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RESEARCH ARTICLE

Prevalence of comorbidity of autism and ADHD and associated characteristics in school population: EPINED study

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Abstract

Autism and attention deficit hyperactivity disorder (ADHD) comorbidity in the school population have been understudied. This study estimates its prevalence considering both parents' and teachers' reports and clinical diagnosis. Sociodemographic, clinical, and cognitive data were compared by diagnostic groups: autism, ADHD, autism and ADHD, subthreshold autism spectrum disorder (ASD), subthreshold ADHD, and children without neurodevelopmental conditions. Following a two-phase design, 3727 parents and teachers (1802 preschoolers, 1925 school-age children) participated in the first phase. Subsequently, 781 participants underwent individual assessment for DSM-5 diagnoses. The estimated prevalence of the comorbid diagnosis was 0.51% (0.28%–0.74%), with significant sex differences (0.16% girls, 0.89% boys). The cooccurrence of symptoms of autism and ADHD reported by parents or teachers was 3.2% and 2.6%, respectively. ADHD comorbidity was observed in 32.8% of autistic children and 31.4% of those with subthreshold ASD. ASD comorbidity was observed in 9.8% of children with ADHD and 5.7% of those with subthreshold ADHD. Comorbidity was reported by at least one informant in 95% of children. Only 15.8% of children with autism and ADHD had been previously diagnosed with both conditions. Early detection and accurate comorbidity diagnosis are crucial to address the clinical and socio-educational needs of these children.

Lay Summary

Autism and attention deficit hyperactivity disorder (ADHD) frequently coexist, but prevalence reports exhibit significant variability based on population characteristics and assessment methods. In the present study, parents and teachers reported a similar 3% prevalence of autism and ADHD traits, with an estimated comorbid diagnosis prevalence of 0.5%. Only 16% of the children had received prior diagnoses for both conditions, although parents and teachers identify traits of autism and ADHD in almost all cases. Based on the findings, early screening for cooccurring autism and ADHD in both school and family settings is recommended, enabling the implementation of socio-educational and clinical strategies to improve the prognosis and quality of life for these children.

KEYWORDS
ADHD, autism, children, comorbidity, prevalence

Josefa Canals and Paula Morales-Hidalgo contributed equally to this study.

INTRODUCTION

Neurodevelopmental disorders (NDD) comprise a group of persistent conditions with an early onset in childhood, commonly addressed within mental health services (Hansen et al., 2018; Zablotsky et al., 2019). attention deficit hyperactivity disorder (ADHD) and autism are among these conditions, which have demonstrated a significant increase in prevalence, involving a high percentage of the population, and leading to individual, social, and family challenges. Recent prevalence studies in children and adolescents estimate rates between 5.5% and 7.6% for ADHD (Canals et al., 2021; Salari et al., 2023) and between 1.5% and 4.3% for autism (Maenner et al., 2023; May et al., 2020; Morales-Hidalgo et al., 2021). Both conditions frequently coexist and common data on the clinical, neurobiological characteristics, and genetic associations have been a focus of study since the recognition of this comorbidity in the DSM-5 (American Psychiatric Association, 2013; Boedhoe et al., 2020; Ghirardi et al., 2019, 2021; Schachar et al., 2023). The prevalence of comorbidity varies widely depending on the type of population or the assessment methods used. While some studies report the frequency of ADHD symptoms in the autism spectrum or vice versa, others strictly consider the prevalence of cooccurrence of both diagnoses, whereas other studies estimate the prevalence of comorbidity.

Regarding the presence of ADHD in the autistic population, the systematic review of Eaton et al. (2023) reported a prevalence of 2.6%–70.6% of ADHD symptoms in autistic youth without intellectual disability. Additionally, a meta-analysis by Rong et al. (2021) estimated a current prevalence and a pooled lifetime prevalence of 38.5% and 40.2%, respectively. In clinical samples, according to DSM-5 criteria, ADHD was present in 61.8% of autistic youth in the U.S. (Rau et al., 2020) while in Italy, the rate was lower in both preschoolers (20.4%) and school-age children (21%) and followed by adolescents (7.3%) (Fucà et al., 2023). In contrast, Bierens et al. (2023) reported in the Netherlands clinical population a higher rate of ADHD in autistic children from 6 to 18 years (34.8%) than in preschoolers (17%). According to recent data from the U.S. National Survey of Children's Health, 43.8% of children were also presenting comorbidity with ADHD at an older age (Casseus et al., 2023), similarly found in the meta analysis conducted by Rong et al. (2021). Considering the ADHD population, the autism comorbidity has typically been reported as relatively lower, with values ranging from 13.9% in U.S. children with DSM criteria (Casseus et al., 2023) up to 29.4% in Swedish children and adolescents diagnosed with ICD-10 criteria (Elwin et al., 2020).

