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ORIGINAL ARTICLE

Developmental Trajectories of Developmental Disorders: Early Diagnosis for an Early Intervention

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Abstract

Purpose Early identification of children at risk for Intellectual Disability (ID) is complex, as formal diagnoses are often deferred until school age. However, early signs may emerge during the preschool years. This study aims to examine longitudinal changes in cognitive, adaptive and emotional-behavioral functioning from preschool to school age, to identify early markers predictive of later ID.

Methods Eighty-eight children were assessed at two time points: preschool age (T0) and school age (T1). At T0, children were categorized into three diagnostic groups: Global Developmental Delay (GDD), Mixed Specific Developmental Disorder (MSDD), and Language Disorder (LD). At T1, the same children were re-evaluated and classified into: Intellectual Disability (ID), Language Disorder (LD), and Other Diagnoses (OD). Assessments included clinical observations, cognitive evaluations, and parent-reported questionnaires and interviews. Analyses were performed separately at T0, T1, and longitudinally.

Results At T0, all groups showed impaired adaptive functioning but differed in cognitive abilities, with the GDD group displaying more pronounced delays. At T1, only the ID group maintained significant deficits in both adaptive and cognitive domains. Regarding emotional-behavioral functioning, children with GDD exhibited more attention problems at T0. At T1, the ID group showed increased internalizing and externalizing symptoms, whereas LD and OD groups did not present significant psychopathological issues. A substantial rise in ID diagnoses was also observed at school age.

Conclusion Monitoring developmental trajectories from an early age is essential to detect risk markers of ID. Early identification can support timely, targeted interventions for children and their families, improving long-term outcomes.

Keywords Intellectual disability · Global developmental disorders · Neurodevelopmental disorders · Psychopathology · Adaptive functioning

Introduction

Intellectual Disability (ID) is a neurodevelopmental condition characterized by significant impairments in both cognitive functioning (e.g., reasoning, problem-solving, learning) and adaptive behaviors (e.g., communication, social skills, independent living) (American Psychiatric Association, 2022). The estimated prevalence of ID falls between 1% and 3%, with studies indicating a higher occurrence in males compared to females, at an approximate male-to-female ratio of 1.6:1 (Leonard & Wen, 2002). It can be determined by different etiological factors, including genetic abnormalities, prenatal, perinatal, and postnatal environmental influences (Sherr & Shevell, 2017; Shevell, 2008; Toth et al., 2022). According to major diagnostic frameworks, including those outlined by the American Psychiatric Association (American Psychiatric Association, 2013, 2022) and the World Health Organization (World Health Organization, 2009, 2022) a formal diagnosis of ID requires that these deficits manifest during the developmental period—which

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spans from birth to approximately 18 years of age. Diagnosis is established through standardized cognitive and adaptive assessments as well as comprehensive clinical evaluations (American Association on Intellectual and Developmental Disabilities, 2025). The severity of ID is determined primarily by the extent of impairment in adaptive functioning, which influences an individual's ability to meet age-appropriate social, academic, and daily life expectations. While severe and profound forms of ID may be identifiable in infancy or early childhood due to marked developmental delays, a formal diagnosis can be made at any age once the DSM-5-TR criteria are fully met, including in preschool-aged children. However, in the common clinical practice, the reliable administration of standardized cognitive and adaptive behavior assessments in very young children can be challenging, potentially resulting in deferred diagnosis (American Psychiatric Association, 2013; Totsika et al., 2022). In such cases, when developmental delays are evident before the age of five but diagnostic certainty is limited, clinicians may assign a diagnosis of Global Developmental Delay (GDD). GDD is used when significant delays are observed in at least twodevelopmental domains, such as motor skills, language, or social-emotional functioning, but standardized assessment tools cannot yet provide a reliable estimate of intellectual functioning (American Psychiatric Association, 2013). Effectively, although cognitive impairments can be evident early in life, especially in severe cases, milder forms of ID may remain undiagnosed until later in childhood, when academic struggles and difficulties with problem-solving or adaptive skills become more noticeable (Reschly, 2009).

Children and adolescents with ID are at a higher risk of developing both externalizing and internalizing problems (De Ruiter et al., 2007; Dekker & Koot, 2003; Green et al., 2005; Hodapp & Dykens, 2005; Marrus & Hall, 2017; Totsika et al., 2022). Specifically, they exhibit behavior problems at rates 3 to 7 times higher than their typically developing peers (Baker et al., 2002; Dekker & Koot, 2003; Emerson et al., 2001). Among the most frequently reported psychiatric disorders in individuals with ID are anxiety and mood disorders (Buckley et al., 2020; Maïano et al., 2018), oppositional defiant disorder and conduct disorders (Buckley et al., 2020; Oeseburg et al., 2011), post-traumatic stress disorder (Emerson & Hatton, 2007; Mevissen & De Jongh, 2010; Sperandini et al., 2024), psychosis (Di Prinzio et al., 2018), self-injurious behaviors and suicidality (Dodd et al., 2016). Notably, approximately 39% of children with ID meet the diagnostic criteria for ADHD (Buckley et al., 2020). Identifying potential psychopathological markers in early childhood is essential for understanding developmental trajectories and implementing targeted early interventions. However, despite its relevance, longitudinal research examining the emotional and behavioural developmental of children with early neurodevelopmental delays and its association with later ID-related symptoms remains limited.

Although intellectual functioning is generally considered relatively stable after early childhood, empirical findings are inconsistent. While IQ stability has been well documented in school-aged children with typical development (Moffitt et al., 1993), a meta-analysis conducted by Whitaker (Whitaker, 2008), examining children over the age of 8, found that approximately 14% exhibited fluctuations of 10 or more IQ points over time, suggesting that individual variability is not uncommon. Greater caution is warranted when assessing cognitive functioning in preschool-aged children, particularly those with developmental delays, as studies have reported more frequent variations in performance within this population (Dietz et al., 2007; Jónsdóttir et al., 2007; Lee et al., 2022). These fluctuations may partly reflect the evolving nature of the abilities assessed at different developmental stages. Early cognitive tests often focus on sensorimotor skills, which are not directly comparable to the conceptual reasoning abilities typically evaluated in later childhood (Rapin, 2003). Moreover, in children with developmental delays, test performance can be influenced by factors such as reduced attention span and communicative or social difficulties, further contributing to variability in scores (Yang et al., 2010). These considerations underscore the importance of accounting for developmental dynamics when interpreting early cognitive assessments and formulating early diagnoses, particularly those related to the presence or absence of ID. Such evaluations should carefully consider the potential for developmental changes shaped by multiple interacting factors, and highlighted the need for repeated follow-up assessments to monitor developmental profile over time.

