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RESEARCH ARTICLE

Racial and ethnic disparities in the co-occurrence of intellectual disability and autism: Impact of incorporating measures of adaptive functioning

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Abstract

Intellectual disability (ID) commonly co-occurs in children with autism. Although diagnostic criteria for ID require impairments in both cognitive and adaptive functioning, most population-based estimates of the frequency of co-occurring ID in children with autism—including studies of racial and ethnic disparities in co-occurring autism and ID—base the definition of ID solely on cognitive scores. The goal of this analysis was to examine the effect of including both cognitive and adaptive behavior criteria on estimates of co-occurring ID in a well-characterized sample of 2- to 5-year-old children with autism. Participants included 3264 children with research or community diagnoses of autism enrolled in the population-based Study to Explore Early Development (SEED) phases 1–3. Based only on Mullen Scales of Early Learning (MSEL) composite cognitive scores, 62.9% (95% confidence interval [CI]: 61.1, 64.7%) of children with autism were estimated to have co-occurring ID. After incorporating Vineland Adaptive Behavior Scales, Second Edition (VABS-II) composite or domains criteria, co-occurring ID estimates were reduced to 38.0% (95% CI: 36.2, 39.8%) and 45.0% (95% CI: 43.1, 46.9%), respectively. The increased odds of meeting ID criteria observed for non-Hispanic (NH) Black and Hispanic children relative to NH White children when only MSEL criteria were used were substantially reduced, though not eliminated, after incorporating VABS-II criteria and adjusting for selected socioeconomic variables. This study provides evidence for the importance of considering adaptive behavior as well as socioeconomic disadvantage when describing racial and ethnic disparities in co-occurring ID in epidemiologic studies of autism.

Lay Summary

Many studies of children with autism classify children as having intellectual disability (ID) if they have very low scores on intelligence tests, without considering their adaptive functioning, which are the skills needed for activities of daily living, social interaction, and communication. However, impairments in both intellectual and adaptive functioning are required for an ID diagnosis. We found that when both IQ and adaptive functioning are used to define ID, the percent of children with autism classified as having co-occurring ID is reduced from 63% to 38%, and racial and ethnic differences are reduced. This analysis demonstrated the importance of considering adaptive functioning when describing the frequency of ID in children with autism, including for the accurate and equitable characterization of diverse populations.

KEYWORDS

adaptive behavior, adaptive functioning, cognitive ability, cognitive development, co-occurring conditions, intellectual disability, IQ, Mullen scales of early learning, Vineland adaptive behavior scales

INTRODUCTION

Autism spectrum disorder (ASD) and intellectual disability (ID) are two distinct but commonly co-occurring forms of neurodevelopmental disability (American Psychiatric Association, 2013). According to recent epidemiologic data from the Centers for Disease Control and Prevention's (CDC) Autism and Developmental Disabilities Monitoring (ADDM) Network, the frequency of co-occurring ID in children with autism was estimated to be 48.5% at age 4 years, 37.9% at age 8 years, and 36.6% at age 16 years (Hughes et al., 2023; Maenner et al., 2023; Shaw et al., 2023). The ADDM Network and other epidemiologic studies of ASD in the United States (US) have consistently found that the proportion of children with co-occurring ID varies across racial and ethnic groups and is significantly higher among non-Hispanic (NH) Black and, less frequently, among Hispanic children than among NH White children with autism (ADDM Network Surveillance Year 2010 Principal Investigators, 2014; Baio et al., 2018; Christensen et al., 2018; Constantino et al., 2020; Hewitt et al., 2016; Maenner et al., 2020; Maenner et al., 2023; Shaw et al., 2023; Van Naarden Braun et al., 2015). These disparities in ID prevalence mirror those seen in children without autism (Patrick et al., 2021; Van Naarden Braun et al., 2015). The increased ID prevalence in minoritized populations occurs in the context of historical racism and accompanying socioeconomic disadvantage, which is a leading risk factor for ID globally and disproportionately affects Black and Hispanic children in the US (Beech et al., 2021; Durkin & Yeargin-Allsopp, 2018; Emerson, 2007; Patrick et al., 2021). The elevated prevalence of ID in minoritized groups may also be related to racial, linguistic, and cultural biases in the diagnostic process and cognitive testing instruments (Dahl et al., 2023; Fisher et al., 2023; Gonthier, 2022; Guthrie et al., 2019; Kalb et al., 2022; Lozano-Ruiz et al., 2021; Mandell & Novak, 2005) as well as stigma surrounding ID diagnoses (Fisher et al., 2023; Mitter et al., 2019), and disparities in early identification and referral for services (Guthrie et al., 2019).

Observed racial and ethnic disparities in the frequency of co-occurring ID among children with ASD in population-based data could also be due in part to how ID is defined in epidemiologic studies of ASD. Whereas widely accepted definitions of ID require significant deficits in both intelligence (e.g., intelligence quotient [IQ] scores) and adaptive behavior scores (American Association on Intellectual and Developmental Disabilities, n.d.; American Psychiatric Association, 2013), most population-based epidemiologic estimates of co-occurring ID in children with autism use the criterion of an IQ score two or more standard deviations (SD) below the population mean without considering adaptive scores (CDC, 2023; Fombonne, 2003; Fombonne, 2009; Hughes et al., 2023; Maenner et al., 2021; Zeidan et al., 2022), often because adaptive test scores are less likely to be available for review in children's health and education records than IQ scores. This practice is applied not only to school-aged children (e.g., Hughes et al., 2023; Maenner et al., 2021), but also to epidemiologic studies of preschool-aged children with autism (e.g., Shaw et al., 2023), whose cognitive scores often improve over time, especially after participation in intensive early intervention programs and therapies (Dawson et al., 2010).

Early studies of the impact of considering adaptive behavior in the definition of ID (Heber, 1961; Leonard & Wen, 2002; Reschly & Ward, 1991; Witt & Martens, 1984) showed that the addition of the adaptive behavior score criterion lowered the number of children meeting

ID criteria by as much as 80% (Childs, 1982) and narrowed disparities in ID prevalence between different racial and ethnic groups (Fisher, 1977; Heflinger et al., 1987; Mascari & Forgnone, 1982; Scott, 1979). Conversely, a more recent population-based study examining the effects of incorporating an adaptive behavior criterion for ID surveillance concluded that the impact on estimated ID prevalence was small and that using IQ alone was sufficient for measuring ID prevalence in population studies (Obi et al., 2011). These previous studies were not limited to and may not have included children with autism. Considering adaptive functioning may be especially important for identifying ID in children with autism because of the well-documented gaps between cognitive and adaptive functioning in this population, which have been reported in children as young as preschool and increase with age in cross-sectional studies (Alvares et al., 2020; Duncan & Bishop, 2015; Kanne et al., 2011; Matthews et al., 2015; McQuaid et al., 2021; Pathak et al., 2019; Perry et al., 2009; Tillmann et al., 2019). Some children with cognitive scores below the cutoff for ID may have no significant adaptive delays or impairments and thus not meet diagnostic criteria for ID (Furnier et al., 2023; Pathak et al., 2019). Additionally, studies looking at cognitive testing in young children have found that testability can be problematic in children with autism, resulting in underestimation of their cognitive ability by some commonly used cognitive tests, such as the Mullen Scales of Early Learning (MSEL) (Akshoomoff, 2006; Courchesne et al., 2019; Nader et al., 2016). Thus, the salience of the adaptive behavior criterion for ID classification may emerge early.