However, there are few studies in community samples estimating the prevalence of autism and ADHD together. Casseus (2022) estimated from a U.S. nationally representative sample that 1.2% of children aged between 3 and 17 years had comorbid autism and ADHD and found that sociodemographic variables were associated with this cooccurrence. Thus, being female, younger, and belonging to higher socioeconomic status and certain racial groups were less likely related to the comorbidity (Casseus, 2022; Casseus et al., 2023). Another aspect that has been scarcely studied is the presentation of ADHD in the comorbidity profiles. In this regard, Rau et al. (2020) and Zablotsky et al. (2020) reported that children diagnosed with both conditions were more likely to have an ADHD combined presentation. The comorbidity between autism and ADHD involves barriers in individuals' daily lives, often resulting in more intense social interaction challenges (McFayden et al., 2022; Sprenger et al., 2013; Vaidya & Klein, 2022), lower cognitive and adaptative skills (Rosello et al., 2023), higher cooccurrence of emotional and behavioral problems (Casseus, 2022; Morales-Hidalgo et al., 2023; Thomas et al., 2018; Zablotsky et al., 2020), and greater treatment needs or increased likelihood of psychotropic medication compared with those with ADHD or autism alone (Casseus, 2022; Zablotsky et al., 2020).

Evidence reported in the literature highlights the importance of the early identification of the cooccurrence of autism and ADHD for improved support and prevention of challenges faced by individuals and their families. To consider not only the clinical care of individuals referred to assistance centers but also implement public health strategies, it is necessary to perform studies recruiting samples from nonclinical settings that provide information on epidemiological data from different geographical locations. Henceforth, the present study aims to fill in the gaps in the literature on the prevalence of autism and ADHD comorbidity in the school population, considering the traits reported by parents and teachers and the clinical diagnoses of both conditions. We present the bidirectional comorbidity between autism and ADHD by severity levels (diagnosis, subthreshold diagnosis, and teacher's and family's symptom reports) for both conditions. Also, the study aims to provide sociodemographic, clinical, and cognitive data comparing diagnostic groups (autism, ADHD, and the comorbidity of autism and ADHD). We expect to find a rate of cooccurrence and comorbidity of autism and ADHD similar to those found in European samples, being higher in older children and boys in relation to autism or ADHD alone.

METHODS

Study design and procedure

The Neurodevelopmental Disorders Epidemiological Research Project (EPINED) was a cross-sectional two-phase study performed between 2014 and 2019 in the province of Tarragona, Spain. It mainly aimed to analyze and further investigate the prevalence of autism and

ADHD in preschool and school-aged children from mainstream schools. The study protocol was validated by the Ethics Committee at the Sant Joan University Hospital (13-10-31/10proj5). Sample size estimation, assessment protocols, as well as prevalence estimates found for autism and ADHD, have been previously described (Canals et al., 2021; Morales-Hidalgo et al., 2021; see Figure S1).

In the screening phase, autism traits were assessed by families using the Childhood Autism Spectrum Test (CAST) (Morales-Hidalgo, Roigé-Castellví, Vigil-Colet, & Canals Sans, 2017; Scott et al., 2002) and by teachers using the EDUTEA (an autism screening questionnaire based on DSM-5 criteria for teachers) (Morales-Hidalgo, Hernández-Martínez, Voltas, & Canals, 2017). Both tests showed good psychometric properties in Spanish population (0.83 of reliability, 85.7% of sensitivity and 91.2% of specificity for CAST and 0.97 of reliability, 87% of sensibility and 91.2% of specificity for EDUTEA) (Morales-Hidalgo, Roigé-Castellví, Vigil-Colet, & Canals Sans, 2017). ADHD traits were assessed by parent and teacher versions of the 10-item Conners indexes for preschoolers (Conners & Goldstein, 2009) or school-aged children (Conners 3 ADHD Index; Conners, 2008). The psychometric study of the Conners indexes in Spanish populations has provided good reliability (0.89 and 0.92 for parents and teachers, respectively) and validity for detecting ADHD traits (Morales-Hidalgo, Hernández-Martínez, Vera, et al., 2017). An increased likelihood of autism was considered when children scored above the cut-off scores for CAST or EDUTEA, and an increased likelihood of ADHD was considered when they obtained high or very high scores ($T \geq 65$) on the parent and teacher Conners indexes. Children with previous diagnoses of autism and/or ADHD reported by the families or with an increased likelihood of autism and/or ADHD and a comparison group without ASD and ADHD increased likelihood (scores below cut-off points) paired by sex, age, and school were then invited to an individual assessment in the second phase of the study.

In the second phase, children and their families participated in individual assessments at the school conducted by specially trained clinicians. The diagnosis of autism and ADHD conditions was performed following DSM-5 criteria. The assessment for autism included the Autism Diagnostic Interview Revised (ADI-R) (Rutter et al., 2003) and the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) (Lord et al., 2012). For ADHD, the ADHD scale from the Schedule for Affective Disorders and Schizophrenia for School-Age Children (K-SADS-PL; Kaufman et al., 1997) was administered to the parents. We also considered clinical and educational information provided by parents and the psychology teams of schools as well as neuropsychological data obtained from the children. Neuropsychological performance was mainly assessed by Wechsler Scales of Intelligence for preschoolers (WPPSI-IV; Wechsler, 2014) and school-age children (WISC-IV; Wechsler et al., 2005). Parents answered the Child Behavior Checklist (CBCL 1½ to −5 or CBCL/6–18) (Achenbach & Rescorla, 2000; Achenbach & Rescorla, 2001) to assess cooccurrent psychological challenges. Emotional dysregulation was assessed using the CBCL-dysregulation profile (DP), calculated by summing the *T*-scores of three CBCL subscales: attention problems, aggression, and anxious/depressed. In the first and second phases of the study, sociodemographic characteristics, previous diagnosis status, and service use information about the child were collected. Socioeconomic levels were estimated according to Hollingshead (2011).