Given the existing findings and the limited number of studies in the literature examining the developmental trajectories of individuals with early developmental delay, as well as the lack of longitudinal data in the Italian population, the present study seeks to address this gap by investigating the long-term developmental outcomes of preschool-aged children with neurodevelopmental diagnosis. Specifically, we aimed to examine early developmental, cognitive, adaptive, and behavioral profiles in this population, and to explore how these characteristics relate to diagnostic outcomes at school age. The study had four objectives:

1. To compare cognitive and adaptive functioning in the preschool period across early diagnostic groups.
2. To investigate early psychopathological symptoms and their potential role in predicting later ID.
3. To assess the developmental trajectory of cognitive, adaptive, and psychopathological functioning between

preschool (T0) and school age (T1), both between and within diagnostic groups.

4. To characterize and analyze diagnostic transitions from T0 to T1, with particular attention to how early neurodevelopmental diagnoses evolved over time and to the emergence of ID later in childhood.

We hypothesized that, at T0, children with a diagnosis of GDD would exhibit greater impairments in both cognitive and adaptive functioning, as well as more pronounced behavioral symptoms, compared to peers with other neurodevelopmental conditions. At T1, we expected a comparable profile among children diagnosed with ID, characterized by significant deficits in cognitive, adaptive, and behavioral domains. Regarding diagnostic transitions between T0 and T1, we anticipated a relatively stable progression from GDD to ID, while acknowledging the potential for variation due to the inherent heterogeneity of neurodevelopmental trajectories.

To the best of our knowledge, this is the first longitudinal study conducted on an Italian preschool sample with neurodevelopmental delays.

Methods

Participants

This longitudinal study recruited eighty-eight children (60 males and 28 females) with neurodevelopmental delay who attended the Child and Adolescents Neuropsychiatry Unit of the Hospital (Rome, Italy). Children were assessed at two time points: in the preschool period (T0; age range: 2 years to 5 years and 11 months) and in the school-age period (T1; age range: 6 years to 8 years and 6 months).

Inclusion criteria at T0 were: (1) the presence of a neurodevelopmental delay, both linguistic and motor, and (2) no prior standardized evaluation. Exclusion criteria included the presence of Down syndrome or cerebral palsy.

All children were evaluated by a multidisciplinary team composed of child psychiatrists, psychologists, and speech therapists. Diagnostic classification was based on developmental history, clinical observation, standardized cognitive and adaptive assessments, motor and language evaluations, and parent interviews. Diagnostic decisions were discussed in case conferences, where at least two clinicians independently reviewed all available data and reached consensus on the final classification.

At T0, children were categorized into three diagnostic groups: Global Developmental Delay (GDD), Mixed Specific Developmental Disorder (MSDD), and Language Disorder (LD). At T1, the same children were reassessed and classified into three diagnostic categories: Intellectual Disability (ID), Language Disorder (LD), and Other Diagnoses (OD), which included Developmental Coordination Disorder (DCD), Social Communication Disorder (SCD), Autism Spectrum Disorder (ASD), and Attention-Deficit/Hyperactivity Disorder (ADHD). Importantly, children with ASD, ADHD, or other neurodevelopmental disorders were not excluded a priori. These conditions were not identifiable at T0 but were documented at T1, and where therefore considered analytically. Diagnoses were assigned according to DSM-5 criteria (American Psychiatric Association, 2013), with the exception of MSDD, which is included in ICD-10 (World Health Organization, 2009) but not DSM-5. MSDD refers to the co-occurrence of specific developmental disorders affecting speech and language, motor function, scholastic skills, or cognitive abilities, without a clear predominance of one disorder over the others. Although limited, the existing literature on MSDD reports variable findings regarding cognitive functioning, which appears to be quite-heterogeneous, ranging from average to below-average IQ scores (Capitello, 2014; Martelli et al., 2025). In Italian clinical practice, MSDD is widely used to identify children who exhibit difficulties across multiple neurodevelopmental domains but do not present severe impairments characteristic of GDD. The high rates of comorbidity among different neurodevelopmental conditions are increasingly reported in the literature (Bonti et al., 2024; Hansen et al., 2018).

The study was conducted in accordance with the guidelines of the Declaration of Helsinki and was approved by the local Ethics Committee (practice number 3341/2024, protocol number 211, approval date: April 22, 2024).

Materials

Cognitive Assessment

Cognitive development was assessed through different measures, selected according to the age and abilities of each child: (1) Griffiths Scales of Child Development – Third Edition (Griffiths III) (Green et al., 2016), (2) Leiter International Performance Scale – Third Edition (Leiter-3) (Roid & Miller, 2013), (3) Wechsler Preschool and Primary Scale of Intelligence – Third Edition (WPPSI–III) (Wechsler et al., 2008), and (4) Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV) (Wechsler et al., 2019).

Griffiths III scales provide a direct measure of psychomotor development in children from birth to 72 months. These scales assess five developmental domains: Foundations of Learning (A Scale), Language and Communication (B Scale), Eye and Hand Coordination (C Scale), Personal-Social–Emotional (D Scale), and Gross Motor Skills (E Scale). An overall development score, known as the Developmental Quotient (DQ), is calculated. Raw scores from each scale and the overall score are converted into Age Equivalent scores and Developmental Quotients. In this study, DQ was used to compare the youngest child with other patients in the cohort.

Leiter-3 is a nonverbal test designed to measure IQ and cognitive ability in individuals aged 3 to 75 + years. It consists of four subtests administered in the following order: Figure Ground, Form Completion, Classifications and Analogies, and Sequential Order. It provides a Non-Verbal Intelligence Quotient (NVIQ), which has a mean score of 100 and a standard deviation (SD) of 15. All subtests have a mean score of 10 and an SD of 3.

WPPSI-III (Wechsler et al., 2008) is designed to measure cognitive ability in children aged 2:6–7:3 years. It comprises a set of core subtests that generate Verbal IQ (VIQ), Performance IQ (PIQ) and Full Scale Intelligence Quotient (FSIQ) scores. All index scores have a mean of 100 and a SD of 15, while subtests scores have a mean of 10 and a SD of 3.

WISC-IV is the most widely used intelligence test for assessing cognitive abilities in children aged 6 to 16 years and 11 months. It focuses on fluid intelligence, working memory, and processing speed. The test measures general IQ (overall cognitive ability) and includes four indices that assess performance in specific areas: Verbal Comprehension, Perceptual Reasoning, Working Memory and Processing Speed. The general IQ and all index scores have a mean score of 100 and a SD of 15, and all the subtests have a mean score of 10 and an SD of 3.