The purpose of this study was to describe the impact of using both IQ and adaptive behavior scores versus IQ scores alone in estimating the prevalence of co-occurring ID in an epidemiologic study of young children with autism. Although we recognize in clinical practice ID is not typically diagnosed in preschool children due to the instability of cognitive scores, our goal was to take advantage of comprehensive data available from a large population-based sample of preschool children to evaluate the impact of including both IQ and adaptive scores versus IQ scores alone in describing the percentage with co-occurring ID. We hypothesized that (1) defining ID based on having both cognitive (IQ) and adaptive behavior scores two or more SDs below the mean will result in a substantial reduction of estimated prevalence of co-occurring ID compared to estimates based only on cognitive scores below that threshold; and (2) incorporating an adaptive behavior criterion to classify ID will result in a greater reduction in estimated prevalence of co-occurring ID for NH Black and Hispanic children with autism than for NH White children with autism, reducing racial and ethnic disparity in the estimated co-occurrence of ID among children with autism.

METHODS

Study sample

Our study sample included 3264 children aged2–5 years with a research or community diagnosis of ASD from phases 1–3 of the Study to Explore Early Development (SEED), a large case–control study. Children with and without prior ASD diagnoses were identified through health, education, early intervention, and other service programs at study sites in eight states (California, Colorado, Georgia, Maryland, Missouri, North Carolina, Pennsylvania, and Wisconsin). Eligible children were born and continued to reside when first contacted by SEED study staff in the geographic catchment area between September 2003–August 2006 (phase 1), January 2008–December 2011 (phase 2), or March 2017–March 2020 (phase 3), and had lived with a caregiver since the age of 6 months who was at least 18 years of age and fluent in English or Spanish. The study was approved by Institutional Review Boards at the CDC and every SEED site. Written informed consent was obtained from every participating family.

Caregivers completed the Childhood Behavior Checklist (CBCL) (Achenbach & Rescorla, 2000). Children with a prior ASD diagnosis or a Social Communication Questionnaire (Rutter, Bailey, & Lord, 2003b; Rutter, Le Couteur, & Lord, 2003a) score ≥11 were administered the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999; Lord et al., 2012), and their caregivers completed the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994; Rutter, Le Couteur, & Lord, 2003a; Rutter, Bailey, & Lord, 2003b) as well as Vineland Adaptive Behavior Scales, Second Edition (VABS-II; Sparrow et al., 2005). The (MSEL; Mullen, 1995) was administered to participating children at an in-person clinical assessment. Final ASD classification was based on results of the ADOS or ADOS, 2nd Edition and the ADI-R, and for children with an early learning age equivalent less than 24 months, clinical judgment (Schendel et al., 2012; Wiggins et al., 2015).

Inclusion criteria for this analysis were meeting SEED ASD criteria or having a previous ASD diagnosis, and for regression analysis, having race and ethnicity information (Figure 1). Distributions of key test scores and model covariates in our sample, overall and broken down by child's race and ethnicity, are shown in Table 1. Our sample was 80% male with a mean age at in-person assessment of 4.6 (range: 2.4–5.8) years (Table 1). The majority of children were from households with a current income above the federal poverty level (76%), and a plurality had mothers with a college or advanced degree (45%). Socioeconomic indicators varied by race and ethnicity (Tables 1).

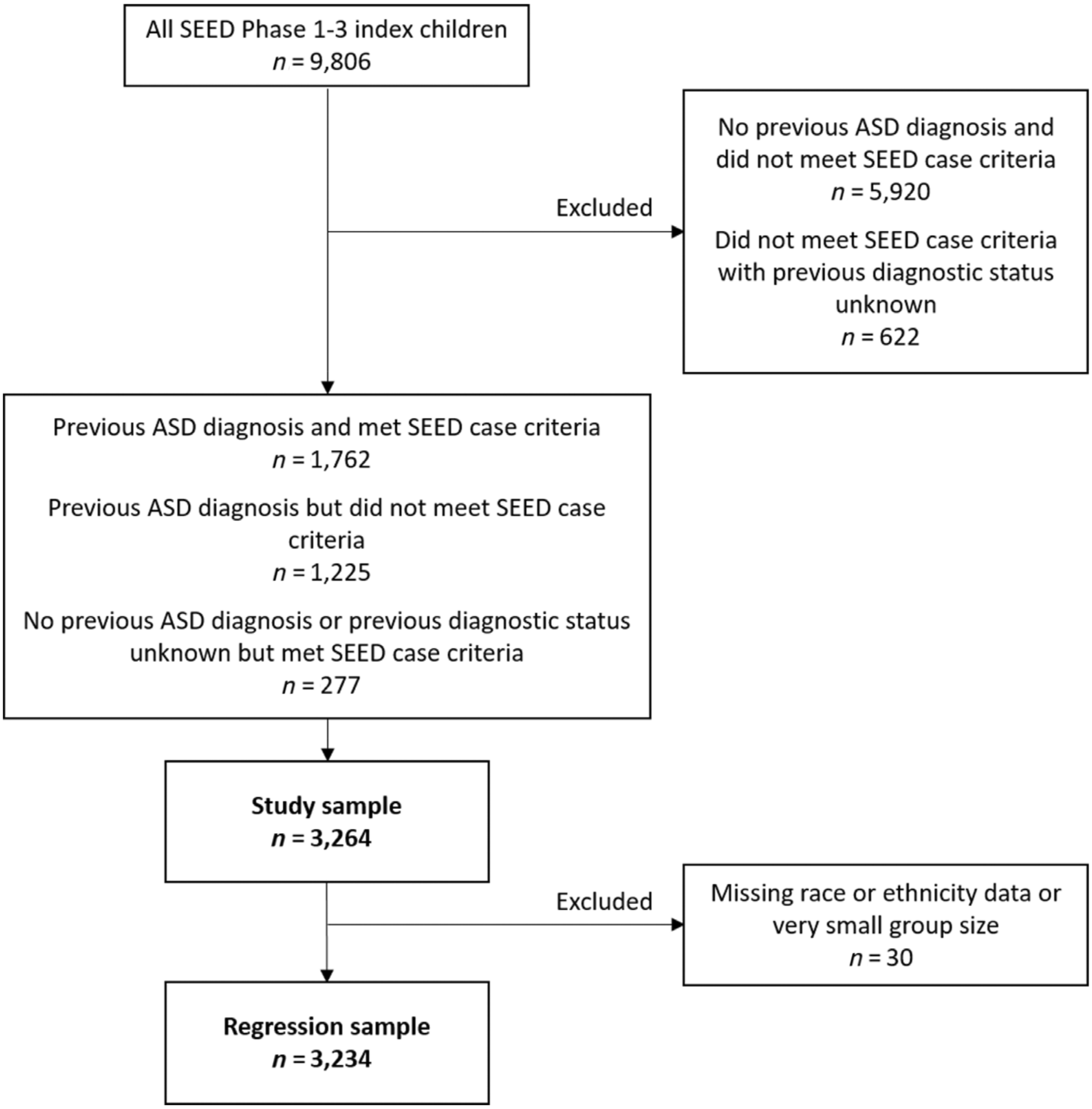

FIGURE 1 Selection of the final study sample, Study to Explore Early Development (SEED) Phases 1–3. ASD, autism spectrum disorder.

Child's race and ethnicity

Maternal and paternal self-reported race and ethnicity were obtained from a maternal interview or, if not available from the interview, linked birth records, and children's race and ethnicity were derived from parental values. Categories included Hispanic, NH White, NH Black or African American, NH Asian or Pacific Islander ("HHS implementation guidance", 2011). Children with parents with different racial and ethnic identities or whose parents themselves indicated they were multiracial were included in a NH multiracial category. If either parent self-reported Hispanic ethnicity, the child was classified as Hispanic. If both parents' racial classifications matched, the child was assigned the same classification. Finally, if one parent was missing a race and ethnicity classification, the child's race was classified based on the non-missing parent's classification.

Our final study sample was 1413 (43%) NH White, 729 (22%) NH Black, 567 (17%) Hispanic, 359 (11%) NH multiracial, and 166 (5%) NH Asian or Pacific Islander children. NH American Indian or Native Alaskan children were not included in regression analyses due to very small sample size, but they were included in the overall group in all other analyses, as were children who had no race and ethnicity recorded.