Participants

The recruitment of the participants was conducted from the schools through an agreement with the Education Department of the Catalan Government. A representative sample of 3374 preschoolers (4–5 years) and 3520 school-aged children (10–11 years) conformed the present sample. The distribution through the different phases of the study can be found in Figure 1. In the first phase, the participation rate was 99.6% for teachers and 53.9% for families, resulting in 3727 children with information from both contexts. The sociodemographic characteristics of the sample and the comparison between participants and nonparticipants have already been widely described by Canals et al. (2021) and Morales-Hidalgo et al. (2021). The individual assessments in the second phase were conducted for 781 children and their families. In this phase, 92.7% of children in the autism and/or ADHD likelihood group participated. Figure 1 shows the total number of autism and/or ADHD diagnoses, including subthreshold diagnoses.

Case definition and prevalence estimates

The likelihood of autism and/or ADHD was determined based on information provided by parents and teachers in the screening phase, which allowed us to estimate the prevalence of traits indicating an increased likelihood of these conditions in the entire sample. Diagnosis of autism and/or ADHD was based on the fulfillment of DSM-5 criteria according to the information collected by parents, teachers, and children in the assessment phase and required an agreement between two investigators. In this project, we also presented data on the subthreshold diagnostic categories for autism and ADHD.

The prevalence of autism and/or ADHD was obtained in agreement with the following case descriptions. Participants received a diagnosis of autism when the child reached or exceeded the cut-off scores for the ADI-R diagnostic algorithm and the ADOS-2 calibrated

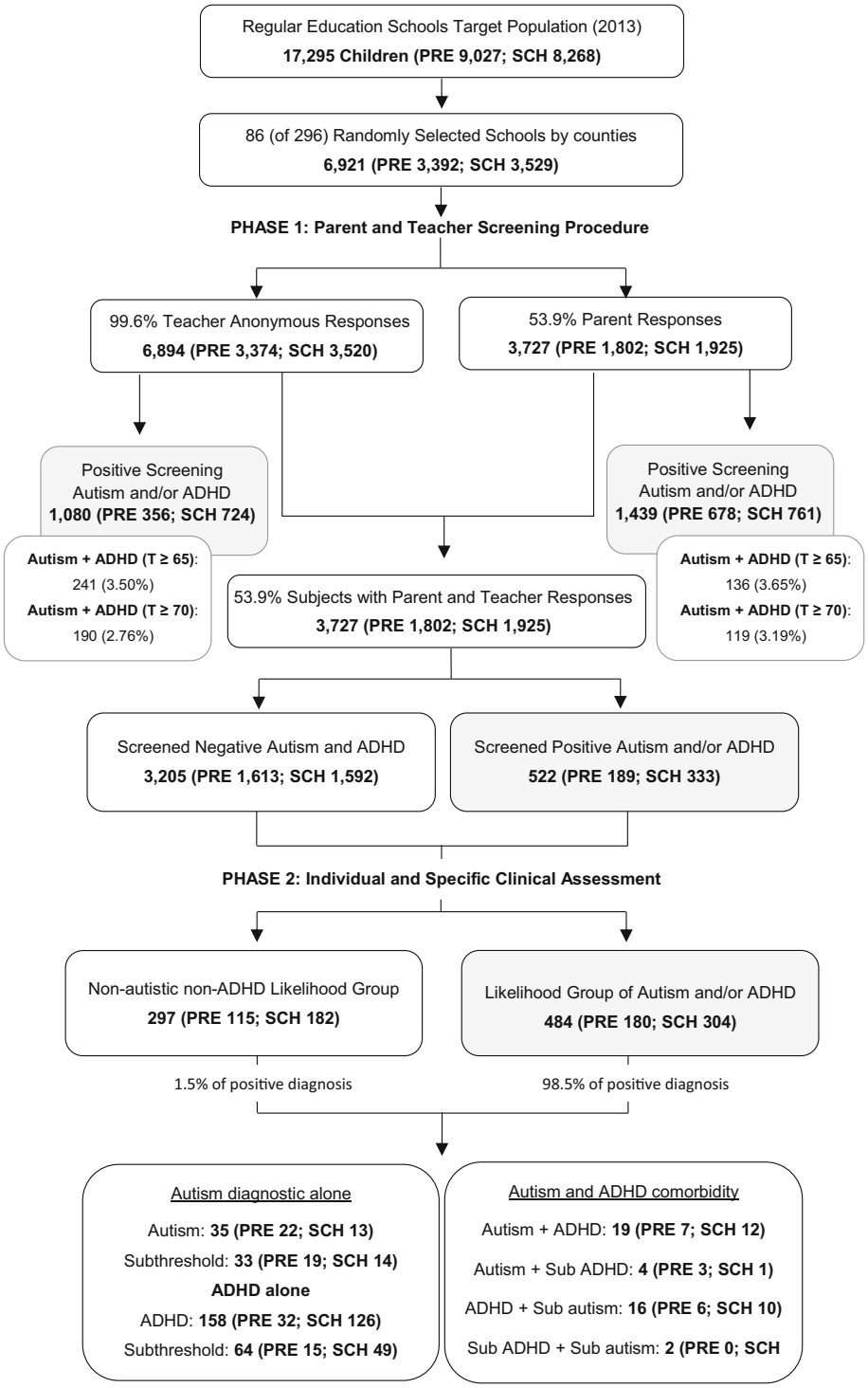

FIGURE 1 Study design and distribution of diagnoses flow chart. ADHD, attention deficit/hyperactivity disorder; PRE: Preschool aged children, SCH: School aged children, Sub: Subthreshold.