Adaptive Functioning

Adaptive functioning was assessed through Adaptive Behavior Assessment System - Second Edition (ABAS II) (Ferri et al., 2014), and Vineland Adaptive Behavior Scales Vineland-II (VABS II) (Sparrow et al., 2012).

ABAS II is a standardized questionnaire designed to evaluate adaptive skills in individuals aged from birth to 21 years. It assesses ten adaptive domains categorized into three overarching categories: conceptual (communication, preschool/school skills, self-control), social (play/leisure, socialization) and practical (self-care, home/school life, use of the environment, health and safety, work). Additionally, motor skills are assessed, for children aged 0 to 5 years. The tool provides a Global Adaptive Composite (GAC) score and domain-specific composite scores: Conceptual Adaptive Composite (DAC), Social Adaptive Composite (DAS), and Practical Adaptive Composite (DAP). Normative data include a mean (M) of 100 and a standard deviation (SD) of 15 for composite scores, while subscales scores have a mean of 10 and an SD of 3.

VABS II is a semi-structured interview conducted with parents to evaluate a child's adaptive functioning. It examines three main domains: Communication, Socialization, and Daily Living skills; for children under 7 years, an additional Motor Skills domain is assessed. The VABS II provides an overall Adaptive Behavior Composite (ABC) score, calculated by summing the scores of its domains. VABSII-ABC and relative domains provide age-based standard scores (M = 100, SD = 15).

Despite utilizing different tools to assess adaptive functioning, it was feasible to integrate scores from comparable domains. A study documented in the manual of the Italian version of Vineland-II (Balboni et al., 2016) demonstrated strong correlations between VABS II and ABAS II scores across similar domains (ranging from 0.60 to 0.74). Specifically, Communication (VABS II) showed a significant positive correlation with the Conceptual domain (ABAS II, r = 0.68), Socialization (VABS II) correlated with the Social domain (ABAS II, r =0.60), and Daily Living Skills (VABS II) correlated with the Practical domain (ABAS II, r = 0.74). Additionally, the Adaptive Behavior Composite score from VABS II and the Global Adaptive Composite score from ABAS II (referred to as the Full-Adaptive Scale) exhibited a strong correlation (r = 0.78). In the present study, we maintained the acronyms used in the ABAS-II for the general domain (GAC) and the three subdomains (DAC, DAS, and DAP) to refer both to the mean scores obtained in the ABAS-II and to the corresponding scores in the VABS-II.

Behavioural and Psychopathological Assessment

To assess the emotional and behavioral profile, the Child Behavior Checklist (CBCL) (Achenbach & Rescorla, 2001) was used. The CBCL is a parent- or caregiver-reported instrument designed to screen for emotional, behavioral, and social problems in children. For preschool-aged children, the CBCL for ages 1.5–5 was employed, consisting of 100 items. This version generates seven *Syndrome Scales* and five *DSM-Oriented Scale* profiles, aligned with the diagnostic categories of DSM-IV-TR and DSM-5. For participants aged 6–18 years, the CBCL 6–18 was utilized, which produces eight *Syndrome Scales* and includes six *DSM-Oriented Scales*. In the present study, we focused on the overlapping scales across the two versions of the instrument, specifically the five *Syndrome Scales* (Anxious/Depressed, Somatic Complaints, Social Problems, Attention Problems, and Aggressive Behavior scales), four *DSM-Oriented Scales* (Affective Problems, Anxiety Problems, Attention Deficit/Hyperactivity Problems, and Oppositional Defiant Problems), as well as the *Internalizing*, *Externalizing*, and *Total Problems* scales.

According to the ASEBA Assessment Data Manager (ADM), for *Syndrome Scale Scores* and for *DSM-Oriented Scales*, a t-score ≤ 64 indicates non-clinical symptoms ("non-clinical"), a t-score between 65 and 69 indicates that the child is at risk for problem behaviours ("borderline"), and a t-score ≥ 70 indicates clinical symptoms ("clinically-relevant"). For *Internalizing*, *Externalizing*, *Total Problems*, a t-score ≤ 59 indicates non-clinical symptoms ("non-clinical"), a t-score between 60 and 63 indicates that the child is at risk for problem behaviours ("borderline"), and a t-score ≥ 64 indicates clinical symptoms ("clinically-relevant").

Procedure

All assessments were conducted by a multidisciplinary team (child psychiatrists, psychologists and speech therapists). The evaluation protocol included the collection of developmental history, clinical observations, standardized cognitive, linguistic and motor evaluations, and parent-reported questionnaires and interviews. All assessments were carried out as part of routine clinical practice and typically completed over two working days.

Regarding diagnostic process, at T0, classification followed a less stringent clinical approach, acknowledging the variability typical of early development and the limits of preschool assessment tools. When significant impairments were present across multiple developmental domains (cognitive, adaptive, motor and linguistic), a diagnosis of GDD was assigned. MSDD was used for heterogeneous developmental difficulties without global impairments, while LD was reserved for children with predominant languagedifficulties. At T1, as all children were older than 6 years and assessed with the same standardized cognitive test (WISC-IV), DSM-5 criteria for ID could be applied more consistently, combining IQ < 70 with significant adaptive deficits. The identification of additional diagnosis at T1 (e.g., ASD, ADHD, motor or social communication disorders included in the OD group) was made possible by the children's developmental growth and the use of more structured instruments, which allowed conditions not detectable at T0 to be identified.

Cognitive test selection followed a structured but flexible hierarchy, informed by both chronological age and observed developmental abilities:

- From age 3, the Leiter-3 was prioritized when the child was able to engage with a structured nonverbal assessment, as it offers a reliable measure of nonverbal IQ without relying on language.
- When children presented with marked developmental delays or had difficulty engaging in structured testings, the Griffiths III was used instead, as it provides a broad developmental profile and reduces the risk of floor effects.
- From age 5, in the absence of significant language impairments, the WPPSI-III was the preferred tool, as it provides detailed assessment across multiple cognitive domains. If clinical evaluation revealed significant language impairments, the Leiter 3 was used in place of the WPPSI-III. In a small number of cases where children showed marked difficulty sustaining test participation (e.g., due to the attentional deficits, emotional dysregulation, or high restlessness), the Griffiths III was administered even in older preschoolers.

At T1, all children were assessed using the WISC-IV.