Estimates of intellectual disability

Because of the young age of our sample, we used cognitive ability as measured by the MSEL (Mullen, 1995), a

TABLE 1 Selected child, maternal, and sociodemographic characteristics of children with autism spectrum disorder (ASD) in the Study to Explore Early Development (SEED) phases 1–3, by child's race & ethnicity; *n* (column %) given unless otherwise specified.

		Child's race & ethnicity				
Child and family characteristics	**Overall**	**Non-Hispanic White**	**Non-Hispanic Black**	**Hispanic**	**Non-Hispanic Asian or Pacific Islander**	**Non-Hispanic multiracial**
Total (row percent)	**3264**	**1413 (43)**	**729 (22)**	**567 (17)**	**166 (5)**	**359 (11)**
Child's age at assessment (years)						
Mean (standard deviation)	4.6 (0.7)	4.5 (0.7)	4.8 (0.7)	4.6 (0.7)	4.8 (0.7)	4.6 (0.7)
Range	2.4–5.8	2.5–5.8	2.6–5.8	2.7–5.7	3.0–5.7	2.4–5.7
Missing	820 (25)	345 (24)	190 (26)	126 (22)	47 (28)	86 (24)
Child's sex						
Male	2605 (80)	1129 (80)	587 (81)	439 (77)	130 (78)	294 (82)
Female	659 (20)	284 (20)	142 (19)	128 (23)	36 (22)	65 (18)
Met SEED ASD criteria						
Yes	2039 (62)	919 (65)	433 (59)	355 (63)	104 (63)	224 (62)
No	1225 (38)	494 (35)	296 (41)	212 (37)	62 (37)	135 (38)
Previous ASD diagnosis						
Yes	2987 (92)	1280 (91)	665 (91)	523 (92)	155 (93)	335 (93)
No	271 (8)	130 (9)	62 (9)	43 (8)	11 (7)	24 (7)
Missing	6 (0)	3 (0)	2 (0)	1 (0)	0 (0)	0 (0)
Child's birth order						
First born	1424 (44)	679 (48)	247 (34)	237 (42)	89 (54)	162 (45)
Second born or later	1629 (50)	678 (58)	400 (55)	302 (53)	70 (42)	169 (47)
Missing	211 (6)	56 (4)	82 (11)	28 (5)	7 (4)	28 (8)
Autism diagnostic observation schedule calibrated severity score						
<4	207 (6)	69 (5)	57 (8)	51 (9)	**	26 (7)
4–6	830 (25)	367 (26)	184 (25)	147 (26)	**	103 (29)
7–10	1370 (42)	619 (44)	288 (40)	236 (42)	84 (51)	139 (39)
Missing	857 (26)	358 (25)	200 (27)	133 (23)	49 (30)	91 (25)
Childhood behavior checklist total problems *T*-score						
<65	1440 (44)	644 (46)	323 (44)	249 (44)	79 (48)	143 (40)
≥65	1162 (36)	500 (35)	253 (35)	218 (38)	46 (28)	142 (40)
Missing	662 (20)	269 (19)	153 (21)	100 (18)	41 (25)	74 (21)
Current household income, relative to federal poverty threshold						
≤100%	342 (10)	59 (4)	151 (21)	91 (16)	**	37 (10)
101%–200%	601 (18)	175 (12)	191 (26)	138 (24)	**	79 (22)
201%–300%	469 (14)	208 (15)	108 (15)	84 (15)	16 (10)	52 (14)
301%–399%	426 (13)	246 (17)	64 (9)	63 (11)	15 (9)	38 (11)
≥400%	979 (30)	572 (40)	95 (13)	118 (21)	90 (54)	104 (29)
Missing	447 (14)	153 (11)	120 (16)	73 (13)	26 (16)	49 (14)
Child health insurance[a]						
Private or dual	1095 (34)	597 (42)	152 (21)	159 (28)	69 (42)	118 (33)
Public only	717 (22)	175 (12)	276 (38)	171 (30)	**	85 (24)
Missing	1452 (44)	641 (45)	301 (41)	237 (42)	**	156 (43)
Maternal education						
High school graduate or less	519 (16)	136 (10)	153 (21)	173 (31)	**	47 (13)
Some college	964 (30)	364 (26)	256 (35)	197 (35)	18 (11)	127 (35)
College graduate or advanced degree	1458 (45)	788 (56)	233 (32)	159 (28)	124 (75)	154 (43)
Missing	323 (10)	125 (9)	87 (12)	38 (7)	**	31 (9)

TABLE 1 (Continued)

Child and family characteristics	Overall	Child's race & ethnicity: Non-Hispanic White	Non-Hispanic Black	Hispanic	Non-Hispanic Asian or Pacific Islander	Non-Hispanic multiracial
Total (row percent)	**3264**	**1413 (43)**	**729 (22)**	**567 (17)**	**166 (5)**	**359 (11)**
Paternal education						
High school graduate or less	858 (26)	253 (18)	252 (35)	243 (43)	12 (7)	98 (27)
Some college	713 (22)	308 (22)	171 (23)	121 (21)	13 (8)	98 (27)
College graduate or advanced degree	1268 (39)	709 (50)	167 (23)	146 (26)	123 (74)	123 (34)
Missing	425 (13)	143 (10)	139 (19)	57 (10)	18 (11)	40 (11)
Maternal age at enrollment (years)						
Mean (standard deviation)	35.0 (5.8)	35.8 (5.3)	34.1 (6.4)	33.8 (6.0)	35.9 (4.7)	35.1 (6.1)
Range	18.0–52.0	18.0–52.0	19.0–51.0	20.0–52.0	22.0–48.0	21.0–52.0
Missing	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Primary language spoken in the home						
English	2631 (81)	1263 (89)	616 (84)	357 (63)	72 (43)	320 (89)
Other	314 (10)	26 (2)	29 (4)	171 (30)	79 (48)	**
Missing	319 (10)	124 (9)	84 (12)	39 (7)	15 (9)	**
Mother born outside the United States						
Yes	569 (17)	82 (6)	85 (12)	217 (38)	129 (78)	56 (16)
No	2376 (73)	1208 (85)	558 (77)	312 (55)	22 (13)	273 (76)
Missing	319 (10)	123 (9)	86 (12)	38 (7)	15 (9)	30 (8)
Study site						
California	389 (12)	99 (7)	19 (3)	132 (23)	77 (46)	59 (16)
Colorado	499 (15)	250 (18)	**	182 (32)	**	53 (15)
Georgia	662 (20)	171 (12)	297 (41)	82 (14)	29 (17)	65 (18)
Maryland	502 (15)	246 (17)	140 (19)	38 (7)	17 (10)	55 (15)
Missouri	172 (5)	102 (7)	29 (4)	14 (2)	**	27 (8)
North Carolina	510 (16)	281 (20)	118 (16)	50 (9)	14 (8)	45 (13)
Pennsylvania	394 (12)	177 (13)	113 (16)	52 (9)	17 (10)	34 (9)
Wisconsin	136 (4)	87 (6)	**	17 (3)	**	21 (6)
Mullen Scales of Early Learning						
Early learning composite						
Mean (standard deviation)	67.6 (20.0)	71.8 (21.4)	61.8 (16.3)	64.8 (18.6)	66.5 (19.9)	67.8 (19.5)
Range	20.0–132.0	49.0–132.0	49.0–117.0	49.0–132.0	49.0–130.0	49.0–121.0
Missing	884 (27)	382 (27)	199 (27)	133 (23)	49 (30)	95 (26)
Visual reception *T*-score						
Mean (standard deviation)	35.3 (15.4)	38.1 (16.1)	30.6 (13.2)	34.0 (14.7)	34.7 (15.5)	35.8 (15.4)
Range	20.0–80.0	20.0–80.0	20.0–79.0	20.0–79.0	20.0–80.0	20.0–74.0
Missing	829 (25)	348 (25)	192 (26)	127 (22)	48 (29)	88 (25)
Vineland Adaptive Behavior Scales, Second Edition						
Adaptive behavior composite						
Mean (standard deviation)	73.8 (13.4)	75.4 (13.5)	71.9 (13.0)	72.5 (13.8)	73.2 (13.3)	73.3 (12.5)
Range	38.0–122.0	39.0–114.0	38.0–108.0	38.0–114.0	46.0–108.0	44.0–122.0
Missing	831 (25)	341 (24)	192 (26)	138 (24)	46 (28)	88 (25)
Communication						
Mean (standard deviation)	77.8 (17.6)	81.2 (17.6)	73.8 (17.1)	74.3 (17.4)	79.2 (17.4)	77.6 (16.4)
Range	34.0–131.0	36.0–131.0	36.0–116.0	34.0–112.0	40.0–118.0	40.0–118.0
Missing	809 (25)	333 (24)	189 (26)	130 (23)	45 (27)	86 (24)