total score of severity (score ⩾4). Subthreshold autistic condition was considered when the child scored slightly below the cut-off point scores in both ADI-R and ADOS-2 diagnostic algorithms (i.e., one or two points below) but it was observed that these traits had a significant impact on their daily life. The intensity of autism traits was assessed using ADOS-2 calibrated scores for the total scale (Gotham et al., 2009) as well as for the social-communication and stereotyped behavior scales (Hus et al., 2014). Participants received a diagnosis of ADHD when the information in the K-SADS-PL interview met the DSM-5 criteria for any of the three presentations of ADHD (inattentive, hyperactive–impulsive [H–I], and combined). Subthreshold ADHD was considered when the child scored $T \geq 65$ on both parent and teacher Conners' 10-item indexes and exhibited four or five inattentive or H–I diagnostic criteria from K-SADS-PL with a considerable impact on daily life functioning.

Statistical analyses

Statistical analyses were performed using IBM SPSS 29 and EPIDAT 4.2. Prevalence estimates were weighted considering both the diagnoses in the screen-positive and screen-negative groups, providing a confidence interval of 95%. Sociodemographic, clinical, and service use characteristics of the sample were provided by groups through descriptive statistics. Depending on the nature of the variables to be processed, comparisons were made by means of chi-squared and *T*-test/analysis of variance (ANOVA) for independent samples with Bonferroni or Tamhane's T2 post hoc analysis. Levene's test was used to assess variance homogeneity in *T*-test/ANOVA. Agreement between informants was calculated using Cohen's kappa (k).

RESULTS

The distribution of the population with an increased likelihood of autism and/or ADHD in each phase of the study has been provided in Figure 1.

Table 1 presents the rates of prevalence of autism and ADHD comorbidity, and bidirectional comorbidity patterns between autism and ADHD by age group. Based on the first phase sample ($N = 3727$ children with parent and teacher responses), 2.63% of the teachers and 3.19% of the parents screened positive for ASD and very high symptoms of ADHD ($T \geq 70$). A different age distribution was found depending on the informant (teacher' report: 1.83% PRE vs. 3.38% SCH, $p < 0.003$; parents' report: 2.44% PRE vs. 3.89% SCH, $p = 0.012$). The informant agreement on an increased likelihood of autism and ADHD symptoms was $k = 0.27$, with values of $k = 0.31$ in males, and $k = 0.17$ in females. The cooccurrence of autism + ADHD symptoms was significantly higher in males than females, both by teachers (4.00% vs. 1.35, $p < 0.001$) and parents (4.95% vs. 1.56, $p < 0.001$) (data not shown in Table).

The estimated prevalence of autism and ADHD comorbidity in the present sample ($N = 3727$) was 0.51% (see Table 1). The estimated prevalence was significantly different according to sex distribution; 0.89% (95% CI 0.46–1.32) for boys and 0.16% (95% CI −0.02–033) for girls ($p = 0.002$). No significant differences were found between age groups, although the prevalence was higher in school-age children (0.62%) than in preschoolers (0.39%). The rate of comorbidity of ADHD in autistic

TABLE 1 Prevalence of autism and attention deficit hyperactivity disorder (ADHD), and bidirectional comorbidity patterns between autism and ADHD by age group.

Autism and ADHD comorbidity				
	Preschool-age children (PRE) $n = 1802$	**School-age children (SCH) $n = 1925$**	***p***	**TOTAL $n = 3727$**
Estimated prevalence of diagnosis, % (95% CI)	0.39 (0.10–0.68)	0.62 (0.27–0.97)	0.314	0.51 (0.28–0.74)
Teacher's symptom report, *n* (%)	33 (1.83)	65 (3.38)	**0.003**	98 (2.63)
Family's symptom report, *n* (%)	44 (2.44)	75 (3.89)	**0.012**	119 (3.19)

	Autism				**Subthreshold autism**			
ADHD comorbidity patterns	**PRE N = 32**	**SCH $N = 26$**	***p***	**Total $N = 58$**	**PRE $N = 25$**	**SCH $N = 26$**	***p***	**Total $N = 51$**
Diagnosis, *n* (%)	7 (21.88)	12 (46.15)	0.050	19 (32.76)	6 (24.00)	10 (38.46)	0.266	16 (31.37)
Subthreshold diagnosis, *n* (%)	3 (9.38)	1 (3.85)	0.409	4 (6.90)	0 (0.00)	2 (7.69)	-	2 (3.92)
Teacher's symptom report, *n* (%)	12 (37.50)	15 (57.69)	0.125	27 (46.55)	9 (36.00)	10 (38.46)	0.856	19 (37.25)
Family's symptom report, *n* (%)	16 (50.00)	22 (84.62)	**0.006**	38 (65.52)	17 (68.00)	17 (65.38)	0.843	34 (66.67)

