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Early childhood development monitoring during the first thousand days: Investigating the relationship between the developmental surveillance instrument and standardized scales☆

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ABSTRACT

Objective: This study aims to investigate the relationship between the Developmental Surveillance Instrument –*Instrumento de Vigilância do Desenvolvimento* (IVD), found in the Child's Booklet *Caderneta da Criança* (CC), and standardized scales: Alberta Infant Motor Scale (AIMS) and Denver Developmental Screening Test (Denver-II).
Methods: Employing an exploratory observational approach, we adopted a prospective longitudinal design with a quantitative approach. The convenience sample included 83 Brazilian children born between May and August 2019 in a public hospital. Of the total, 45 (54.22 %) were male, and 38 (45.78 %) were female. Developmental screening utilized the IVD, AIMS and Denver-II tests. Comparative analysis between groups employed Mann–Whitney or Kruskal–Wallis tests for numerical variables and chi-square/Fisher tests for categorical variables, with a significance level of 5 % ($p < 0.05$).
Results: A significant correlation was observed between the IVD and the AIMS and Denver-II tests ($p < 0.001$) at months 1, 4, and 8.
Conclusion: The presence of a robust correlation between the IVD and the AIMS and Denver-II tests at months 1, 4, and 8 implies that the IVD in the Child's Booklet serves as a reliable and effective indicator for screening infant development during this critical period. Detecting issues early through these methods is crucial to ensure the well-being of children, allowing for appropriate interventions as needed.

1. Introduction

During the initial one thousand days of life, a child undergoes significant developmental changes. It is crucial to conduct regular and comprehensive monitoring of these processes to identify potential health-related issues, whether direct or indirect. However, there is currently a shortage of professionals conducting early assessments of infant development [1–4]. This results in delayed referrals to institutions when deficiencies are already present, hampering intervention and relegating the prevention of pathological developmental alterations to a secondary concern [2,4–7].

The best healthcare practices, ranging from prenatal care to obstetric procedures, have played a significant role in reducing mortality rates and improving the survival of newborns (NBs). However, it is vital to note that the emphasis extends beyond survival to the quality of survival. A notable example is Switzerland, which has been implementing systematic neurodevelopmental assessments of NBs since 2000 through standardized examinations in accordance with national guidelines [8,9].

Furthermore, both the American Academy of Pediatrics (AAP) and the National Health and Medical Research Council of Australia (NHMRC) [8–10] recommend the implementation of a universal Child Development Surveillance (CDS) system, with a particular focus on the first one thousand days of life [11,12]. This system would encompass a comprehensive evaluation, including not only physical growth but also neuropsychomotor development [11,13–16].

In Brazil, the Unified Health System stands out as a successful and widely encompassing program across the country's states. While pediatricians are not part of the Family Health Strategy, in this dynamic, family physicians, nurses, and community health agents can play

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significant roles in surveillance. In addition to the public health system, many families opt for monitoring the growth and development of their children in the private sector, where often the responsibility for child development surveillance falls on the pediatrician, who is also, in many countries, the primary healthcare professional. However, assigning exclusively to a single professional the responsibility, given the inherent complexity of child development, is, at the very least, contradictory. Hence arises a significant challenge regarding the effectiveness of this approach.

The literature emphasizes the importance of using standardized tests for screening CD to appropriately identify possible delays [8,17]. Moreover, a study highlighted concerns in various countries, including Brazil, about the availability of culturally adapted, validated, accessible, and feasible instruments for developmental screening in primary care [8,18].

In Brazil, the Child Booklet – *Caderneta da Criança (CSD)* is an official document provided by the Brazilian Ministry of Health in Portuguese Language, given to all mothers after the child's birth. It includes, among other elements, a section dedicated to developmental surveillance, known as the Instrumento de Desenvolvimento Infantil (IVD). In the Brazilian context, CSD plays a crucial role. Among its components, the IVD stands out for its practicality, which facilitates its widespread use by healthcare professionals throughout the country and supports family tracking of developmental milestones. A study conducted in Brazil in 2015 involving 282 children up to 36 months old demonstrated a sensitivity of 70 % for identifying possible delays and a specificity of 74 % for normal development in children with risk factors [19]. According to this research, although the IVD does not exhibit high sensitivity, it provides objective and comparable data, similar to screening tests. The IVD stands out for its ease of use and application, setting it apart from more complex developmental screening tests. Furthermore, when integrated into the same immunization record document, it ensures access to a wide range of professionals throughout the territory while enabling families who possess this document to stay informed and effectively track developmental milestones periodically. This approach not only keeps families informed but also empowers them to actively participate in monitoring their children's development.