(Continues)

TABLE 1 (Continued)

Child and family characteristics	Overall	Child's race & ethnicity: Non-Hispanic White	Non-Hispanic Black	Hispanic	Non-Hispanic Asian or Pacific Islander	Non-Hispanic multiracial
Total (row percent)	**3264**	**1413 (43)**	**729 (22)**	**567 (17)**	**166 (5)**	**359 (11)**
Socialization						
Mean (standard deviation)	73.3 (12.9)	74.6 (13.1)	72.5 (12.2)	72.6 (13.2)	69.4 (13.9)	72.8 (12.1)
Range	22.0–132.0	22.0–112.0	48.0–108.0	44.0–114.0	44.0–112.0	48.0–132.0
Missing	811 (25)	335 (24)	189 (26)	130 (23)	45 (27)	86 (24)
Daily living skills						
Mean (standard deviation)	75.3 (15.0)	76.5 (15.2)	73.9 (14.3)	74.9 (15.5)	74.5 (15.0)	74.9 (14.3)
Range	34.0–121.0	38.0–121.0	40.0–121.0	36.0–119.0	41.0–105.0	34.0–111.0
Missing	809 (25)	333 (24)	189 (26)	130 (23)	45 (27)	86 (24)

Note: Small cell sizes were suppressed to preserve participant anonymity.
[a]Variable was not available for SEED Phase 1.

standardized assessment that measures early learning in young children up to 68 months of age, to represent IQ for alternative ID prevalence estimates in our study. The MSEL produces an Early Learning Composite (ELC) score (mean 100, SD 15) as well as visual reception (VR), fine motor, expressive language, and receptive language subscale *T*-scores (mean 50, SD 10).

Adaptive ability was measured using the VABS-II, a semi-structured interview administered by a clinician to caregivers to gauge a child's current behavior. Domains included in the VABS-II are communication, socialization, daily living skills, and motor skills. The adaptive behavior composite is derived from the domain scores and represents overall adaptive ability. For the composite and each domain score, we used standard scores (mean 100, SD 15).

We used two approaches to characterize cognitive functioning and describe co-occurring ID (Table 2): one based on cognitive scores alone, as is frequently done in epidemiologic studies of autism, and one based on both cognitive and adaptive scores, in accordance with ID diagnostic criteria. Separate definitions were based on either the MSEL ELC or the VR score as a proxy of nonverbal cognitive ability. Use of VR scores may avoid underestimating communication abilities by accounting for temporary language delays, which might be present in preschool-aged children but eventually resolve with intervention or maturation (Ellis Weismer et al., 2021); for this reason, for our VR-based estimates of cognitive functioning, we focused on the VABS-II daily living skills and socialization domains. For the adaptive behavior criterion, we incorporated measures of the conceptual, social, and practical adaptive skill domains described in the AAIDD and Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) definitions of ID through use of the VABS-II composite, communication, daily living skills, and socialization scores (American Association on Intellectual and Developmental Disabilities, n.d.; American Psychiatric Association, 2013). Because the DSM-5 definition of ID requires impairments in only one

TABLE 2 Definitions of intellectual disability, including formal diagnostic definitions from the American Association of Intellectual and Developmental Disabilities (AAIDD) and the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) and present study-specific definitions incorporating the Mullen Scales of Early Learning (MSEL) and Vineland Adaptive Behavior Scales, Second Edition (VABS-II).

Source	Definition
AAIDD[a]	"Intellectual disability is a condition characterized by significant limitations in both intellectual functioning and adaptive behavior that originates before the age of 22."
DSM-5[b]	"Intellectual disability…is a disorder with onset during the developmental period that includes both intellectual and adaptive functioning deficits in conceptual, social, and practical domains."

Present Study	Cognitive Criterion	Adaptive Criterion
1	MSEL early learning composite ≤70	None
2	MSEL early learning composite ≤70	VABS-II adaptive behavior composite ≤70
3	MSEL early learning composite ≤70	VABS-II communication, daily living skills, and/or socialization ≤70
4	MSEL visual reception *T*-score ≤ 30	None
5	MSEL visual reception *T*-score ≤ 30	VABS-II adaptive behavior composite ≤70
6	MSEL visual reception *T*-score ≤ 30	VABS-II daily living skills and/or socialization ≤70

[a]American Association on Intellectual and Developmental Disabilities, n.d.
[b]American Psychiatric Association, 2013.

or more of the adaptive domains, we included definitions of ID that included impairments in only communication, daily living skills, or socialization (Table 2, Estimates 3 and 6) (Papazoglou et al., 2014). Finally, for every score, we utilized a score cutoff of two or more SDs below the population mean, resulting in the following six estimates of ID.

Statistical analysis

To examine the effect of incorporating an adaptive behavior criterion on the percentage of children considered to have co-occurring ID, we estimated this percentage, with 95% Wald confidence intervals (CI), for all six definitions of ID overall and stratified by child's race and ethnicity. To determine if the addition of an adaptive criterion reduced racial and ethnic disparities in the percentage of children meeting ID criteria, we also calculated both unadjusted and adjusted odds ratios (OR) and 95% CIs using multiple logistic regression. We controlled for potential confounders based on previous literature and identification of variables univariately associated with meeting ID criteria and with child's race and ethnicity in our study sample, which included child's birth order, current household income relative to the federal poverty level, current maternal and paternal education, study site, CBCL total *T*-score, ADOS calibrated severity score (Gotham et al., 2009), and primary language spoken in the home. We considered other factors which past research suggests are associated with having co-occurring ID, such as child's sex and low birth weight, but did not include them in the adjusted models because they were not associated with either child's race and ethnicity or meeting ID criteria in our observed data. To further examine whether relationships between cognitive and adaptive scores differed by race and ethnicity, we also calculated Spearman correlations between MSEL and VABS-II scores within each racial and ethnic group; 95% CIs were calculated using the standard error formula proposed by Bonett and Wright (2000). Correlations were compared using *Z*-tests with NH White as the reference group.

Statistical analyses were performed using SAS Version 9.4 (SAS Institute Inc., 2010). Statistical precision was limited for the NH Asian or Pacific Islander and NH multiracial groups due to smaller sample sizes, but we included these groups in an exploratory analysis.

To account for missing covariates and missing test scores, we performed multiple imputation using the mice package in R version 4.2.2 (R Core Team, 2022; van Buuren & Groothuis-Oudshoorn, 2011), which utilizes a chained equations approach and allows the user to specify the type of regression model used for imputation of each variable (e.g., logistic regression may be specified for imputation of a binary variable). We performed 50 imputations, and imputation models included all model variables as well as auxiliary variables that were associated with model variables. More details on the imputation procedure, missingness, and auxiliary variables are available in the Supplementary Materials (Tables S1–S3). The percentage of children meeting ID criteria, ORs, and Spearman correlation coefficients were then estimated in each of the 50 imputed datasets, and the results were pooled using the PROC MIANALYZE SAS procedure to produce estimates and 95% CIs that accounted for both within- and between-imputation variance. Results from complete case analysis as well as a sensitivity analysis including only individuals with non-imputed test scores are available in the Supplementary Materials (Table S8, Figures S1–S5).