Adaptive functioning was measured using the ABAS-II or VABS-II, selected according to the child's abilities and context. Although not identical, these measures show moderate-to-strong correlations across comparable domains (Balboni et al., 2016), which supported their combined use in scientific studies (Alfieri et al., 2021; Dentici et al., 2020).

Particular attention was taken to minimize floor effects through careful test selection. Across the full sample, a floor effect occurred in only one case, where a child obtained the minimum possible score on a standardized test (see Supplementary Table 7S for details on test administered and individual participant scores).

Statistical Analyses

All statistical analyses were performed using JAMOVI software (version 2.3.26.0). Descriptive analyses were conducted to characterize participant groups at T0 and T1. To analyze differences between diagnostic groups at both the initial visit (T0) and follow-up (T1), we performed a one-way ANOVA, followed by Tukey's correction for multiple comparisons when appropriate. At T0, the factor "diagnosis" included GDD, MSDD, and LD, while at T1, the factor "new diagnosis" included ID, OD, and LD.

To determine whether predictive differences between groups could be identified before the formal diagnosis at T1, we conducted a repeated-measures one-way ANOVA. This compared follow-up measures (T1) for each diagnostic group (ID, OD, LD) with their respective evaluations at T0. Before conducting univariate analysis, we provided requested assumptions, including homogeneity of variance, independence of observations, and normal distribution of the dependent variable (Tabachnick & Fidell, 2019). However, we did not conduct a power analysis beforehand, as our research was exploratory and lacked a directional hypothesis, primarily focusing on the distinctiveness of our sample. The proportion of total variance accounted for by the independent variables was calculated using

Table 1 Demographic and clinical characteristics of the participants

Timeline	Mean Age in months (DS)	Diagnosis N° subjects	Mean Age in months (SD)	Gender N° M/F	Average IQ (SD)
T0	60.1 (8.2)	GDD N 39	58.1 (9.2)	21 M 18 F	60.3 (11.59)
		MSDD N 28	59.8 (9.7)	23 M 5 F	83.8 (7.25)
		LD N 21	62.3 (5.6)	16 M 5 F	95.4 (9.25)
T1	83.6 (11.2)	ID N 53	86.2 (11.1)	35 M 18 F	62.1 (10.63)
		OD N 10	82.3 (12.1)	5 M 5 F	94.8 (15.63)
		LD N 25	82.2 (10.5)	20 M 5 F	89.2 (6.90)

T0 = preschool period age range 2 years to 5 years and 11 months; T1 = school-age period age range 6 years to 8 years and 6 months; SD = standard deviation; GDD = Global Developmental Delay; MSDD = Mixed Specific Developmental Disorder; LD = Language Disorder; ID = Intellectual Disability; OD = Other Diagnoses; IQ = intelligent quotient

Table 2 Comparisons of measures among GDD, MSDD and LD at T0

Measures	Groups	Mean	Standard Deviation	Post Hoc Comparisons
IQ	GDD	60.3	11.6	GDD < MSDD*** (p < 0.001)
	MSDD	83.8	7.2	GDD < LD*** (p < 0.001)
	LD	95.4	5.2	MSDD < LD*** (p < 0.001)
ABAS II/VABS II GAC	GDD	60.5	11.8	GDD < MSDD* (p = 0.028)
	MSDD	69.4	14.6	GDD < LD* (p = 0.031)
	LD	70.1	15.5	
ABAS II/VABS II DAC	GDD	59.7	11.2	GDD < MSDD * (p = 0.042)
	MSDD	67.9	15.5	GDD < LD ** (p = 0.003)
	LD	72.2	14.5	
CBCL Attention Problems	GDD	64.7	8.1	GDD > MSDD * (p = 0.017)
	MSDD	59.3	7.1	
	LD	61.6	7.8	

T0 = preschool period age range 2 years to 5 years and 11 months; GDD = Global Developmental Delay; MSDD = Mixed Specific Developmental Disorder; LD = Language Disorder; IQ = intelligent quotient; GAC = General Adaptive Composite score from ABAS II and Adaptive Behavior Composite score from VABS -II; DAC = Conceptual Adaptive domain from ABAS II and Communication domain from VABS II; *p < 0.05, **p < 0.01 **, p < 0.001***

partial eta squared (pη² ≤ 0.06 = small; 0.06–0.14 = medium, 0.14 ≥ large) (Cohen, 2013). $P < 0.05$ was considered statistically significant.

Results

Initial Evaluation, T0

At T0 participants were distributed into three diagnostic groups: GDD (44.3%), MSDD (31.8%), and LD (23.9%). The groups were comparable in age and presented a male predominance. Demographic data and clinical characteristics of the children are summarized in Table 1. Cognitive level differed substantially across groups: the GDD group showed significant cognitive impairment, the MSDD group scored at the lower normative limit, and the LD group had average cognitive scores (Table 1).

Adaptive functioning (Table 2) was compromised in all groups, with the most pronounced difficulties in the DAC domain for GDD and MSDD, and in DAP for LD. All mean scores fell below the normative range.

On the CBCL (Tables 2 and 2S), scores for all groups were within the non-clinical range. However, the Social Problem and Attention Problems scales showed slightly higher scores, albeit still within the non-clinical range, across all groups.

Between-group comparisons revealed significant differences in IQ level, ($F_{(2,\ 87)} = 98.9$, $p < 0.001$, $\eta^2 p = 0.699$), with a clear gradient: GDD < MSDD < LD. Adaptive functioning differed significantly for GAC ($F_{(2,\ 87)} = 4.89$, $p = 0.010$, $\eta^2 p = 0.103$) and DAC ($F_{(2,\ 87)} = 6.66$, $p = 0.002$, $\eta^2 p = 0.136$), with the GDD group scoring lower than both MSDD and LD (Table 2, also see Table 2S for all statistics).

Regarding psychopathological functioning, a significant difference emerged only in the Attention Problem scale ($F_{(2,\ 87)} = 4.05$, $p = 0.021$, $\eta^2 p = 0.087$), where the GDD group manifest more pronounced symptoms compared to the MSDD group (Table 2, also see Table 2S for all statistics).

Follow-Up Evaluation, T1

At T1, the sample was reclassified into three new diagnostic groups: ID (60.2%), OD (11.4%), LD (28.4%). As presented in Table 1, the three groups have a mean age of 83.6 months (SD = 11.2).

Diagnostic transitions are illustrated in Figs. 1 and 2. Notably, the number of children diagnosed with ID increased, drawing from all three original T0 groups.