To support findings in the realm of public health and primary care, this study longitudinally utilized the IVD as a tool for screening infant developmental milestones in NBs. The objective was to investigate the relationship between the IVD, found in the Child's Booklet, and the screening instruments Denver Developmental Screening Test (Denver-II) and Alberta Infant Motor Scale (AIMS), aiming for a more comprehensive understanding of this association over the months.

2. Methods

A prospective cohort study with an exploratory observational design and a longitudinal approach was conducted with a quantitative analysis. The nonprobabilistic convenience sample comprised children born in 2019, regardless of gender. This manuscript has been submitted and approved by an Institutional Review Board in accordance with ethical principles and applicable regulations. Legal guardians signed the informed consent form and received a copy of the document. The inclusion criteria for the study were as follows: all Brazilian neonates born between May and August 2019, except those with outdated contact information. The exclusion criteria were as follows: absence from any stage of the study, loss of the Child's Booklet – *Caderneta da Criança* (CC), and formal medical contraindication to participate in the study immediately after birth. This study was voluntary, and each guardian was contacted by phone beforehand and invited to participate. Structured interviews were conducted, where each guardian responded to a protocol constructed specifically for this purpose, containing open and closed questions, divided into blocks: family sociodemographic identification, personal data, maternal health data, pregnancy-related data, birth data, and newborn health. The following instruments were used for screening the Neuropsychomotor Development of newborns:

2.1. Developmental surveillance instrument - Instrumento De Vigilancia Do Desenvolvimento (IVD)

The IVD present in the CC with developmental milestones CD was used. From the 2005 version, there is a section intended for use by healthcare professionals, containing expected milestones for each age group (zero to 36 months), divided into four domains of development. Subsequently, a table guides the decision-making process for professionals based on the findings. Additionally, the instrument includes a shaded area that should be filled with the abbreviations P = present milestone, A = absent milestone, and NV = unverified milestone. In each age group, the presence or absence of milestones corresponding to four types of domains/skills should be assessed: cognition or social/emotional, fine motor skills, language, and gross motor skills. This instrument does not contain illustrations of the expected developmental stages and uses technical terms to describe developmental phases. However, as it represents an important document with permanent records of the CD of the newborn, including vaccinations, it facilitates access and monitoring of CD by the healthcare team as well as the guardian [19].

2.2. AIMS

The Brazilian version titled "*Escala Motora Infantil de Alberta*" was translated in 2007, an instrument published in 1994 by Canadian physiotherapists that identifies infants aged zero to 18 months with motor developmental delay. It is easy to administer and quickly completed (20 to 30 min). Screening of infants is performed in different postures, and the examiner establishes the most primitive and the most advanced for this infant, defining a window of motor skills. Each item receives a score of one if the skill was observed and zero if not observed by the examiner. This score is summed and added to the infant's age and then transferred to a percentile chart of infant motor performance. The higher the percentile, the lower the chance of motor developmental delay. The AIMS is a validated instrument for the Brazilian population, including the monitoring of the DI of Brazilian premature infants. According to its authors, no training is needed for its application, but it is necessary for the professional to have a deep understanding of DI [20].

2.3. Denver-II

A standardized instrument, translated and adapted for Brazil in 2017 with the manual published in Portuguese. Used for screening children at risk for global developmental delay. The Denver-II is the most widely used standardized screening test in clinical practice and Brazilian research due to its ease of application, age range, and low cost. The test consists of 125 items distributed in four areas of DI: personal-social (25 items), fine-adaptive motor (29 items), gross motor (32 items), and language (39 items), included in a standardized kit with an explanatory manual. Each evaluated item is classified as caution when the child does not perform or refuses to perform the activity expected for 75 to 90 % of children of their age; delay when the child does not perform or refuses to perform the activity expected for >90 % of those their age. The result is considered normal when the child presents a maximum of 1 caution and no delays; suspicious when presenting 1 delay and/or 2 or more cautions; and abnormal when presenting 2 or more delays [21].