RESULTS

Percentage of children with ASD who would be classified as having co-occurring ID under different approaches

MSEL early learning composite

More than 60% of children with ASD had MSEL composite scores that were at least two SDs below the mean (62.9% [95% CI: 61.1%–64.7%]). Addition of adaptive criteria reduced the overall percentage classified as having co-occurring ID, to 38.0% (95% CI: 36.2%–39.8%) using both MSEL composite and the VABS-II composite scores, and to 45.0% (95% CI: 43.1%–46.9%) using an MSEL composite and VABS-II domain scores (Table 3).

The percentages of children with ASD and MSEL composite scores at least two SDs below the mean were significantly higher for NH Black children (74.9% [95% CI: 71.4%–78.5%]) and Hispanic children (68.6% [95% CI: 64.4%–72.8%]) relative to NH White children (54.3% [95% CI: 51.4%–57.2%]) (Table 3). The largest absolute reduction in the percentage classified as having co-occurring ID after adding the VABS-II composite criterion was for NH Black children (30.1 percentage points), followed by Hispanic (26.7), NH multiracial (24.6), NH Asian or Pacific Islander (23.2), and NH White (21.8) children (Table 3). The pattern was similar using the VABS-II communication/daily living skills/socialization domains criterion, though reductions were smaller (Table 3).

MSEL visual reception *T*-score

Compared to using MSEL composite scores, using MSEL VR *T*-scores resulted in a lower percentage of children with scores at least two SD below the population mean (48.7% [95% CI: 46.8%–50.6%]) (Table 3). Addition of adaptive criteria reduced the overall percentage of children with ASD classified as having co-occurring ID to 33.6% (95% CI: 31.8%–35.4%) using the VABS-II

TABLE 3 The percentage of children with autism meeting intellectual disability (ID) criteria under six classifications of ID in the Study to Explore Early Development phases 1–3, overall and by child's race and ethnicity.

		Intellectual disability Percentage[a] Estimate (95% confidence interval)		
		MSEL score only	MSEL score & VABS-II composite criterion	MSEL score & VABS-II domains criterion
	n	Est (95% CI)	Est (95% CI)	Est (95% CI)
MSEL early learning composite				
Overall	3264	62.9 (61.1–64.7)	38.0 (36.2–39.8)	45.0 (43.1–46.9)
Child's race & ethnicity				
NH White	1413	54.3 (51.4–57.2)	32.5 (29.8–35.2)	38.6 (35.7–41.4)
NH Black	729	74.9 (71.4–78.5)	44.8 (40.9–48.8)	52.7 (48.7–56.6)
Hispanic	567	68.6 (64.4–72.8)	41.9 (37.3–46.5)	49.9 (45.3–54.4)
NH Asian or Pacific Islander	166	64.5 (55.8–73.2)	41.3 (32.5–50.1)	48.3 (39.3–57.3)
NH Multiracial	359	61.8 (56.3–67.2)	37.2 (31.8–42.5)	44.7 (39.0–50.4)
MSEL visual reception *T*-score				
Overall	3264	48.7 (46.8–50.6)	33.6 (31.8–35.4)	36.3 (34.5–38.1)
Child's race & ethnicity				
NH White	1413	41.3 (38.4–44.2)	28.2 (25.6–30.8)	30.9 (28.3–33.6)
NH Black	729	60.9 (56.9–64.8)	41.7 (37.8–45.5)	43.7 (39.7–47.7)
Hispanic	567	51.1 (46.6–55.6)	35.6 (31.2–40.0)	38.8 (34.4–43.2)
NH Asian or Pacific Islander	166	50.2 (41.2–59.1)	37.6 (29.0–46.1)	41.7 (33.0–50.4)
NH Multiracial	359	47.6 (41.9–53.4)	32.2 (27.0–37.4)	34.9 (29.6–40.3)

Abbreviations: CI, confidence interval; Est, estimate; ID, intellectual disability; MSEL, Mullen Scales of Early Learning; NH, Non-Hispanic; VABS-II, Vineland Adaptive Behavior Scales, Second Edition.
[a]Estimates are from multiply imputed data.

composite criterion and 36.3% (95% CI: 34.5%–38.1%) using the daily living skills/socialization domains criterion. The percentages with MSEL VR *T*-scores below the threshold for ID were greater for NH Black children (60.9% [95% CI: 56.9%–64.8%]) and Hispanic children (51.1% [95% CI: 46.6%–55.6%]) relative to NH White children (41.3% [95% CI: 38.4%–44.2%]) (Table 3), and patterns were similar using the VABS-II domain scores (Table 3).

Variations in the odds of co-occurring ID by race and ethnicity

MSEL early learning composite

In unadjusted analysis, relative to NH White children, all other racial and ethnic groups had significantly higher odds of a co-occurring ID classification based on MSEL composite scores only, with ORs ranging from 1.36 (95% CI: 1.05–1.76) for NH multiracial children to 2.52 (95% CI: 2.01–3.15) for NH Black children. These ORs were reduced although still elevated after addition of either the VABS-II composite or domains criteria with the largest reductions for NH Black and Hispanic children (Figure 2).

The observed racial and ethnic disparities in the percentage of children meeting ID was reduced after adjustment for potential confounders, and they were further reduced with the addition of the adaptive criteria (Figure 2). NH Black (OR 2.18 [95% CI: 1.66–2.87]) and Hispanic (OR 1.52 [95% CI: 1.12–2.05]) children had significantly higher odds of meeting the MSEL composite-only ID criterion relative to NH White children. However, with the addition of the VABS-II composite criterion, no racial or ethnic group had significantly higher odds of meeting ID criteria relative to NH White children (NH Black OR 1.23 [95% CI: 0.95–1.58]; Hispanic OR 1.24 [95% CI: 0.92–1.65]; NH Asian or Pacific Islander OR 1.38 [95% CI: 0.85–2.24]; NH multiracial OR 1.12 [95% CI: 0.83–1.52]), although all point estimates were higher than one. Using the communication/daily living skills/socialization domains criterion, only NH Black (OR 1.40 [95% CI: 1.09–1.79]) children had significantly higher odds of meeting ID criteria than NH White children, but these disparities were also reduced relative to those observed when ID was measured by the MSEL composite only (Figure 2).

MSEL VR *T*-score

In unadjusted regression analysis, relative to NH White children, NH Black (OR 2.21 [95% CI: 1.80–2.72]), Hispanic (OR 1.48 [95% CI: 1.20–1.84]), and NH multiracial