As shown in Table 3, the ID group presented with cognitive scores well below the normative range, while OD and LD groups remained within average limits. Adaptive

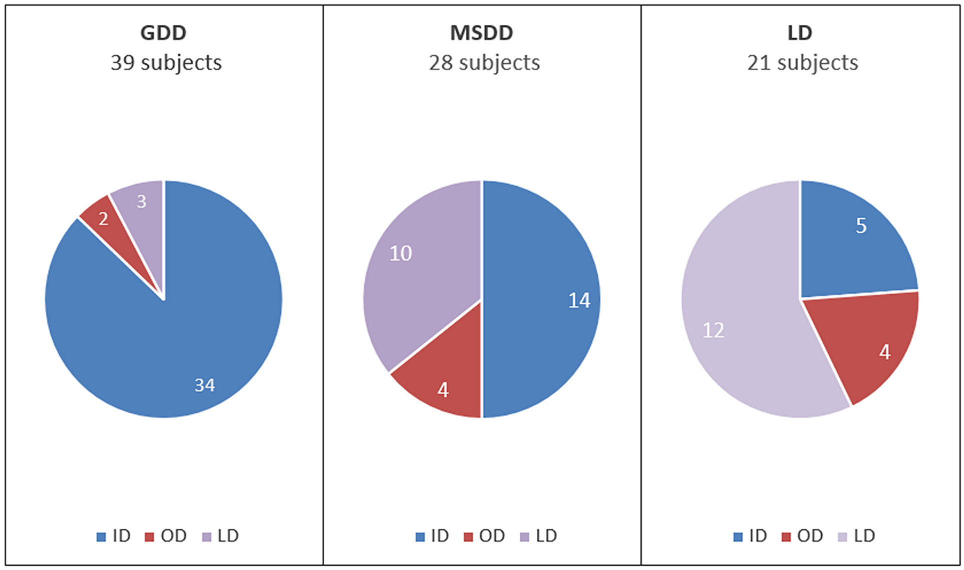

Fig. 1 Diagnostic groups at T0 and distribution of subjects based on T1 diagnoses. Pie charts show the number of subjects within each diagnostic group at T0 (GDD, MSDD, LD) and their distribution into ID, OD, or LD at T1. T0 = preschool period age range 2 years to 5 years and 11 months; T1 = school-age period age range 6 years to 8 years and 6 months; GDD = Global Developmental Delay; MSDD = Mixed Specific Developmental Disorder; LD = Language Disorder; ID = Intellectual Disability; OD = Other Diagnoses

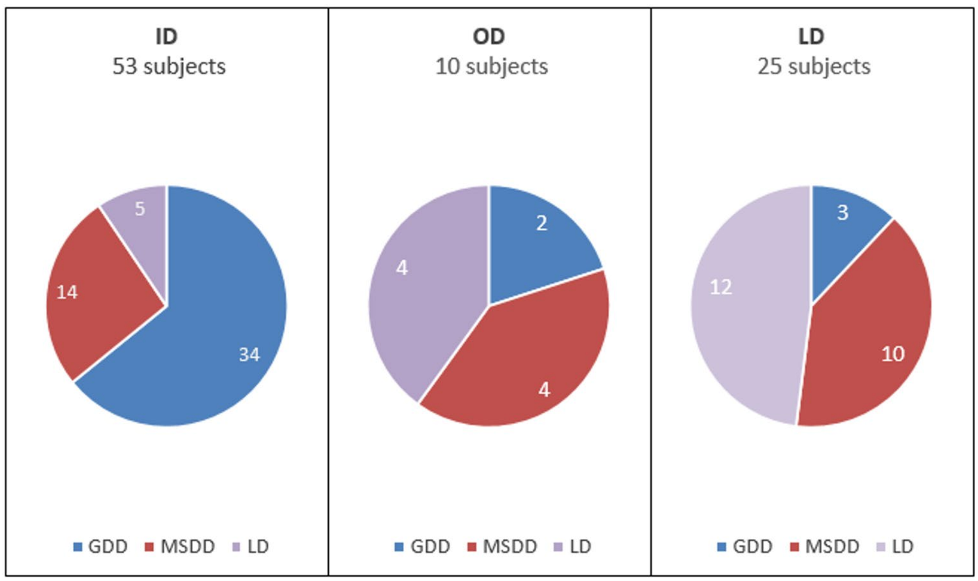

Fig. 2 Diagnostic groups at T1 and distribution of subjects based on T0 diagnoses. Pie charts show the number of subjects within each diagnostic group at T1 (ID, OD, LD) and their distribution into GDD, MSDD, or LD at T0. T0 = preschool period age range 2 years to 5 years and 11 months; T1 = school-age period age range 6 years to 8 years and 6 months; GDD = Global Developmental Delay; MSDD = Mixed Specific Developmental Disorder; LD = Language Disorder; ID = Intellectual Disability; OD = Other Diagnoses

functioning continued to show difficulties across all groups, particularly in the ID group, which exhibited the lowest scores in all subdomains (Table 3).

CBCL results (Tables 3 and 3S) indicated clinical scores on the Internalizing Problem scale and borderline scores on the Total Problem scales in the ID group, whereas the OD and LD groups remained within the normal range.

Between-group comparisons confirmed significant IQ differences ($F_{(2, 87)} = 70.3$, $p < 0.001$, $\eta^2p = 0.623$), with the ID group scoring lower than both OD and LD (Table 3). Adaptive functioning also differed significantly in GAC ($F_{(2, 87)} = 5.22$, $p = 0.007$, $\eta^2p = 0.109$), DAC ($F_{(2, 87)} = 6.77$, $p = 0.002$, $\eta^2p = 0.137$), DAS ($F_{(2, 87)} = 3.67$, $p = 0.030$, $\eta^2p = 0.079$), and DAP ($F_{(2, 87)} = 3.27$, $p = 0.043$, $\eta^2p = 0.072$), with the ID group more impaired than LD for all domains. Additionally, DAC scores were significantly lower in the ID group compared to OD (Table 3, also see Table 3S for all statistics).

Regarding psychopathological functioning, the ID group showed significantly higher scores in the Oppositional Defiant Problems scale compared to LD ($F_{(2, 87)} = 5.83$, $p = 0.004$, $\eta^2p = 0.121$) (Table 3, also see Table 3S for all statistics).

Longitudinal Within-Group Comparisons, T0-T1

Starting from the three diagnoses conducted at T1, comparative analyses were performed between each group from T0 to T1.