Since the study was divided into stages [1–3,and], each child was followed during the first months of life. In each stage, developmental screening was performed through an individual protocol that included the IVD and the standardized AIMS and Denver-II instruments. The protocol was applied in an infant rehabilitation center by a single researcher, with the presence of the guardian, always in the same peaceful and pleasant environment.

Stage 1: Brazilian child aged 1 month, both chronologically (for term infants) and corrected (for preterm infants). In this phase, guardians answered the interview and signed the ICF. On this day, the first record of the developmental milestones present in the IVD was also made, as was the application of the standardized AIMS and Denver-II tests.
Stage 2: Brazilian child aged four months, both chronologically (for term infants) and corrected (for preterm infants). In this stage, the second record of the developmental milestones present in the IVD was made, and the AIMS and Denver-II tests were applied.
Stage 3: Brazilian children at the age of eight months, both chronologically (for full-term infants) and corrected (for preterm infants). In this phase, the third recording of developmental milestones present in the IVD was conducted, along with the administration of the AIMS and Denver-II tests. The calculation of corrected age involves adjusting the chronological age considering the degree of prematurity. This practice includes deducting the weeks needed for the newborn to reach 40 weeks of gestation, ensuring a proper assessment of development during the first months of life.

Fig. 1 below provides a brief overview of the data collection process over the first one thousand days of life.

In the original project, children were to be examined after birth and throughout the first one thousand days of life. However, adaptations were necessary due to the COVID-19 pandemic. Therefore, starting from stage 4, in-person data collection had to be halted, and assessments were conducted via phone or WhatsApp.

Group comparisons were performed using the Mann–Whitney test or Kruskal–Wallis test for numerical variables and chi-squared/Fisher's tests for categorical variables. In all cases, a significance level of $p \leq 0.05$ was adopted.

3. Results

Sample Characteristics: Eighty-three subjects born between May and August 2019 participated in the study, with 45 (54.22 %) girls and 38 (45.78 %) boys. Seventeen (20.42 %) participants were of black ethnicity, 50 (60.24 %) were of white ethnicity, and 49 were born through vaginal delivery (59.04 %). The mean gestational age was 37.49 weeks (SD = 1.59), the 5-min APGAR score was 9.45 (0.75), and the average birth weight was 2985.9 g (SD = 445.13). The mothers had a mean age of 31 (± 6.04) years and an average of 6 (± 2.30) years of education.

The results of this study demonstrated a significant correlation between the IVD and the AIMS and Denver-II assessments at the first, fourth, and eighth months of life, as evidenced in the following graphs, with a p value of <0.001 (Figs. 2 and 3).

4. Discussion

The present study revealed that the IVD at one, four, and eight months showed a strong correlation with AIMS and Denver-II, and these standardized instruments allow screening for the acquisition of skills in various domains, including postural mastery. These instruments aim to select, among those investigated, the most likely to have developmental delays [16,21–23].

The literature [3,4] highlights the scarcity of instruments capable of screening CD in the early years of life in the context of public health, and this study is the first to investigate the relationship between IVD and the AIMS scale, an instrument that stands out for considering the interaction between the individual and the different systems with their contextual and social factors [24].

