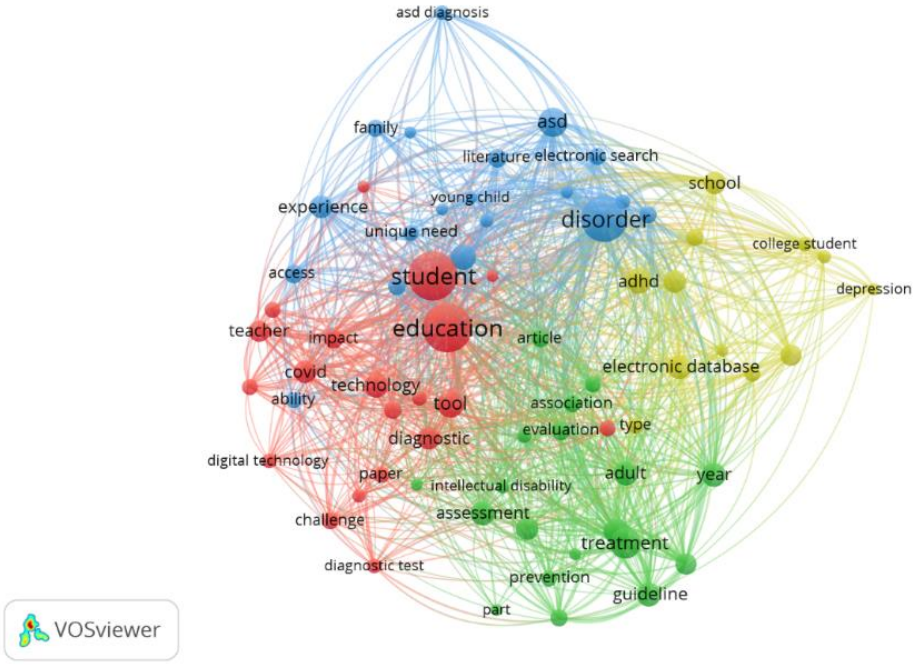

Figure 8. Network visualization based on co-occurrence of terms.

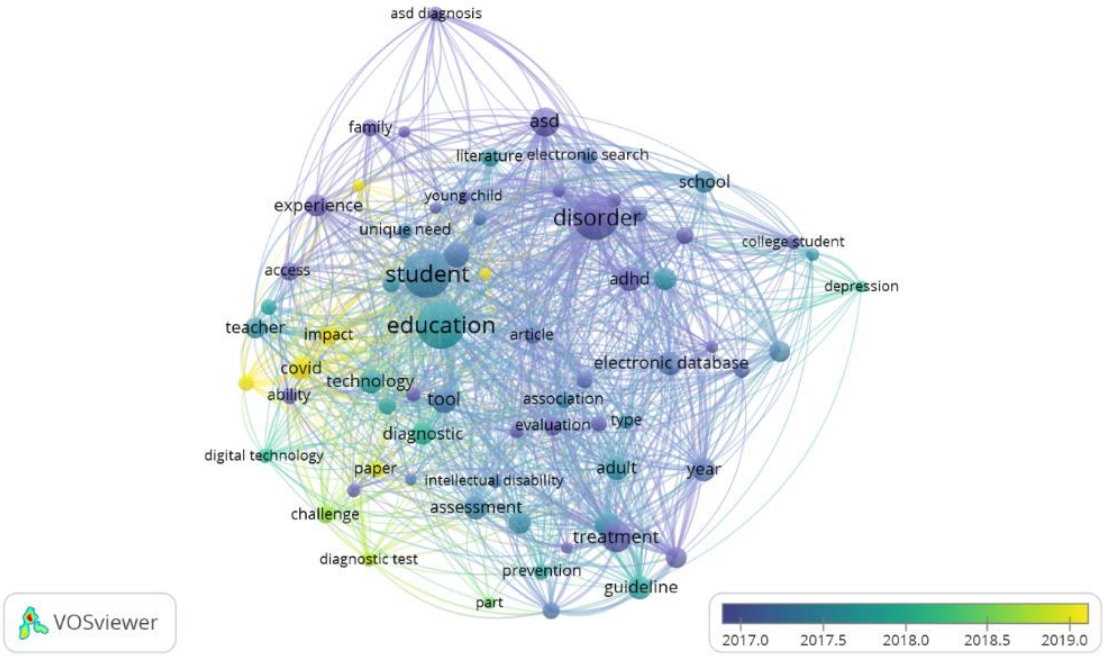

Figure 9. Overlay visualization based on co-occurrence of terms.