	ADHD				**Subthreshold ADHD**			
Autism comorbidity patterns	**PRE $N = 45$**	**SCH $N = 148$**	***p***	**Total $N = 193$**	**PRE $N = 18$**	**SCH $N = 52$**	***p***	**Total $N = 70$**
Diagnosis, *n* (%)	7 (15.56)	12 (8.11)	0.142	19 (9.84)	3 (16.67)	1 (1.92)	**0.020**	4 (5.71)
Subthreshold diagnosis, *n* (%)	6 (13.33)	10 (6.76)	0.161	16 (8.29)	0 (0.00)	2 (3.85)	-	2 (2.86)
Teacher's symptom report, *n* (%)	15 (33.33)	40 (27.03)	0.412	55 (28.50)	6 (33.33)	7 (13.46)	0.062	13 (18.57)
Family's symptom report, *n* (%)	12 (26.67)	42 (28.38)	0.823	53 (27.46)	5 (27.78)	5 (9.62)	0.058	10 (14.29)

Note: Prevalence, % (95 confidence interval); Comorbidity and cooccurrence, frequency (%). In bold $p \leq 0.05$. Symptom co-occurrence has been reported by Conners 10-item indexes ($T \geq 70$) for ADHD and by childhood autism spectrum test or EDUTEA (scores above the cut-off point) for autism.

children was 32.76%, with a higher rate in older (46.15%) than in younger children (21.88%) ($p = 0.050$). The comorbidity of autism in children with ADHD was 9.84%, without significant differences between age groups, although was higher in younger (15.56%) than in older children (8.11%). The rate of cooccurrence of ADHD in children with subthreshold autism was 31.37% (24.00% and 38.46%, respectively, by age group), and the cooccurrence of autism in children with subthreshold ADHD was 5.71% (16.67% and 1.92%, respectively by age group, $p = 0.020$). On the other hand, the cooccurrence of subthreshold ADHD in children with autism was 6.90% (9.38% and 3.85%) and the rate of subthreshold autism in ADHD was 8.29% (13.33% and 6.76%). Regarding the cooccurrence of symptoms with the diagnosis (see Table 1), the frequency of ADHD symptoms ($T \geq 70$) reported by parents or teachers in children on the autistic spectrum (autism and subthreshold autism) was also higher than those of autism symptoms in ADHD. Children with autism presented 46.55% and 65.52% (up to 84.62% for school-aged children) of concurrent ADHD symptoms according to their teachers and parents, respectively; and children with ADHD exhibited 28.50% and 27.46% of cooccurring autistic symptomatology according to their teachers and parents, respectively. Of the children who received a diagnosis of autism and ADHD, 63% had previously screened positive for both conditions by both parents and teachers. The comorbidity was reported by at least one informant in 95% of cases. Teachers correctly identified the coexistence of symptoms in 68% of cases (in two cases autism was not detected and in four cases ADHD was not detected) and parents in 89% of cases (in only two cases autism was not detected).

Sociodemographic, clinical and cognitive profile, and service use characteristics of children with a comorbid diagnosis of autism and ADHD compared to those with autism or ADHD alone are presented in Table 2. Data on children without NDD are also shown. The male-to-female ratio differed across diagnosis groups with values of 5.3:1 in the comorbid group, 4:1 in autism, and 2.2:1 in ADHD, despite no significant differences being found. There were also no significant differences between these clinical groups in terms of age, socio-demographic status, or ethnicity. As far as age was concerned, more school-age children were found in the comorbid group (63.16%) than in those with autism alone (37.14%) ($p = 0.067$). Regarding the severity of nuclear symptomatology (Table 2), we observed no significant differences between the comorbid group and the autism or ADHD alone groups. However, the comorbid group showed a higher rate of H–I– symptoms and a lower proportion of cases of inattentive presentation than those with ADHD alone. In relation to cognitive and emotional profiles, no significant differences were found between the comorbid group and the autism or ADHD alone groups, but the children with comorbidity showed the lowest scores on working memory and a higher severity of emotional dysregulation symptoms.

The rate of previous diagnoses and the use of services were very different between groups (Table 2). Only 15.79% of children with autism and ADHD had been correctly diagnosed with both conditions, a much lower proportion than in those groups with only one diagnosis. ADHD was less diagnosed (31.58%) in comparison with autism (68.42%). Conversely, children with autism and ADHD comorbidity were receiving more educational and psychological support than those with autism and significantly much higher than the ADHD group ($p \leq 0.002$). Pharmacological treatment was more common in the comorbid group (15.79%) than in children with autism alone (2.86%) but lower than in children with ADHD (21.52%).

DISCUSSION

The first aim of the present study was to estimate the prevalence of autism and ADHD comorbidity in a representative school sample of Spanish children. We found a prevalence of 0.51%, with no significant differences by age group but significant differences by sex. Total comorbidity was lower than the 1.2% found by the National Survey of Children's Health (Casseus, 2022). The discrepancy could be explained by methodological differences between both studies since the sample of the present study was constituted of participants from mainstream schools (not special needs schools), which may provide a population with less intense + diagnoses in comparison with parent/caregiver diagnoses reported in a national survey. Also, the sample of Casseus et al. (2023) comprised children and adolescents until 17 years old (with 26% of them between the age of 13–17 years old) whereas the current sample included children of 4–5 years old and 11–12 years old, with a lower probability of both diagnoses.