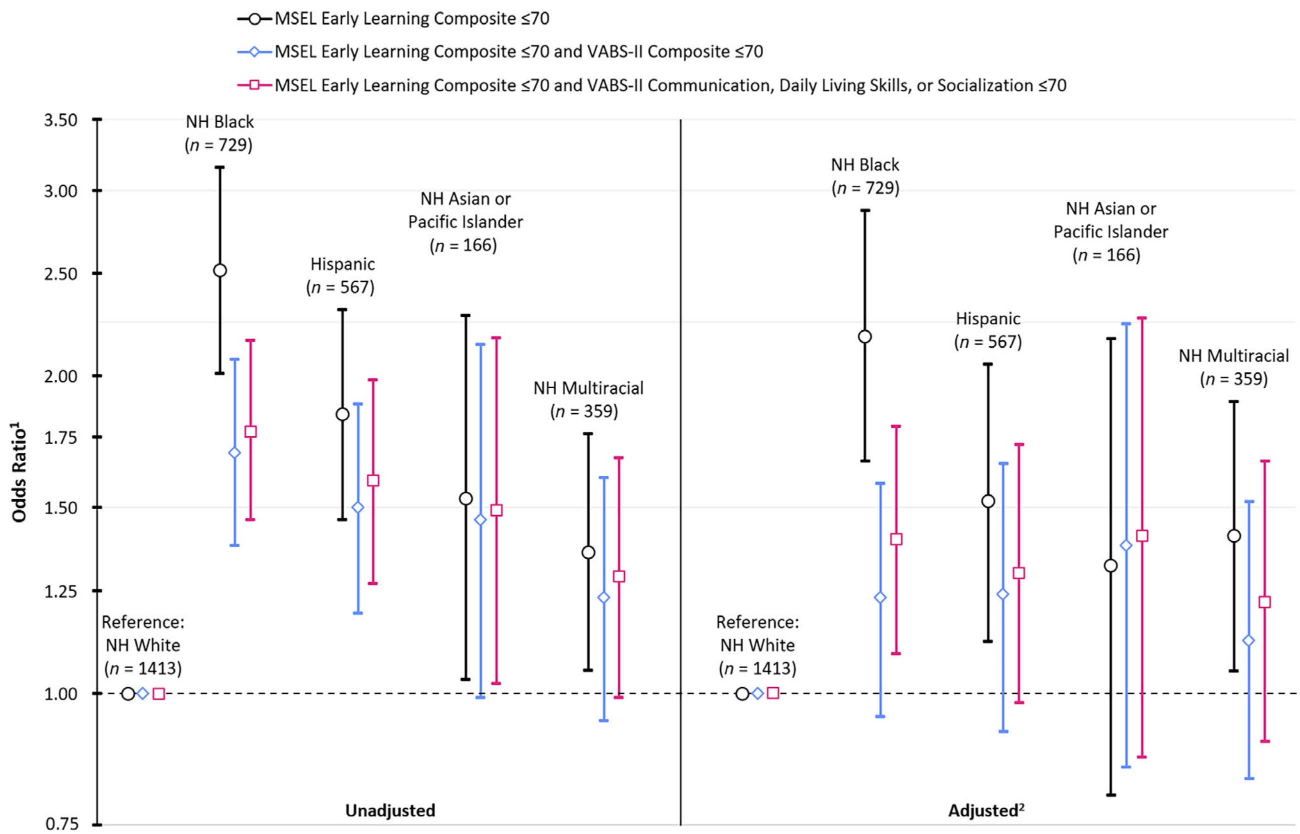

FIGURE 2 Association between child's race and ethnicity and meeting intellectual disability criteria under three classifications of intellectual disability incorporating the Mullen Scales of Early Learning (MSEL) Early Learning Composite and Vineland Adaptive Behavior Scales, Second Edition (VABS-II), scores in children with autism in the Study to Explore Early Development phases 1–3. [1]Estimates are from multiply imputed data. [2]Adjusted for: child's birth order, current household income relative to the federal poverty level, current maternal and paternal education, study site, childhood behavior checklist total *T*-score, autism diagnostic observation schedule calibrated severity score, and the primary language spoken in the home. MSEL, Mullen Scales of Early Learning; NH, Non-Hispanic; VABS-II, Vineland Adaptive Behavior Scales, Second Edition.

(OR 1.29 [95% CI: 1.00–1.66]) children had significantly higher odds of meeting MSEL VR *T*-score-only ID criteria, and these disparities remained significant for NH Black and Hispanic children after addition of either the VABS-II composite or domain criteria (Figure 3). The borderline statistically significantly increased odds of ID for NH Asian or Pacific Islander relative to NH white children increased slightly after addition of the adaptive criteria (OR 1.53 [95% CI: 1.04–2.26] for the composite criterion; OR 1.59 [95% CI: 1.09–2.33] for the domain criterion) (Figure 3).

In adjusted analysis, NH Black (OR 1.93 [95% CI: 1.50–2.48]) and Hispanic (OR 1.44 [95% CI: 1.09–1.90]) children had significantly higher odds of meeting the MSEL VR *T*-score-only ID criterion relative to NH White children. After incorporating VABS-II criteria, NH Black children still had significantly higher odds of meeting ID criteria relative to NH White children (OR 1.37 [95% CI: 1.06–1.78] for the VABS-II composite criterion; OR 1.41 [95% CI: 1.09–1.82] for the VABS-II daily living skills/socialization criterion), although point estimates were reduced relative to MSEL VR *T*-score-only estimates (Figure 3).

Correlation analysis

Spearman correlation coefficients between MSEL and VABS-II scores were similar across racial and ethnic groups, regardless of the MSEL or VABS-II score examined (Figure 4), and correlations did not differ significantly from NH White children for any other racial or ethnic group. Correlations were generally stronger for the MSEL ELC than MSEL VR *T*-scores and were stronger between MSEL and VABS-II communication scores than other domains, overall and within each racial and ethnic group.

DISCUSSION

The addition of an adaptive functioning criterion substantially reduced the percentage of children with ASD classified as having co-occurring ID relative to defining ID based only on cognitive scores; the estimated percentage of children who were classified with co-occurring ID was reduced from over 60% using the MSEL composite-only criterion to 38% when the MSEL composite and