A study with 282 children up to 36 months of age compared IVD with Denver-II and found that sensitivity was 70 % for probable delay, 57 % for alert, and 21 % for normal development with risk factors; it also

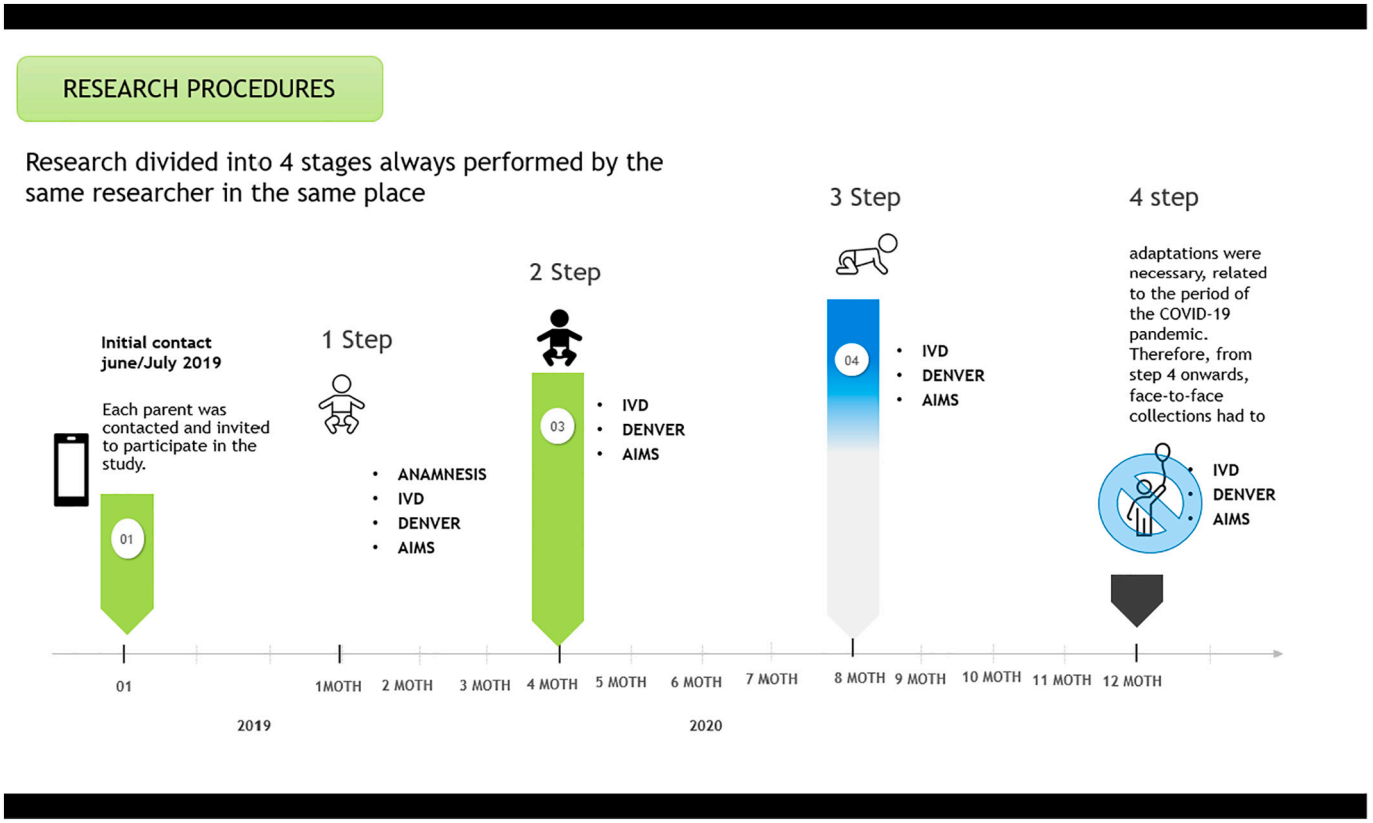

Fig. 1. Data collection procedures over the months.