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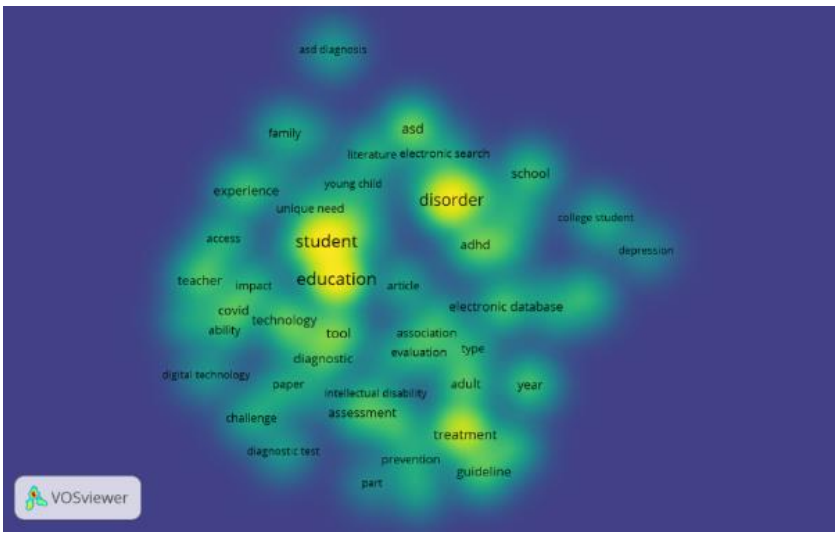

Figure 10. Density visualization is based on the occurrence of terms.

In addition, based on the network visualization (**Figure 9**), the terms used as keywords are in cluster 1, such as test which has 520 occurrences with a total link strength of 2230, and different which has 361 occurrences with a total link strength of 1062, and which has 185 occurrences with a total link strength of 859.

4.2. Smart Diagnostic Application

Designing the user interface (UI) and user experience (UX) for a smart diagnostic application for children with special needs requires a deep understanding of their unique requirements and challenges. The design process must prioritize accessibility, ensuring the app can be used by children with various disabilities and their caregivers. This means incorporating features like high-contrast colors, adjustable font sizes, and voice assistance capabilities. Accessibility considerations should also include visual cues, such as icons and images, to complement text and aid understanding for non-verbal children or those with limited reading skills.

The home screen of the application should be welcoming and intuitive, featuring a cheerful banner with the child's name and a friendly character or mascot. The navigation menu should be simple, using large, easily tappable icons for different sections such as Assessments, Progress Reports, Resources, and Settings. Quick actions for common tasks, like starting an assessment or viewing recent activity, should be prominently displayed to facilitate easy access and reduce the number of steps required to perform essential functions. **Figure 11** shows the home screen of the Smart Diagnostic Application.

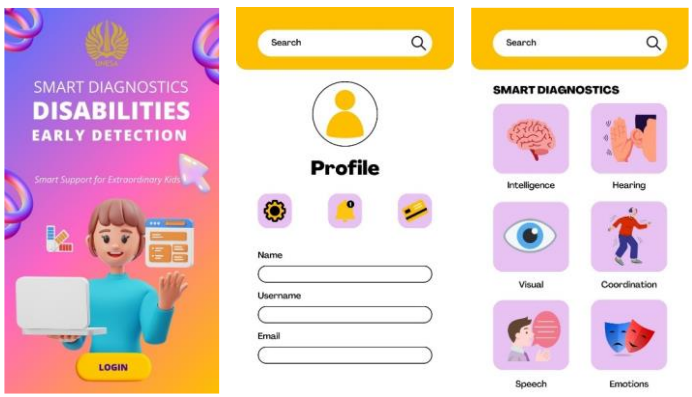

Figure 11. Smart diagnostic application.