Regarding the rate of ADHD comorbidity in autistic children, our figure (32.8%) is remarkably similar to the 29.5% referred in community samples by the meta-analysis of Rong et al. (2021), but lower than those found in clinical samples (40.4%–61.8%) (Casseus et al., 2023; Houghton et al., 2017; Rau et al., 2020; Rong et al., 2021). However, considering the age group, the 21.9% found in preschoolers was similar to the 20.4% rate shown by Fucà et al. (2023) and the 17% by Bierens et al. (2023) in Italian and Netherlands clinical samples, respectively. We found a significantly higher rate of autism and ADHD comorbidity in school-aged children (46.2%) than in preschool-age children (21.9%), differences also shown by Casseus et al. (2023) (45.4% and 14.6%, respectively) but not obtained by other authors (Fucà et al., 2023; Houghton et al., 2017; Rong et al., 2021).

On the other hand, the comorbidity of autism in children diagnosed with ADHD (9.8%) is below the reported comorbidity of ADHD in autistic children (32.8%). Our rate of autism in ADHD is lower than the 13.9% or

TABLE 2 Sociodemographic characteristics, clinical and cognitive profile, and service use of the diagnosis groups.

		Autism + ADHD[a] $n = 19$	Autism[b] $n = 35$	ADHD[c] $n = 158$	No NDD[d] $n = 375$	p	ab	ac	ad
Sociodemographic characteristics, *n* (%)									
Sex	Boys	16 (84.21)	28 (80.00)	108 (68.35)	215 (57.33)	**0.002**	0.704	0.154	**0.020**
	Girls	3 (15.79)	7 (20.00)	50 (31.65)	160 (42.67)				
Age	Preschool-age children	7 (36.84)	22 (62.86)	32 (20.25)	160 (42.67)	**<0.001**	0.067	0.099	0.616
	School-age children	12 (63.16)	13 (37.14)	126 (79.75)	215 (57.33)				
SES	Low	2 (10.53)	8 (22.86)	40 (25.32)	49 (13.07)	**<0.001**	0.883	0.305	0.999
	Medium	12 (63.13)	20 (57.14)	99 (62.66)	240 (64.00)				
	High	5 (26.32)	7 (20.00)	19 (12.03)	86 (22.93)				
Ethnicity	Autochthonous	16 (84.21)	28 (80.00)	136 (86.08)	316 (84.27)	0.836	-	-	-
	Nonautochthonous	3 (15.79)	7 (20.00)	22 (13.92)	59 (15.73)				
Clinical severity and symptom's profile									
Autism: ADOS-2 severity, *M* (SD)	Social communication	5.00 (2.03)	5.46 (1.93)	1.65 (1.14)	1.82 (1.30)	**<0.001**	0.964	**<0.001**	**<0.001**
	Stereotyped behavior	5.89 (2.35)	5.14 (2.26)	1.33 (1.16)	1.32 (1.07)	**<0.001**	0.841	**<0.001**	**<0.001**
	Total ASD severity	5.32 (2.06)	5.37 (1.82)	1.24 (0.73)	1.32 (0.92)	**<0.001**	0.999	**<0.001**	**<0.001**
Autism: ADI-R severity, *M* (SD)	Social reciprocity	14.42 (7.01)	13.37 (5.78)	2.82 (2.94)	1.89 (2.07)	**<0.001**	0.995	**<0.001**	**<0.001**
	Communication	12.16 (4.15)	10.23 (3.40)	2.52 (2.15)	1.44 (1.53)	**<0.001**	0.442	**<0.001**	**<0.001**
	Stereotyped behavior	4.42 (2.82)	4.17 (2.24)	0.89 (1.05)	0.66 (0.94)	**<0.001**	0.999	**<0.001**	**<0.001**
ADHD: K-SADS Severity, *M* (SD)	Inattentive	21.68 (4.78)	12.31 (4.22)	21.68 (3.83)	11.14 (2.79)	**<0.001**	**<0.001**	0.999	**<0.001**
	Hyperactive–impulsive	20.89 (4.90)	11.83 (3.52)	19.08 (5.50)	11.27 (3.18)	**<0.001**	**<0.001**	0.613	**<0.001**
	Total ADHD severity	46.58 (6.54)	27.17 (7.30)	44.75 (6.10)	25.12 (5.97)	**<0.001**	**<0.001**	0.835	**<0.001**
ADHD: Presentation, *n* (%)	Inattentive	3 (15.79)	-	57 (36.08)	-	0.094	-	-	-
	Hyperactive–impulsive	5 (26.32)	-	19 (12.03)	-		-	-	-
	Combined	11 (57.89)	-	82 (51.90)	-		-	-	-
Cognitive and emotional profile									
Wechsler intelligence scale, *M* (SD)	VCI	93.65 (19.99)	81.08 (21.33)	98.57 (13.61)	103.55 (13.25)	**<0.001**	0.308	0.914	0.308
	PRI	102.18 (13.37)	92.81 (23.41)	99.44 (13.45)	107.25 (13.83)	**<0.001**	0.480	0.967	0.608
	WMI	85.65 (19.04)	90.48 (15.35)	89.92 (12.83)	101.82 (13.21)	**<0.001**	0.949	0.943	**0.018**
	PSI	94.71 (19.68)	81.16 (14.76)	97.19 (13.71)	101.98 (12.07)	**<0.001**	0.128	0.997	0.621
	FISQ	93.06 (20.29)	83.92 (19.22)	94.52 (13.07)	104.49 (12.67)	**<0.001**	0.630	0.999	0.190
CBCL-dysregulation profile, *M* (SD)		200.06 (22.20)	186.15 (19.93)	192.19 (22.29)	165.22 (15.20)	**<0.001**	0.341	0.825	**<0.001**
Service use characteristics, *n* (%)									
Previous diagnosis		3 (15.79)*	22 (62.86)	54 (34.18)	-	**<0.001**	**0.001**	0.105	-
Psychological therapy		14 (73.68)	22 (62.86)	58 (36.71)	32 (8.53)	**<0.001**	0.420	**0.002**	**0.001**
Educational support		13 (68.42)	21 (60.00)	41 (25.95)	19 (5.07)	**<0.001**	0.541	**0.001**	**0.001**
Speech therapy treatment		9 (47.37)	17 (48.57)	27 (17.09)	48 (12.80)	**<0.001**	0.933	**0.002**	**0.001**
Medication (stimulant or/and antipsychotic)		3 (15.79)	1 (2.86)	34 (21.52)	0 (0.00)	**<0.001**	0.083	0.562	**0.001**