Regarding the ID group, a significant decrease in IQ over time was found ($F_{(1, 52)} = 8.11$, $p = 0.005$, $\eta^2p = 0.072$). While adaptive functioning remained stable, CBCL scores indicated a significant decrease in both syndromic and

Table 3 Comparisons of measures among ID, OD and LD at T1

Measures	Groups	Mean	Standard Deviation	Post Hoc Comparisons
IQ	ID	62.1	10.6	ID < OD*** ($p < 0.001$)
	OD	94.8	15.6	ID < LD*** ($p < 0.001$)
	LD	89.2	6.90	
ABAS II/VABS II GAC	ID	64.6	22.1	ID < LD** ($p = 0.009$)
	OD	76.8	15.9	
	LD	79.3	16.5	
ABAS II/VABS II DAC	ID	63.9	21.8	ID < OD* ($p = 0.025$)
	OD	81.5	13.3	ID < LD** ($p = 0.008$)
	LD	78.2	14.4	
ABAS II/VABS II DAS	ID	73.5	18.2	ID < LD* ($p = 0.049$)
	OD	84.1	15.3	
	LD	83.6	16.2	
ABAS II/VABS II DAP	ID	70.3	19.9	ID < LD* ($p = 0.034$)
	OD	76.1	17.1	
	LD	82.2	18.7	
CBCL Oppositional Defiant Problems	ID	61.2	9.2	ID > LD** ($p = 0.009$)
	OD	54.8	5.2	
	LD	55.1	6.8	

T1 = school-age period age range 6 years to 8 years and 6 months; ID = Intellectual Disability; OD = Other Diagnoses; LD = Language Disorder; IQ = intelligent quotient; GAC = General Adaptive Composite score from ABAS II and Adaptive Behavior Composite score from VABS -II; DAC = Conceptual Adaptive domain from ABAS II and Communication domain from VABS II; DAS = Social Adaptive domain from ABAS II and Socialization domain from VABS II; DAP: Practical Adaptive domain from ABAS II and Daily Living Skills domain from VABS II; *$p < 0.05$, **$p < 0.01$ **, $p < 0.001$***

Table 4 Within comparisons ID group T0-T1

Measures	Timeline	Mean	Standard Deviation	Post Hoc Comparisons
IQ	T0	71.0	15.3	T1 < T0** ($p = 0.005$)
	TI	64.0	10.6	
CBCL Anxious/Depressed	T0	57.4	7.7	T1 > T0* ($p = 0.039$)
	TI	61.3	11.2	
CBCL Aggressive Behavior	T0	56.9	9.3	T1 > T0** ($p = 0.003$)
	TI	62.8	11.0	
CBCL Internalizing Probl.	T0	58.1	11.0	T1 > T0* ($p = 0.039$)
	TI	64.4	10.8	
CBCL Attention/Hyper. Prob.	T0	59.0	7.6	T1 > T0* ($p = 0.016$)
	TI	63.0	9.3	
CBCL Opposit. Defiant Prob.	T0	55.0	6.6	T1 > T0*** ($p < 0.001$)
	TI	61.1	9.2	

T0 = preschool period age range 2 years to 5 years and 11 months; T1 = school-age period age range 6 years to 8 years and 6 months; IQ = intelligent quotient; CBCL Internalizing Probl.= Internalizing Problems scales; CBCL Attention/Hyper. Prob.= Attention Deficit/Hyperactivity Problems scale; CBCL Opposit. Defiant Prob.= Oppositional Defiant Problems scale; *$p < 0.05$, **$p < 0.01$ **, $p < 0.001$***

Table 5 Within comparisons OD group T0-T1

Measures	Timeline	Mean	Standard Deviation	Post Hoc Comparisons
ABAS II/VABS II DAC	T0	67.1	16.1	T1 > T0* ($p = 0.043$)
	TI	81.5	13.3	

T0 = preschool period age range 2 years to 5 years and 11 months; T1 = school-age period age range 6 years to 8 years and 6 months; DAC = Conceptual Adaptive domain from ABAS II and Communication domain from VABS II; *$p < 0.05$, **$p < 0.01$ **, $p < 0.001$***

Table 6 Within comparisons LD group T0-T1

Measures	Timeline	Mean	Standard Deviation	Post Hoc Comparisons
ABAS II/VABS II GAC	T0	70.4	15.3	T1 > T0* ($p = 0.054$)
	TI	79.3	16.5	
ABAS II/VABS II DAP	T0	70.6	13.8	T1 > T0* ($p = 0.016$)
	TI	82.2	18.7	

T0 = preschool period age range 2 years to 5 years and 11 months; T1 = school-age period age range 6 years to 8 years and 6 months; GAC = General Adaptive Composite score from ABAS II and Adaptive Behavior Composite score from VABS –II; DAP: Practical Adaptive domain from ABAS II and Daily Living Skills domain from VABS II; *$p < 0.05$, **$p < 0.01$ **, $p < 0.001$***

DSM-oriented scales, particularly Anxious/Depressed ($F_{(1, 52)} = 4.407$, $p = 0.039$, $\eta^2p = 0.041$), Aggressive Behavior scale ($F_{(1, 52)} = 8.99$, $p = 0.003$, $\eta^2p = 0.080$), Attention Deficit/Hyperactivity Problem ($F_{(1, 52)} = 5.96$, $p = 0.016$, $\eta^2p = 0.054$), Oppositional Defiant Problem scale ($F_{(1, 52)} = 15.72$, $p < 0.001$, $\eta^2p = 0.131$), as well as Internalizing Problems scale ($F_{(1, 52)} = 9.03$, $p = 0.005$, $\eta^2p = 0.080$) (Table 4, also see Table 4S for all statistics).

Regarding the OD group, IQ remained stable, but adaptive functioning improved significantly in the DAC domain ($F_{(1, 9)} = 4.75$, $p = 0.043$, $\eta^2p = 0.209$). No clinically significant psychopathological changes were detected (Table 5, also see Table 5S for all statistics).

In the LD group, as in the OD group, no differences in IQ were found. Improvements were observed in adaptive functioning, particularly in GAC ($F_{(1, 24)} = 3.90$, $p = 0.054$, $\eta^2p = 0.075$) and DAP ($F_{(1, 24)} = 6.25$, $p = 0.016$, $\eta^2p = 0.115$). No changes emerged in psychopathological functioning. (Table 6, also see Table 6S for all statistics)

Discussion

This exploratory study aimed to evaluate cognitive and adaptive functioning during the preschool period by examining potential group differences across early diagnostic categories. It further assessed the presence of early-emerging psychopathological symptoms and their prognostic utility in predicting subsequent diagnosis of ID. Longitudinal trajectories of cognitive, adaptive, and psychopathological functioning were analyzed from preschool to school age, both within and between diagnostic groups. Additionally, the study examined patterns of diagnostic continuity and change over time. To our knowledge, this is the first longitudinal study conducted on an Italian preschool population with developmental delays to attempt to explore the evolution of cognitive, adaptive, and behavioral functioning over time.