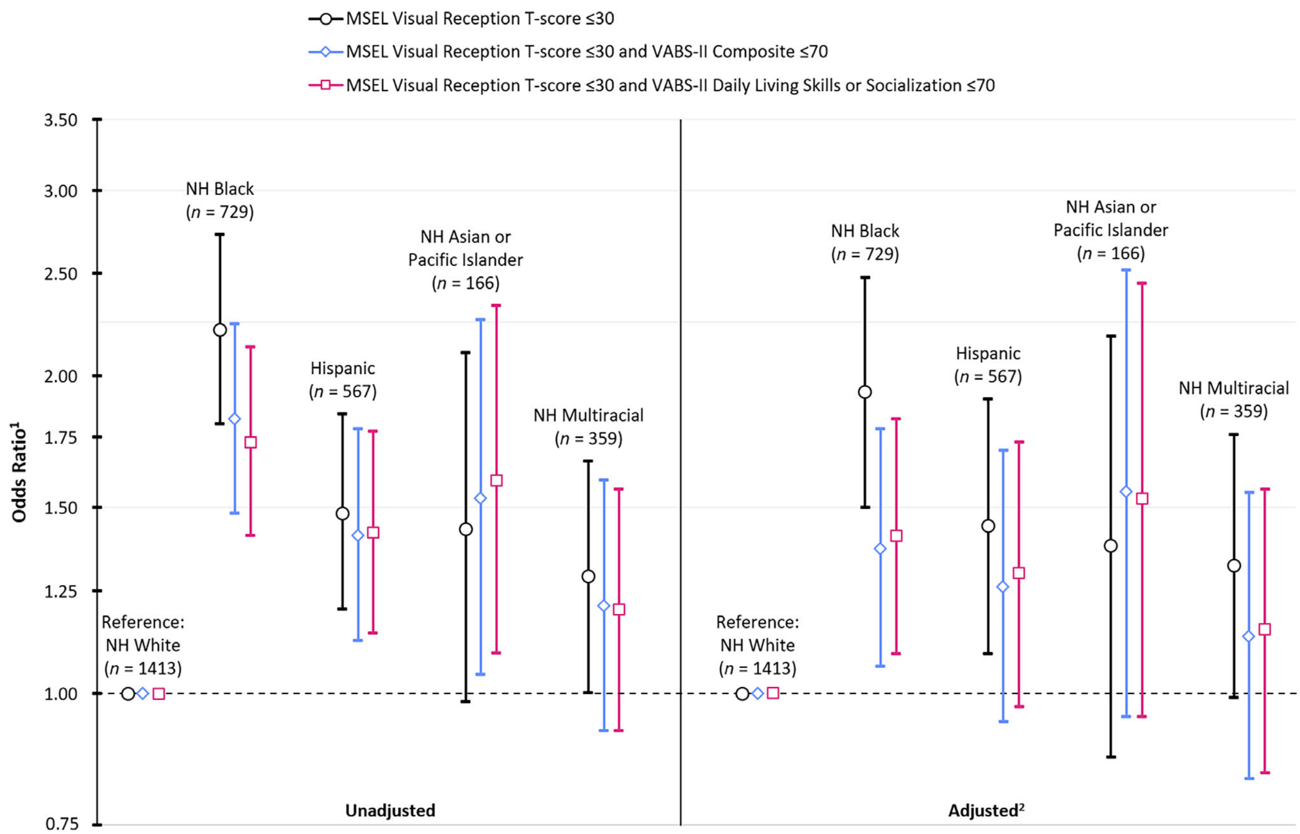

FIGURE 3 Association between child's race and ethnicity and meeting intellectual disability criteria under three classifications of intellectual disability incorporating the Mullen Scales of Early Learning (MSEL) Visual Reception T-score and Vineland Adaptive Behavior, Second Edition (VABS-II), scores in children with autism in the Study to Explore Early Development phases 1–3. [1]Estimates are from multiply imputed data. [2]Adjusted for: child's birth order, current household income relative to the federal poverty level, current maternal and paternal education, study site, Childhood Behavior Checklist Total T-score, Autism Diagnostic Observation Schedule calibrated severity score, and the primary language spoken in the home. MSEL: Mullen Scales of Early Learning; NH, Non-Hispanic; VABS-II: Vineland Adaptive Behavior Scales, Second Edition.

VABS-II composite criteria were used. In each racial and ethnic group, the VABS-II composite criterion resulted in larger reductions in the percentage classified with ID than the criterion requiring impairment in only one adaptive domain. These findings are consistent with past research documenting large discrepancies between IQ and adaptive scores in children with autism, with gaps sometimes exceeding one or even two SDs and adaptive scores often exceeding cognitive scores among children with IQ scores within the ID range (Alvares et al., 2020; Bölte & Poustka, 2002; Duncan & Bishop, 2015; Furnier et al., 2023; Kanne et al., 2011; Klin et al., 2007; Saulnier & Klin, 2007). These findings suggest epidemiologic studies of co-occurring ID in children with autism based on IQ alone likely overestimate the prevalence of co-occurring ID. Our study focused on young children; the impact of considering adaptive scores might differ for older children, as past research has found a negative association between age and adaptive functioning, potentially resulting in increasing adaptive delays relative to cognitive ability as children age (Alvares et al., 2020; Bradshaw et al., 2019; Kanne et al., 2011; Klin et al., 2007; Pathak et al., 2019).

Consistent with our second hypothesis, addition of an adaptive functioning criterion resulted in larger absolute reductions in the percent of children classified with co-occurring ID for NH Black and Hispanic children than for NH White children. In addition, disparities in the odds of meeting ID criteria in NH Black and Hispanic children relative to NH White children were reduced, although not eliminated, when adaptive score criteria were used. After adjusting for socioeconomic confounders and using both MSEL composite and VABS-II composite scores to define ID, the disparities in estimated ID prevalence were diminished and not significantly different from NH White children for any other racial and ethnic groups. However, point estimates were still elevated, indicating that disparities remained when incorporating the VABS-II domains criteria and using ID definitions based on the MSEL VR *T*-score.

These findings raise the question of why racial and ethnic disparities in co-occurring ID among children with ASD are not entirely eliminated after controlling for selected socioeconomic factors and incorporating adaptive scores. Extensive racial and ethnic disparities in the US in autism screening and access to autism diagnostic

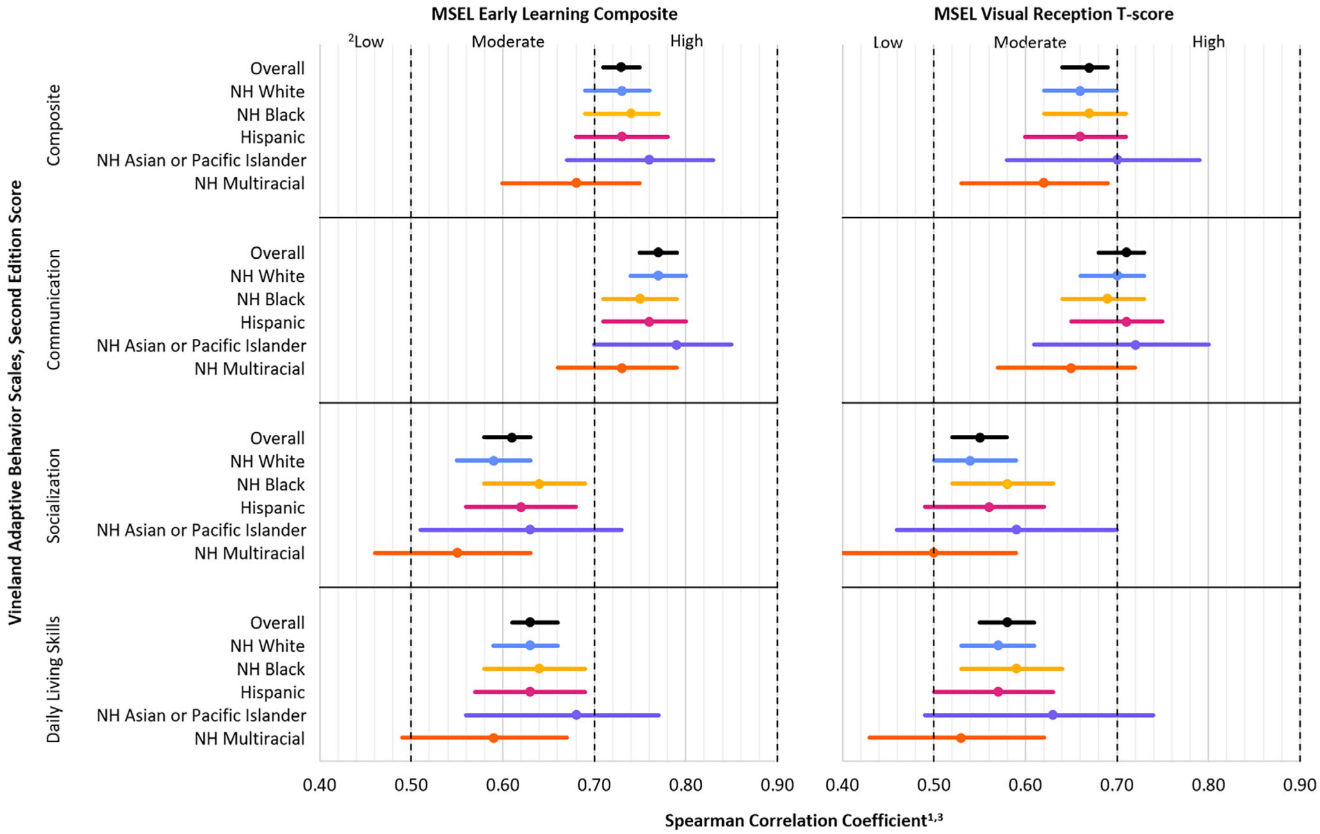

FIGURE 4 Spearman correlations (with 95% confidence intervals)[1] between Mullen Scales of Early Learning (MSEL) and Vineland Adaptive Behavior Scales, Second Edition (VABS-II), scores in children with autism in the Study to Explore Early Development phases 1–3, overall and by child's race and ethnicity. [1]Estimates are from multiply imputed data. [2]Interpretation of correlation strength taken from Mukaka (2012). [3]No correlations were statistically significantly different from correlations in NH White children at $p < .05$. MSEL, Mullen Scales of Early Learning; NH, Non-Hispanic; VABS-II, Vineland Adaptive Behavior Scales, Second Edition.