Abbreviations: ADHD, attention deficit/hyperactivity disorder; ADI-R, Autism Diagnostic Interview Revised; ADOS-2, Autism Diagnostic Observation Schedule, Second Edition; CBCL, child behavior checklist; NDD, neurodevelopmental disorders.

*Both disorders diagnosed (15.79%), only autism (52.63%) and only ADHD (15.79%). Significant differences in bold.

29.4% found by Casseus et al. (2023) and Elwin et al. (2020) in U.S. and Swedish children and adolescents, respectively. As for age differences, the rate of comorbidity was higher in preschoolers (15.6%) compared with school-age children (8.1%) in contrast with the age ratio found in the presence of ADHD in autism. This could be explained by the fact that generally autism is diagnosed earlier than ADHD. The diagnosis of ADHD in preschoolers is typically less frequent and becomes more evident with greater severity of traits (hyperactivity–impulsivity characteristics are the most frequent at this age). In contrast, the prevalence of ADHD in school-age children is higher and is mainly related to an increase in the inattentive and combined presentations (Canals et al., 2021; Danielson et al., 2018). Thus, older children with autism may be more likely to be diagnosed with ADHD than younger children, since the latter are less likely to receive a diagnosis.

It is worth noting the ADHD comorbidity rate in children with subthreshold autism (31.4%) and of subthreshold autism in children with ADHD (8.3%) were alike to those with full diagnosis, supporting similarities in comorbidity patterns within the heterogeneity in the clinical spectrum.

The agreement between parents and teachers reports on the likelihood of autism and/or ADHD was relatively low, but both informed similar prevalence rates (3.17% and 3.19%, respectively). The presence of ADHD traits in children with autism and subthreshold autism was high in teacher reports and very high in parents' reports, which may be important in detecting the likelihood of this comorbidity. However, the high rate of ADHD traits reported by the parents of school-age children suggests that they may overestimate these characteristics in the family environment because probably they detect milder profiles and/or with cooccurrence of externalizing problems, as has been found in other studies (Garcia-Rosales et al., 2021; Takeda et al., 2016). With this exception, our rates are within the range of 2.6%–70.6% found by Eaton et al. (2023), who reported different rates of ADHD traits depending on to the informant and questionnaire used. Nevertheless, although no differences were observed between parent and teacher reports in the cooccurrence of autistic traits in children with ADHD and subthreshold ADHD is important to highlight that teachers detect more autistic traits already at preschool age in children diagnosed with ADHD. Overall, the cooccurrence of symptoms in subthreshold and diagnosis levels of autism and ADHD support the claim of Deserno et al. (2023) that autism and ADHD cannot be unequivocally characterized as two separate clinical entities or opposite ends of the spectrum.

Regarding sociodemographic factors, in comparison with ADHD or autism alone, the autism and ADHD comorbidity did not present significant differences in the sex ratio. In all clinical groups we found more males, with the highest ratio in the comorbid group (84.2%). Several authors have found a higher significantly percentage of males in the autism and ADHD comorbidity group than in diagnoses alone (Casseus, 2022; Elwin et al., 2020; Zablotsky et al., 2020). As for age, we found a higher ratio of school-age children versus preschool-age children in the ADHD alone and comorbid groups, conversely as the tendency found in autism alone. As mentioned above, the confirmation of the diagnosis of ADHD does not usually occur at preschool age, rather later. In addition, Casseus (2022) and Harkins et al. (2022) reported that older age was associated with a higher likelihood for autism and ADHD comorbidity compared with autism alone, but no differences in age were found compared with ADHD (Harkins et al., 2022). Furthermore, no differences were found between the comorbid group and those with autism or ADHD alone in terms of socioeconomic status and ethnicity, in contrast to data from Casseus (2022). Nevertheless, our sample can be biased because in the first phase of the study the families' participation was significantly higher in autochthonous population (Canals et al., 2021).