Regarding adaptive functioning at T0, all groups of children exhibited impairments, suggesting that generally neurodevelopmental disorders are associated with deficits in adaptive skills, according to existing data in literature (American Psychiatric Association, 2013). However, children with GDD showed significantly poorer overall adaptive functioning, particularly in the conceptual domain, compared to children with MSDD and LD. This may be due to the more pronounced cognitive deficits characteristic of GDD, which specially affect communication, pre-academic skills, and self-regulation. In contrast, no significant differences were observed in the social and practical domains, where all children displayed similar levels of impairment. These findings are consistent with existing literature indicating a relationship between IQ and adaptive functioning (Åsberg Johnels et al., 2021), particularly in the conceptual domain, which appears to be more directly influenced by cognitive ability (Tassé & Kim, 2023). It can therefore be speculated that marked difficulties in conceptual functioning, along with global adaptive deficits, may represent early indicators of GDD. At the same time, it is important to highlight that significant adaptive impairments were also observed in pre-schoolers with other neurodevelopmental conditions. These results further support the idea that neurodevelopmental delays - whether limited to a specific area, as in language disorders, or generalized across multiple domains with mild severity, as in MSDD, or severe impairment, as in GDD - substantially impact children's daily functioning and developmental outcomes, emphasizing the importance of early interventions (Lindblad et al., 2013; Mathiassen et al., 2012).

Regarding psychopathological functioning at T0, no significant differences were found between groups, except for attentional problems. Specifically, children with GDD exhibited greater attentional difficulties compared to those with MSDD. This finding is particularly noteworthy, as it underscores challenges in sustaining attention, heightened distractibility, impulsivity, and a tendency to shift focus rapidly. Such difficulties can significantly impact early cognitive, social, and emotional development, potentially interfering with the acquisition of fundamental skills necessary for later academic and adaptive functioning. Attention deficits are well-documented in individuals with ID, often impairing a wide range of related abilities, including academic performance, perceptual processing, executive functioning, and motor coordination (Delfos, 2004; Bigby et al., 2007; Deutsch et al., 2008; Kurtz, 2008; Djuric-Zdravkovic et al., 2010; Buckley et al., 2020). These deficits may contribute to increased frustration, behavioral challenges, and difficulties in social interactions, further compounding the impact on overall development (Du Rietz et al., 2021). Notably, attentional difficulties have been observed in the preschool years (Overgaard et al., 2022) and are often associated with broader cognitive challenges (Ross & Perlman, 2022), as the ability to sustain attention play a critical role in early learning and, consequently, in cognitive functioning. Therefore, it is plausible to hypothesize that attentional impairments are present from the earliest stages of development and may serve as potential early markers of ID during this critical period. However, these findings should be interpreted as exploratory, given the limited sample size, the heterogeneous age range, and the reliance on parent-report measures, which may introduce variability. Identifying and addressing these challenges at an early stage could be crucial for implementing timely interventions aimed at mitigating their long-term impact and promoting more adaptive developmental trajectories. Further research with larger and more homogeneous samples will be necessary to confirm these preliminary observations and to clarify the role of early attentional difficulties in predicting later ID.

Concerning the trajectory of psychopathological and adaptive functioning from T0 to T1, our findings indicate a modification of diagnoses over time, with a marked increase in ID diagnoses at school age. This result reflects the variability of neurodevelopment and the diagnostic challenges present in its early stages, emphasizing the need for continuous monitoring and specific follow-up assessment for these children (Juneja et al., 2022), It also confirms the substantial interindividual variability in neurodevelopmental outcomes between preschool and school age, as highlighted in previous studies (Dietz et al., 2007; Jónsdóttir et al., 2007; Lee et al., 2022). Furthermore, our results revealed differences across groups in the developmental trajectories of cognitive, adaptive and psychopathological functioning. Specifically, children with ID exhibited a decline in IQ scores from T0 to T1, a pattern consistently reported in the literature (Farmer et al., 2020; DiStefano et al., 2020; Thurm et al., 2020). This decline should not be understood as a loss of previously acquired abilities, but rather as a cohort-relative shift, that reflects a widening deviation from normative developmental expectations. Because norm-referenced assessments compared an individual's performance to that of age-matched peers, slower developmental progress results in lower standardized scores over time, even when children continue to acquire new skills (Farmer et al., 2020; Thurm et al., 2020). Moreover, the transition to more structured, demanding, and often linguistically loaded cognitive assessments at school age may accentuate this divergence, as such instrument may underestimate the abilities of children with ID. The frequent co-occurrence of comorbid impairments, particularly in language and motor domains, may further compound these difficulties, as such impairments can interfere with task comprehension, response execution, and overall test engagement, thereby reducing the validity of cognitive estimates. These findings collectively underscore the developmental variability and complexity characterizing the cognitive trajectories of children with ID. They highlight the need for dynamic, developmentally appropriate, and individualized assessment approaches that move beyond static test scores to consider the broader context of a child's functional abilities. Importantly, such approaches should be implemented from the earliest stages of development and sustained longitudinally to inform tailored interventions and supportplanning throughout the child's growth.