and intervention services (Angell et al., 2018; Čolić et al., 2022; Constantino et al., 2020; Fisher et al., 2023; Guthrie et al., 2019; Magaña et al., 2013; Mandell et al., 2002; Mandell et al., 2007; Mandell et al., 2009; Pham et al., 2022) may explain the persistence of these differences, as exposure to intensive early intervention has been shown to boost IQ with little impact on autism severity (Asta & Persico, 2022; Dawson et al., 2010; Reichow et al., 2018; Shi et al., 2021). Persistence of these disparities might also be explained by disparities within the diagnostic process leading to under-identification of autism in Black and Hispanic children who have cognitive scores in the average or above average range, thereby inflating the proportions with low cognitive scores. Children with autism with cognitive delays may be more likely than children with autism without those delays to be identified early and referred for developmental assessments. Considerable family resources to cover out-of-pocket expenses, time off work, and travel may be required to obtain an autism diagnosis. Such resources are less available to Black relative to White children in the US (Čolić et al., 2022; Liu et al., 2023). Additionally, studies describing the experience of parents of children with autism from underrepresented racial and ethnic groups have found that parents report numerous barriers to having their children evaluated, including long wait times or low availability of service providers, racial and ethnic bias from providers, a lack of serious attention given to their concerns about their child's behavior or development, and language barriers that limited caregivers' ability to communicate effectively with their child's healthcare provider (Čolić et al., 2022; Constantino et al., 2020; Fisher et al., 2023; Zuckerman et al., 2017). All of these factors likely lead to preventable delays in diagnosis and subsequent delays in receipt of early intervention services shown to improve both cognitive scores and adaptive behavior.

Cultural expectations of child behavior and stigma surrounding developmental disabilities may also contribute to delayed identification of autism in certain populations (Fisher et al., 2023; Pham & Charles, 2023; Zuckerman et al., 2018). Studies of parent reports of autism symptoms have found Black parents to be less likely than White parents to report concerns about their children's social skills or restricted and repetitive behaviors and interests (Azad et al., 2022; Donohue et al., 2019), even after controlling for autism severity (Donohue et al., 2019), and may place more emphasis on behavioral concerns (Mandell et al., 2007). Persistent racial and ethnic disparities in the prevalence of autism with co-occurring ID point to the need for increased access to culturally appropriate autism diagnostic and treatment services (Dababnah et al., 2018) and improved outreach to provide parents the resources to recognize symptoms of ASD (Čolić et al., 2022; Fisher et al., 2023).

Upstream disparities in exposures that are causally associated with ID may also contribute to disparities in rates of co-occurring ID in children with autism. Exposures that have been found to disproportionately affect underserved populations include lead poisoning and other environmental toxins (Carrington et al., 2019; Emerson et al., 2019; Gaylord et al., 2020; Grineski et al., 2022; Thompson et al., 2022) and pre- and perinatal complications (Bilder et al., 2013; Huang et al., 2016; Yeargin-Allsopp et al., 1995). These factors may also contribute to the higher prevalence of ID in NH Black children without autism (Patrick et al., 2021; Van Naarden Braun et al., 2015).

Biases in the instruments used to measure both cognitive and adaptive functioning could also contribute to racial and ethnic disparities in the proportion of children with autism classified as having co-occurring ID. Cultural bias may result from the items included in standardized tests (Gonthier, 2022), nonrepresentative norming samples (Lozano-Ruiz et al., 2021), and differential performance of autism assessment tools across racial and ethnic groups (Dahl et al., 2023; Guthrie et al., 2019; Kalb et al., 2022; Pham & Charles, 2023). Lack of reliable translations of ASD screening and diagnostic tools may complicate the diagnostic process as well and could potentially negatively affect test performance in some groups (Scarpa et al., 2013).

It is also possible that residual or unmeasured confounding contributed to the elevated odds of ID among Black and Hispanic children relative to White children in our adjusted analyses. Although we were able to adjust for household income and parental education, these measures are likely insufficient for capturing the intersectionality of racism and socioeconomic disadvantage in the US (Bowleg, 2012; Hull et al., 2023) and their impacts on cognitive development and adaptive functioning of young children. Further, we had limited information on family, home, or community environment, which have been shown to be associated with cognitive development (Breslau et al., 2001; Tong et al., 2007).

An important limitation of this study is the young age of our study sample. Preschool children are not typically given an ID diagnosis because of IQ instability at this age, although early childhood IQ has been shown to be predictive of adult outcomes among people with autism (Pickles et al., 2020). Despite the young age of the sample, data from the SEED study provides a valuable opportunity to evaluate the impact of considering adaptive scores on racial and ethnic disparities in the classification of ID. Because verbal IQ has been shown to increase significantly with maturation in childhood (Chawarska et al., 2009), it is likely that our sample would exhibit gains in verbal scores as they age and receive intervention services. Although we examined definitions of ID focused on the MSEL VR subscale in an attempt to mitigate the impact of these potentially impermanent communication delays, it is important to note that certain items in the VR subscale, particularly at the older ages, include verbal instructions that accompany examiner gestures and models of the desired response, for example, matching, categorizing, and visual memory. Thus, use of the MSEL VR subscale does not eliminate, but may mitigate, the influence of language difficulties on cognition. Additionally, issues related to the ability of children with autism to complete the MSEL may have also influenced the MSEL scores obtained, potentially underestimating the cognitive ability of our sample (Akshoomoff, 2006; Courchesne et al., 2019). We observed a floor effect in MSEL scores in our sample; among children with an MSEL ELC recorded, 31% obtained the minimum score, whereas among children with a VR *T*-score recorded, 37% obtained the minimum possible score. Hispanic children whose primary language was Spanish were assessed with measures that were translated into Spanish but have not been normed in this population. Also, children were diagnosed with ASD using the DSM, Fourth Edition, Text Revised, before 2013, and these findings may have differed if we had included only children who were diagnosed with the DSM-5. Missing data were another limitation of our analyses. Although we used multiple imputation to account for this missingness, multiple imputation assumes that the data are missing at random, an assumption which we believe to be reasonable but cannot formally test. However, of note, we saw similar patterns in analyses in complete cases (see Supplementary Materials Table S8, Figures S1–S3) and our multiply imputed data. An additional limitation of this study is that sample sizes for NH Asian or Pacific Islander and NH multiracial children were small, and while we included these groups in analyses for exploratory purposes, we had less power to detect significant differences for these groups.

CONCLUSION

In summary, this study provides evidence for the importance of the adaptive behavior criterion in describing the co-occurrence of ID in children with autism and in evaluating racial and ethnic disparities. Studies that quantify the co-occurrence of ID in children with autism based solely on IQ scores, often due to lack of availability of adaptive test information, likely overestimate this co-occurrence. Accurate estimation of the proportion of children with autism with co-occurring ID may be important for understanding the magnitude and nature of racial, ethnic, and socioeconomic disparities in autism and for addressing these disparities. These findings point to the need for future research into the root causes of racial and ethnic disparities in co-occurring ID and strategies for improving early identification and treatment of children with autism from underserved racial and ethnic groups. Although our findings may be specific to the unique intersection of race and ethnicity, socioeconomic status, and disability in the context of historical racism in the US, they also suggest the need for future research to assess the racial, linguistic, and cultural appropriateness and validity of tools used in diagnosis of both autism and ID. Although the association between low socioeconomic status and ID has been observed across the world (Durkin & Yeargin-Allsopp, 2018; Leonard et al., 2022), less is known from diverse countries about this association among children with autism.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Research data are not shared.

ETHICS STATEMENT

The study was approved by institutional review boards at the Centers for Disease Control and Prevention and every SEED study site. Written informed consent was obtained from every participating family. All procedures performed in SEED were in accordance with ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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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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