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Setting up the child's profile should be a guided process, with clear instructions and visual progress indicators to ensure caregivers can effortlessly enter necessary information. This includes personal details, developmental history, and existing diagnoses. The profile section should also allow for customization, such as uploading a profile picture and adjusting settings for notifications, accessibility options, and assessment schedules. A step-by-step guide helps caregivers navigate this setup smoothly, enhancing their overall experience. The assessment section should be designed to be engaging and child-friendly, using interactive elements such as games, quizzes, and video-based tasks.

The assessments should be developed with input from experts in developmental psychology to ensure they are both enjoyable and effective in gathering diagnostic data. Clear, concise instructions for each assessment, along with a real-time progress bar, help maintain the child's interest and reduce any potential anxiety associated with the diagnostic process. Progress reports are a crucial component of the application, providing caregivers with valuable insights into the child's development. The overview dashboard should offer a summary of key metrics, such as developmental milestones, areas of concern, and recent assessments. Detailed reports should include charts and graphs to illustrate progress visually, making it easier for caregivers to understand the information. Options to share the reports with healthcare providers and educators should be included to facilitate collaboration and informed decision-making. **Figure 12** explains the diagnostic options made, and examples of questions in diagnosis.

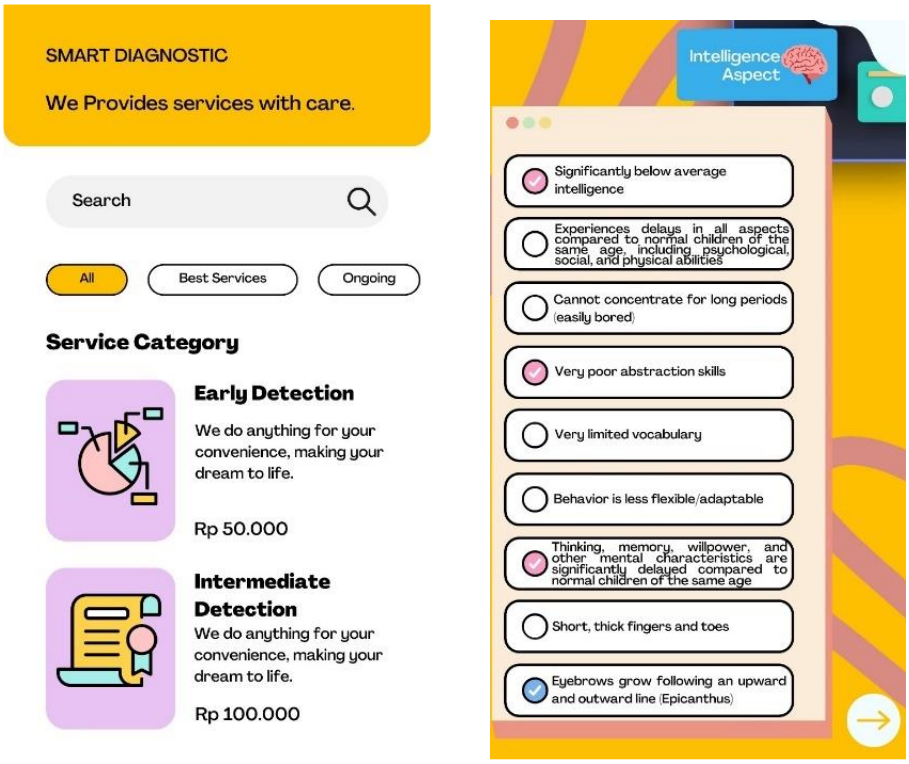

Figure 12. Example of diagnostic form.