Following the second aim of the study, we have not found significant differences in the intensity of autism and/or ADHD traits comparing comorbidity group with those with only autism or ADHD. Even though the size of our sample is small, these data are consistent with those of Harkins et al. (2022), who demonstrated no significant differences between the comorbid group and the autism alone group, but it contrasts with Factor et al. (2017) and Rao and Landa (2014). We agree with Harkins et al. (2022) that characteristics reported by parents (SRS-2, or ADI-R in our case) may also include differences in social skills related to ADHD or inhibited personality traits, which would explain the presence of some of these traits in the ADHD group and somewhat higher scores in the comorbid group. Concerning on the intensity of ADHD traits, no significant differences were found between the comorbidity group and the ADHD alone group. These data contrast with those of Zablotsky et al. (2020), who found more intense total and H–I traits in children with ADHD and autism comorbidity in larger samples. Consequently, we also found slightly more cases of H–I and combined presentations as Rau et al. (2020).

In terms of cognitive functioning, we did not find significant differences Wechsler indexes or total intelligence quotient (IQ) between children in the comorbid group and those in the autism or ADHD alone groups. In a clinical sample, Harkins et al. (2022) found significantly lower IQ in the autism group than in both ADHD and comorbidity groups. The difference may be in that our participants come from mainstream schools and their IQs were higher than those reported by Harkins et al. (2022) for the three groups. Instead, in the current study, a trend toward higher scores on all scales of the Wechsler scales, with exception of working memory, was observed in the comorbid group when comparing with autism alone. The working memory index scores in the comorbid group were lower than in autism or ADHD alone, which could suggest more challenges in executive functioning. Also, without reaching significant differences probably due to

the small size of this sample, the emotional DP showed a slightly higher score in the comorbid compared with the other clinical groups. Other authors have found that impaired emotional self-regulation is more prevalent in youth with ADHD or/and autism (Bierens et al., 2023; Ventura et al., 2022) and that the shared association of these characteristics could predict social challenges (Jaisle et al., 2023).

In regard to the rate of prior diagnosis and service use, it is notable that a small number of children with comorbid diagnosis had received both diagnoses beforehand (15.8%). This situation may worsen the course and prognosis, as adequate treatment cannot be provided if the condition has not been detected. In clinical and school settings are necessary to carry out both screening and early diagnosis of bidirectional comorbidity between autism and ADHD, considering that early interventions may prevent the greatest likelihood of negative or challenging outcomes (Casseus, 2022; Casseus et al., 2023; Houghton et al., 2017; Manohar et al., 2018; Rong et al., 2021). Although only a small proportion of children with comorbidity had received both diagnoses, around 70% were receiving psychological and educational interventions, which support the greatest functional complexity of this condition. The frequencies of intervention were somewhat higher than in autism and significantly higher than in ADHD. These data are in line with those of Zablotsky et al. (2020), where both in-school and out-of-school treatment needs were significantly higher for ADHD and autism than for children with ADHD, but not for autism. They also reported no differences in treatment medication.

While this study had some limitations, also demonstrate strengths. Strengths include assessment of the autism and ADHD comorbidity at several levels of clinical intensity in a nonclinical sample, collection of symptoms from both parents and teachers, comprehensive individual assessment of parents and children and DSM-5 diagnoses. As a limitation, although our sample is representative of schools in an entire Spanish region, it is not a national study, and this has limited the sample size. Since we started from a sample of 6894 participants, the individual diagnostic phase was conducted with participants with increased likelihood for autism/ADHD and the comparison group included 781 participants. Thus, only a small number of children with autism and ADHD comorbid diagnoses were accessible to describe clinical and sociodemographic correlates, potentially limiting the statistical power of these analyses.

CONCLUSION

This study contributes to the literature by estimating the prevalence of autism and ADHD comorbidity in a community-based population of Spanish children in two age groups, preschool and school-age. We provide the estimated prevalence of comorbid diagnosis (0.51%), with significant differences in sex (0.16% in girls and 0.89% in boys) but not in age distributions, and the prevalence of cooccurrent symptoms by teachers (3.17%) and parents (3.19%). We found remarkable comorbidity of ADHD in children with ASD (32.8%) and subthreshold ASD (31.4%), whereas lower comorbidity of ASD (9.84%) and subthreshold ASD (8.29%) in children with ADHD. The data of this study have practical implications. The high rate of identification of comorbid profiles from parent or teacher reports suggests that combined data from both informants should be considered from an early age for adequate early detection and more accurate diagnosis of autism and ADHD comorbidity. Consequently, this will allow the implementation of specific socio-educational and clinical interventions to improve the prognosis and quality of life for these children. A further follow-up study would be interesting to better understand the evolutionary course not only of the autism and/or ADHD diagnoses but also of the cooccurrence of autism + ADHD in subthreshold diagnoses and those with symptoms reported by different informants.

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DATA AVAILABILITY STATEMENT

Research data are not shared.

ETHICS STATEMENT

Ethics Committee at the Sant Joan University Hospital (13-10-31/10proj5).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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