As for adaptive functioning, it appeared to remain unchanged in children with ID, who continued to exhibit significant deficits across all domains, whereas improvements were observed in the other groups over time. This persistent impairment in children with ID suggests that their difficulties in acquiring age-appropriate adaptive skills may be more resistant to natural developmental progress and require targeted interventions. Specifically, although their scores remained below average, children with OD demonstrated measurable gains in the conceptual domain, likely reflecting progress in cognitive flexibility, reasoning, and language-related abilities. Meanwhile, children with LD exhibited improvements in both overall adaptive functioning and the practical domain, suggesting enhanced problem-solving skills, self-care abilities, and daily living competencies. These findings support the notion that, as development unfolds, the distinction between the presence or absence of ID becomes more evident in adaptive functioning (Liss et al., 2001). The trajectory of adaptive skill acquisition appears to diverge between children with and without ID, reinforcing the importance of continuous monitoring and individualized support strategies. Although adaptive functioning remains impaired relative to the expected levels in the general population, as consistently reported in previous studies (Åsberg Johnels et al., 2021; Lindblad et al., 2013; Mathiassen et al., 2012), our data indicate a tendency for improvement over time in children without ID. This suggests that while some neurodevelopmental conditions may delay or hinder the acquisition of adaptive skills, children without ID can still develop these abilities through early intervention, education, and environmental support. These findings provide valuable insights into the longitudinal development of adaptive functioning in children with neurodevelopmental disorders, emphasizing the necessity of further research with larger samples to explore the underlying mechanisms driving these developmental changes. Additionally, the data underscores the critical importance of early and targeted interventions aimed at stimulating adaptive skill acquisition in children with ID. Structured support programs focusing on enhancing daily living skills, social competence, and executive functioning may help mitigate long-term limitations and promote greater independence in adulthood. Future studies should investigate the specific intervention strategies that yield the most significant improvements in adaptive functioning, considering the diverse needs of children with ID across different developmental stages.

In contrast to the stability of adaptive functioning, significant differences in emotional and behavioral symptoms in children with ID were observed between T0 and T1. Specifically, there was an increase in both internalizing symptoms, particularly anxiety and depression, and externalizing symptoms, including aggression, inattention, hyperactivity, and oppositional-defiant behaviors. Although the rise in symptomatology did not reach the clinical threshold, indicating no severe difficulties, greater challenges were evident compared to earlier stages. These findings are consistent with existing literature, which highlights a higher prevalence of emotional difficulties in children with ID compared to typically developing peers (Baker et al., 2002; Green et al., 2005; Hauser-Cram & Woodman, 2016). Additionally, both internalizing and externalizing disorders are commonly reported comorbidities, particularly in adolescence and adulthood (De Ruiter et al., 2007; Dekker & Koot, 2003; Green et al., 2005; Hodapp & Dykens, 2005; Marrus & Hall, 2017; Molteno et al., 2001; Totsika et al., 2022). However, very few studies have examined early developmental stages, leaving uncertainties regarding the age of onset and early manifestations (Einfeld et al., 2011). Within this cohort, we observed indications that emotional difficulties can appear during the transition from preschool to school age, although their progression into clinically evident problems in later childhood and adolescence remains to be established. Particular attention may be warranted in the preschool years for heightened attentional symptoms, which could serve as an early signal of later ID, although this requires further confirmation. Given the higher prevalence of mental health disorders in children with ID and the limited number of controlled studies on psychological interventions in this group (Totsika et al., 2022), additional structured research on early behavioral treatments would be valuable. Expanding our understanding of the efficacy of early interventions could lead to the development of tailored approaches that address the unique emotional and behavioral needs of young children with ID. Additionally, improving accessibility to early psychological interventions within local services is essential to ensuring that children receive timely support, reducing the risk of long-term impairments in emotional well-being, adaptive functioning, and overall quality of life. Future efforts should focus on integrating behavioral and psychological interventions into routine care, promoting interdisciplinary collaboration, and advocating for policy changes that prioritize early identification and intervention for this vulnerable population. Equally important is the longitudinal monitoring of developmental trajectories, as ongoing follow-up can provide valuable insights into the long-term impact of early interventions and the potential diagnostic shifts that may occur across different stages of development.

Although this study holds significant implications for the developmental trajectory of preschool children with neurodevelopmental delays, several limitations are worth noting. The first limitation concerns the heterogeneity of the sample in terms of both sex and age. The sample consists predominantly of males rather than females, a difference that reflects the higher incidence of neurodevelopmental disorders in males. Additionally, at both T0 and T1, children were categorized into preschool and school-age groups; however, within these categories, their ages remained heterogeneous. Future studies should aim to refine age stratification within these groups to provide a more precise depiction of adaptive and psychopathological profiles and their evolution over time. A second limitation relates to the heterogeneity and variability of the assessment tools employed, particularly for cognitive evaluation at preschool age. Different instruments were administered at T0 based on age and developmental level, which may have introduced measurement noise and limited the generalizability of the findings. Another limitation is the lack of long-term follow-up assessments, particularly during preadolescence, adolescence, and adulthood. Such follow-ups would be crucial to comprehensively track the developmental trajectories of the children over time and better understand their long-term outcomes. Moreover, the sample exhibits variability in diagnoses between T0 and T1. Intragroup comparisons were conducted based on diagnoses at T1, with the primary aim of assessing the evolution of ID over time. However, specific differences among individuals whose diagnoses changed between T0 and T1 were not analyzed, as the study's objective was to provide a longitudinal description of the sample based on diagnostic groups. Future studies could explore these aspects in greater detail through more specific analyses. A further consideration concerns the diagnostic category of MSDD adopted at T0, which is commonly employed in Italian clinical practice but is not included in DSM 5, and may therefore limit the generalizability of the findings. Another limitation concerns the decision to aggregate heterogeneous neurodevelopmental conditions (ASD, ADHD, DCD and SCD) into a single OD group at T1. While this choice was necessary to ensure adequate statistical power given the limited number of subjects in each diagnostic category, it may have obscured meaningful clinical distinctions and potentially masked differential developmental trajectories across the conditions. Considering the different cognitive, adaptive and behavioral profiles associated with each diagnosis, future research would benefit from examining these groups separately to better capture disorder-specific patterns and more precisely delineate their developmental courses. Finally, a limitation concerns the statistical power of the analyses. Although the overall sample size was adequate for exploratory longitudinal analyses, subgroup sizes, particularly at T1 and within the OD group, were relatively small. This limited statistical power may have reduced the ability to detect subtle or moderate group differences, increasing the likelihood of Type II errors. Consequently, non-significant findings should be interpreted with caution and should not be considered evidence of the absence of meaningful developmental or clinical differences. Future studies with larger samples and greater diagnostic stratification will be essential to confirm and extend these findings.

While the study haslimitations, it offers preliminary insights with potential clinical and ID during the preschool years, which could inform more accurate diagnoses and guide the development of tailored early interventions for children and their families. Such interventions may help support adaptive functioning and well-being, although further longitudinal research will be needed to clarify their impact and to monitor developmental changes over time.

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Data Availability All the materials described in the present study are available from the corresponding author on justified request.

Declarations

Conflict of interest The authors declare no conflict of interest.

Ethical Approval All procedures were in accordance with the Helsinki Declaration. Institutional review board statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by Ethics Committee of Bambino Gesù Children's Hospital, practice number 3341/2024, protocol number 211, approval date: April 22, 2024.

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