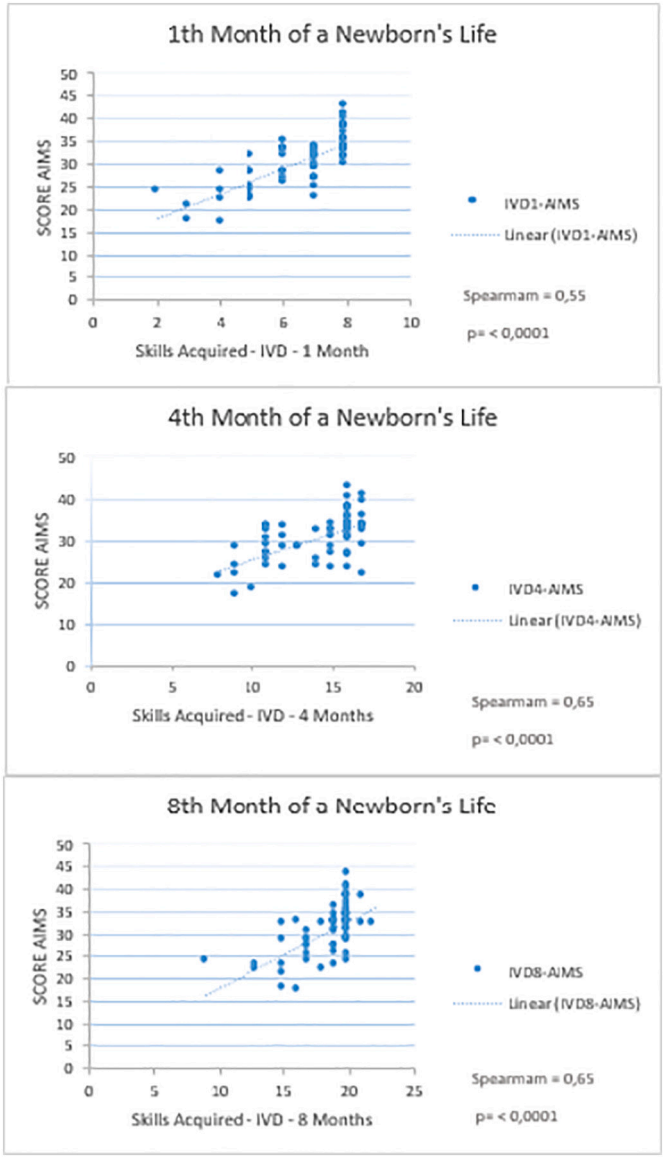

Fig. 2. The relationship between AIMS score and IVD at 1, 4, and 8 months of age.

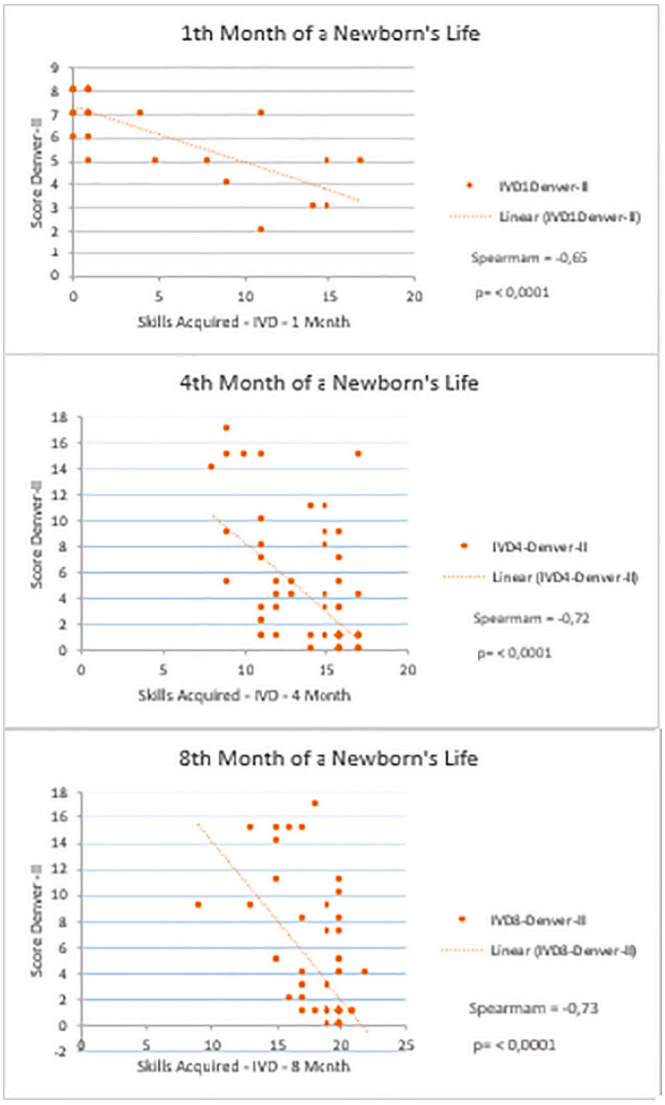

Fig. 3. The relationship between Denver-II score and IVD at 1, 4, and 8 months of age.

found that specificity was 56 %, 70 %, and 74 %, respectively. The prevalence of probable developmental delay was 53 % [25].