The resources and support section should be comprehensive, offering a library of articles, videos, and tutorials on developmental disorders, interventions, and support strategies. This section should be well-organized, with content categorized for easy browsing. Interactive features, such as comment sections and ratings for resources, can help caregivers find the most useful information quickly. Additionally, a community forum where parents and caregivers can connect, share experiences, and seek advice can provide invaluable peer

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support. Settings should be easily accessible and straightforward to adjust, featuring user-friendly controls for accessibility options, notification preferences, and data privacy settings. Simple toggle switches and sliders can make the adjustments more intuitive. A built-in help section with guides and FAQs for each setting option ensures users can quickly find answers to their questions without feeling overwhelmed. Throughout the design process, it is essential to maintain a focus on simplicity and engagement. The application should be free of clutter, with a clean layout and consistent design elements to guide users seamlessly through the app. Using playful elements and friendly characters can make the experience more enjoyable for children, while immediate, positive feedback for completed tasks can encourage ongoing participation.

Iterative testing and refinement based on user feedback are crucial for ensuring the application's effectiveness and user-friendliness. By conducting usability testing with small groups of users and making necessary adjustments based on their experiences, the application can be continuously improved. This process helps identify any potential issues early on and ensures the final product meets the needs of its users. The goal of the smart diagnostic application is to support the early diagnosis and management of developmental disorders in children with special needs. By prioritizing accessibility, simplicity, and engagement in the design of the UI and UX, the application can provide a valuable tool for caregivers and healthcare professionals. This, in turn, can lead to better diagnostic outcomes and enhanced support for children with special needs, helping them achieve their full potential. **Figure 13** shows the diagnostic results in the smart diagnostic application.

Figure 13. Result of diagnostic.

Testing a smart diagnostic application for children with special needs involves several important steps to ensure that the tool is accurate, effective, and beneficial for the intended users. Tests were carried out on all types of children with disabilities which resulted in several recommendations. **Table 4** shows the results of experiments on several children with disabilities.

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Table 4. Experiment result.

Type of Disabilities	Information filled in by the caregiver	Recommendation
Mental	Children don't want to contract their eyes, their facial expressions are less lively, and their movements are less focused. Children have no empathy. Children don't like to be hugged. Likes to walk on "tiptoes". Children are fixated on ritualistic activities or routines are of no use. Ways of playing are less varied, less imaginative, and less able to imitate.	Suspected of being autistic
Physical	The child has stiff/weak/paralyzed limbs and there are limb parts that are different from normal (smaller/bigger/long/short)	Suspected of being quadriplegic
Sensory	Children have difficulty pronouncing words clearly and are difficult to understand. Children often tilt their heads to hear. Children always pay more attention to vibrations. The child does not react to sounds more than 1 meter away.	Suspected of being deaf
Intelectual	Average learning achievement is always low. Can read letters, fails to read words. Understand commands after repetition	Suspected slow learner

Diagnosing children with special needs promptly is crucial for their development and well-being (Elder *et al*., 2017). Early and accurate diagnosis allows for the implementation of targeted interventions and support systems that can significantly improve their cognitive, social, and emotional development (Jeon *et al*., 2018). Without timely diagnosis, children may struggle unnecessarily, facing challenges in academic settings, social interactions, and daily activities. Furthermore, early diagnosis can provide parents and caregivers with critical information and resources to understand and support their child's unique needs effectively. By addressing developmental issues early, we can foster a more inclusive environment that helps children with special needs reach their full potential and improve their quality of life. After receiving the diagnostic test results for children with special needs, the following steps should be taken to ensure appropriate support and interventions. After using the smart diagnostic application, caregivers and parents feel many benefits. The advantages of using the smart diagnostic application are explained in **Table 5**.

Table 5. Advantages of smart diagnostic application.

Advantages	Information
Early Detection and Intervention	One of the primary advantages of a smart diagnostic application is its ability to facilitate early detection of developmental issues (Dwivedi *et al*., 2022). By regularly monitoring a child's behavior and developmental milestones through interactive assessments, the application can identify potential concerns much earlier than traditional methods. Early detection is crucial for timely intervention, which can significantly improve long-term outcomes for children with special needs (Zwaigenbaum *et al*., 2019).
Personalized Assessments	Smart diagnostic applications can provide highly personalized assessments tailored to the individual needs of each child (Şen & Akbay, 2023). The applications adjust the difficulty and type of tasks based on the child's age, abilities, and progress, ensuring the assessments are both challenging and achievable. Personalization helps in obtaining more accurate diagnostic data and can keep the child engaged throughout the process (Tetzlaff *et al*., 2021).
Continuous Monitoring	Unlike traditional diagnostic methods that may rely on periodic check-ups, smart applications allow for continuous monitoring of a child's development. Parents and caregivers can regularly update the app with new information, enabling ongoing assessment and tracking of progress. Continuous monitoring helps in identifying subtle changes in a child's development that might otherwise go unnoticed (Cuomo *et al*., 2021).

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Table 5. (Continue) Advantages of smart diagnostic application.

Advantages	Information
Enhanced Data Collection and Analysis	Smart diagnostic applications leverage advanced technologies such as AI and machine learning to collect and analyze vast amounts of data. This can lead to more accurate and comprehensive insights into a child's developmental status (Lanza & Cooper, 2016). The application can detect patterns and correlations that may not be evident through manual observation, providing a deeper understanding of the child's needs (Cohen & Goldhaber, 2016).
Increased Accessibility	The applications make diagnostic tools more accessible to a wider audience. Families in remote or underserved areas can benefit from high-quality diagnostic services without the need for frequent travel to specialized centers (Goodridge & Marciniuk, 2016). The accessibility ensures more children receive the diagnostic attention they need, regardless of geographical or economic barriers.
Empowerment of Parents and Caregivers	Smart diagnostic applications empower parents and caregivers by providing them with detailed reports and actionable insights about their child's development (Wang *et al*., 2024). Equipped with this information, they can make informed decisions about interventions and seek appropriate professional help. The application can also offer educational resources and support networks, helping caregivers feel more confident and supported in their roles (Rathnayake *et al*., 2019).
Facilitation of Professional Collaboration	The application can streamline the sharing of diagnostic data with healthcare providers, educators, and therapists. This facilitates better collaboration among the professionals involved in the child's care, ensuring a more cohesive and coordinated approach to intervention. Easy access to detailed reports can enhance the quality of consultations and the effectiveness of prescribed therapies (Holmes *et al*., 2017).
Cost-Effectiveness	By providing a comprehensive diagnostic tool that can be used at home, smart diagnostic applications can reduce the need for frequent and potentially costly visits to specialists. It can make the diagnostic process more affordable for families while still ensuring high-quality assessments. Additionally, early detection and intervention can prevent more severe and costly issues in the future, further reducing long-term expenses (Schiffman *et al*., 2015).
User-Friendly Experience	Designed with user experience in mind, the applications are typically user-friendly and engaging. Interactive elements, gamified assessments, and child-friendly interfaces make the diagnostic process enjoyable for children (Acharya *et al*., 2024). For parents and caregivers, intuitive navigation and clear instructions simplify the use of the application, making it a convenient tool in their daily routines (Zahabi *et al*., 2023).
Continuous Improvement through Feedback	Smart diagnostic applications can continuously improve through user feedback and data collection. Developers can update the app to include new features, improve existing functionalities, and address any user concerns. The iterative process ensures the application remains relevant, effective, and aligned with the latest research and technological advancements (Ni *et al*., 2020).

In summary, a smart diagnostic application offers numerous advantages for children with special needs and their families. From early detection and personalized assessments to enhanced data analysis and increased accessibility, the applications can significantly improve the diagnostic process and outcomes. They empower caregivers, facilitate professional collaboration, and provide a cost-effective, user-friendly solution that can evolve with ongoing feedback and technological progress.

5. CONCLUSION

Biodiversity Smart diagnostic applications for children with special needs provide a transformative approach to early detection, personalized assessment, and continuous monitoring of developmental progress. By leveraging advanced technologies and user-friendly interfaces, the applications empower parents, caregivers, and professionals with

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valuable insights and tools, facilitating timely and effective interventions. The increased accessibility, cost-effectiveness, and potential for ongoing improvement through feedback make smart diagnostic applications a vital resource in enhancing the quality of care and outcomes for children with special needs.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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