In Brazil, a vast country, the IVD is a freely accessible tool for various professionals (healthcare, education, social services, among others), provided free of charge shortly after a child's birth throughout the Brazilian territory. Unfortunately, studies reveal that, despite being easy to use and train, the IVD is underutilized, as each healthcare professional ends up opting for private recording of their clinical observations [26]. However, when developmental screening is conducted in the early months and by various professionals, it allows for a deeper understanding of this life stage, promoting a more comprehensive, precise, and integrated approach in the development process. Additionally, it also serves as a facilitator in making more effective and assertive decisions in primary care, as well as in other professional sectors. [3]. Therefore, by integrating into a document accessible to a network of professionals, the IVD enables all those in contact with the child to intervene, according to their expertise, when they perceive difficulties in acquiring skills in any domain and/or refer to other professionals to prevent or minimize delays in cognitive development [3,27]. It is important to emphasize that developmental screening in children is the responsibility of a multidisciplinary network because the convergence of knowledge is a decisive factor in promoting overall development [21,27].

The screening of gross motor development is also an integral part of monitoring the first thousand days of a baby's life, especially when they are at risk of developmental disorders, such as prematurity [2,3]. The identification of a strong correlation between the acquisition of skills at 1, 4, and 8 months with the AIMS scale, which focuses on gross motor skills, draws attention to the possibility that the IVD also allows monitoring changes in motor development and detecting atypical motor behaviors up to the first 18 months, making it a useful observational tool for screening this ability.

Gross motor development encompasses fundamental motor skills that develop in a predictable sequence, with a time limit for each phase, although it varies from one child to another [15,28]. In this initial stage of life, which is characterized by a period of great sensitivity and responsiveness to stimuli, the relevance of adequately stimulating motor abilities is emphasized [16,29]. Progress in this crucial phase is essential, as it plays a substantial role in building the foundations for the child's subsequent motor development. The early childhood phase, encompassing these first thousand days, is characterized by an extraordinary rate of progress in motor skills [28,30]. It is a time frame

during which the child absorbs a variety of stimuli from the environment, enabling rapid development of their motor skills and establishing the basis for future achievements [11,15].

The Denver-II test stands out as a screening tool recommended by the Brazilian Society of Pediatrics. The literature emphasizes that the Denver-II Test is a widely used screening tool applied in various countries around the world. Its scope transcends borders, as it was designed to monitor CD in different cultures and contexts [14]. This is because the test was developed to consider universal aspects of CD, including the domain of "Personal-Social," which encompasses elements of a child's socialization; the domain of "Fine-Adaptive Motor," which covers the coordination between manual dexterity and vision; the domain of "Gross Motor," which is related to body movement control; and the domain of "Language," which includes the ability to recognize, understand, and use language. The IVD also includes monitoring domains similar to those present in the Denver-II test, such as cognitive or social/emotional skills, fine motor skills, language, and gross motor skills.

The present study, by noting a strong correlation between the IVD and the Denver-II test, suggests its use in culturally diverse populations in an agile and cost-effective manner, significantly increasing its relevance in developmental surveillance. Furthermore, it stands out as a potential universal value model in CD surveillance. Even though the Denver-II test is strongly recommended, its application requires specific care, from adequate training to the costs associated with test acquisition. These factors can sometimes represent a challenge in implementing surveillance, especially in public health contexts. Thus, the surveillance of development in this important period is often neglected [4].

Regrettably, the routine practice of professionals responsible for child neurodevelopment rehabilitation (including physiotherapists, psychologists, speech therapists, and occupational therapists, among others) is often characterized by a complaint about delayed referrals from primary care professionals, contrary to the scientific understanding that early referral leads to improved outcomes [3,27].

Unfortunately, current culture often does not align with scientific evidence that clearly demonstrates the benefits of early intervention in child health terms. Timely referrals enable the early implementation of appropriate interventions, maximizing rehabilitation opportunities and minimizing potential health sequelae in a healthcare context [3].

The reasons supporting this scenario are multifaceted and encompass various considerations. Initially, the challenge lies in the costs associated with developmental screening, which can sometimes limit the implementation of more proactive practices. Additionally, the need for adequate training of professionals to conduct accurate and appropriate assessments should not be underestimated. Furthermore, limitations in healthcare systems, especially in contexts where resources are scarce, can also play a significant role. The allocation of financial and human resources for preventive approaches, such as early referrals, can often be deprioritized in relation to other aspects of healthcare delivery.

On the other hand, the IVD emerges as a tool that can overcome these difficulties. This instrument is characterized by its accessibility and ease of use for healthcare professionals. Its inclusion in the CC, a document routinely taken to primary care appointments, positions the IVD as a potentially effective tool to mitigate the mentioned obstacles. By providing a practical framework for assessing development, the IVD can contribute to more comprehensive and timely surveillance, especially in resource-limited contexts.

Within this context, vigilant monitoring and intervention, mainly through the use of a facilitating tool capable of promoting adequate development screening, play an essential role. Through constant monitoring during the first thousand days, we can ensure that the child reaches the expected developmental milestones for their age. This, in turn, minimizes the risks of delays in motor development and maximizes opportunities for early intervention when needed, as well as healthy growth and the acquisition of skills that will continue to be essential throughout the child's life.

It is worth mentioning that despite the literature stating that the IVD has moderate sensitivity, we recommend considering its use, either as an initial option or as a complement to standardized screening tests. This is based on the perspective of providing support to healthcare professionals in monitoring development, especially in the context of primary healthcare, to strengthen this approach, particularly in the context of public health [17].

Therefore, the comprehensiveness of the topic of growth and development in early childhood, as well as the surveillance of these acquisitions at specific times, favor the acquisition of essential future skills for full development in adulthood. Thus, actions capable of minimizing complications before and after birth are fundamental, as the first thousand days are recognized as a period marked by the opportunity to provide a better start in life.

In this sense, strategies are needed to promote the widespread integration of the IVD throughout the Brazilian healthcare system, emphasizing it as a potential valuable tool for universal developmental surveillance. Promoting IVD as a useful instrument with international visibility strengthens collaborative efforts with the Brazilian government, facilitating evidence-based practices around IVD and allowing better access to data through national public policies.

5. Public health implications

This study has demonstrated that the IVD has a strong correlation with standardized tools. This finding suggests that the IVD can be a useful tool in the early identification of developmental delays in children. This has significant implications in public health, allowing for the implementation of early interventions and improvements in the quality of maternal and child health services. Additionally, the use of the IVD is cost-effective and can be integrated into primary care, reducing health disparities and emphasizing the importance of the first one thousand days of life in child development.

6. Limitations of the study

The study's sample size was relatively small and consisted of children born within a specific timeframe, limiting generalizability. The study relied on self-reporting and may be subject to reporting bias. Coordinating data collection during the COVID-19 pandemic led to adaptations, impacting the study's original design.

7. Future directions

Future research should focus on a larger and more diverse sample to enhance generalizability. Long-term follow-up studies can provide insights into the continued impact of early interventions based on IVD results. Investigating the effectiveness of integrating IVD into routine public health practices is a valuable direction for future research.

8. Conclusion

The data presented in this study revealed a significant correlation between the IVD and the standardized instruments AIMS and Denver-II. The information obtained in this study can be effective in improving the quality of services provided to postpartum women and infants in the first year of life. Findings from this study also suggest that the IVD is a useful tool in CD screening and health promotion. This enables the implementation of early interventions that ensure the complete development of children, even in public health settings.

Consent for publication (consent statement regarding publishing an individual's data or image)

Not applicable.

Code availability (software application or custom code)

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Kedma Teixeira Montedori: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Conceptualization. **Maria Cecília Marconi Pinheiro Lima:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare no conflicts of interest.

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