



## Predictive Validity of the Modified Checklist for Autism in Toddlers (M-CHAT) Born Very Preterm

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**Objective** To examine the predictive validity of the Modified Checklist for Autism in Toddlers (M-CHAT) administered at age 24 months for autism spectrum disorder (ASD) diagnosed at 10 years of age in a US cohort of 827 extremely low gestational age newborns (ELGANs) followed from birth.

**Study design** We examined the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the M-CHAT in predicting an ASD diagnosis at age 10 years based on gold standard diagnostic instruments. We then assessed how these predictive parameters were affected by sensorimotor and cognitive impairments, socioeconomic status (SES), and emotional/behavioral dysregulation at age 2 years.

**Results** Using standard criteria, the M-CHAT had a sensitivity of 52%, a specificity of 84%, a PPV of 20%, and an NPV of 96%. False-positive and false-negative rates were high among children with hearing and vision impairments. High false-positive rates also were associated with lower SES, motor and cognitive impairments, and emotional/behavioral dysregulation at age 2 years.

**Conclusions** Among extremely preterm children with ASD, almost one-half were not correctly screened by the M-CHAT at age 2 years. Sensorimotor and cognitive impairments, SES, and emotional/behavioral dysregulation contributed significantly to M-CHAT misclassifications. Clinicians are advised to consider these factors when screening very preterm toddlers for ASD. (*J Pediatr* 2016;178:101-7).

The Modified Checklist for Autism in Toddlers (M-CHAT)<sup>1,2</sup> is a widely used screening instrument for autism spectrum disorder (ASD) in toddlers. The M-CHAT consists of 2 phases: a parent-administered questionnaire and an inconsistently used follow-up interview with the parent.<sup>3</sup> Because the most recent version of the M-CHAT (M-CHAT-Revised with Follow-Up) was validated in 2014, previous studies mainly used the M-CHAT as a questionnaire alone (as we did in this study), which resulted in high sensitivity and specificity (all >90%).<sup>4,5</sup> In the absence of interview follow-up, positive predictive values (PPVs) of the M-CHAT have ranged from 0.14 to 0.64 in community-based samples.<sup>4,5</sup>

Although the prevalence of ASD is 1%-2% in the general population,<sup>6,7</sup> the prevalence in preterm children is several magnitudes higher (1.8%-8%<sup>8-11</sup>). Sensory, motor, and cognitive impairments,<sup>11-13</sup> as well as emotional/behavioral dysregulation,<sup>14</sup> all of which can affect the validity of the M-CHAT, occur more often in very preterm toddlers compared with term-born children; therefore, misclassification rates might be higher in preterm children with such deficits. A recent study examined the validity of the M-CHAT in preterm toddlers in relation to a concurrent ASD diagnosis made at age 2-4 years,<sup>13</sup> but to date no studies of preterm toddlers have assessed how well the M-CHAT predicts the much more reliable, longer-term diagnosis of ASD in these children at school age.

The purpose of this study was to examine the predictive validity of the M-CHAT administered at age 24 months in relation to the diagnosis of ASD at school age

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ADOS	Autism Diagnostic Observation Schedule	GMFCS	Gross Motor Functional Classification System
ADI-R	Autism Diagnostic Interview-Revised	ID	Intellectual disability
ASD	Autism spectrum disorder	M-CHAT	Modified Checklist for Autism in Toddlers
BSID-II	Bayley Scales of Infant Development-Second Edition	MDI	Mental Developmental Index
		NPV	Negative predictive value
		PDI	Psychomotor Developmental Index
CBCL 1.5-5	Child Behavior Checklist for Ages 1.5-5	PPV	Positive predictive value
		SES	Socioeconomic status
ELGAN	Extremely low gestational age newborn	SCQ	Social Communication Questionnaire

in a cohort of extremely low gestational age newborns (ELGANs) followed from birth. We evaluated the overall predictive validity of the M-CHAT, as well as the validity of each specific item with regard to a diagnosis of ASD. We also examined the extent to which developmental, demographic, behavioral, and cognitive characteristics of extremely preterm children affect the M-CHAT's predictive validity.

## Methods

The Extremely Low Gestational Age Newborn (ELGAN) Study is a multicenter prospective, observational study of the risk of structural and functional neurologic disorders in extremely preterm infants.<sup>15</sup> A total of 1506 infants born before the 28 weeks' gestation were enrolled between 2002 and 2004, and 1200 of them survived to age 2 years. Analyses at age 2 years resulted in a report of overall rates of M-CHAT positivity and the association of M-CHAT positivity with concurrent motor, cognitive, visual, and hearing impairments.<sup>12</sup> Of the 1200 surviving children, 889 were enrolled for the 10-year follow-up (Table I and Figure; Figure available at [www.jpeds.com](http://www.jpeds.com)), when they were carefully evaluated for ASD. This enabled us to assess the predictive validity of the M-CHAT for ASD.

At approximately 24 months corrected age, each child underwent a developmental assessment that included a neurologic examination, the Bayley Scales of Infant Development, Second Edition (BSID-II),<sup>16</sup> and several parent-reported assessments, including the M-CHAT and Child Behavior Checklist for Ages 1.5-5 (CBCL 1.5-5)<sup>17</sup> (Figure). The parent completed questionnaires regarding the child's sensory and motor impairments.

A total of 966 families who participated in the 24-month evaluations were contacted by mail and then by phone to invite them to participate in the 10-year follow-up. We searched for families who were lost to follow-up using state vaccination registries and other openly available websites. Facebook also was used when approved by the local Institutional Review Board. The enrollment and consent processes were approved by the Institutional Review Boards at each site.

### M-CHAT

Primary caregivers completed the M-CHAT screener,<sup>12,13</sup> consisting of 23 items for which the primary caregiver rates whether the child has the behavior specified.<sup>4</sup> A child was considered to screen positive if 2 of 6 "critical" items (Table II) or 3 of any of the 23 total items were endorsed. A follow-up caregiver interview was not completed as part of the present investigation.

### Gross Motor Function Classification System

Children's motor function was assessed with the BSID-II Psychomotor Developmental Index (PDI) and the Gross Motor Function Classification System (GMFCS) at age 2 and 10 years.<sup>18</sup> At age 2 years, a child was classified as GMFCS level 2 or higher if he or she could not sit, stand, or walk independently. A child who needed assistance to walk was classified as level 1, and a child who could walk was classified as level <1. At age 10 years,

**Table I. Characteristics of the children positive on the M-CHAT and positive for ASD**

	M-CHAT positive, n	ASD positive, n	Row N
<b>Maternal characteristics</b>			
Race			
White	15*	7	532
Black	24	8	202
Other	29	4	91
Hispanic			
Yes	28*	5	76
No	18	7	749
Maternal age, y			
<21	19	5	102
21-35	20	7	553
>35	14	8	172
Years of education			
≤12	26*	8	342
13-15	17	4	185
≥16	11	7	300
Single			
Yes	24*	7	319
No	15	7	508
Public insurance			
Yes	28*	7	284
No	13	7	543
<b>Perinatal characteristics</b>			
Any antenatal corticosteroids			
Yes	17*	7	731
No	26	7	95
Delivery complications			
PE/PI	23	9	140
Spontaneous†	18	7	687
<b>Newborn characteristics</b>			
Sex			
Male	21	9*	421
Female	16	5	406
Gestational age, wk			
23-24	25	15*	166
25-26	17	6	370
27	16	3	291
Birth weight, g			
≤750	23*	11*	301
751-1000	17	4	361
>1000	14	5	165
Maximum column N	153	58	827

PE/PI, preeclampsia/fetal indication.

Data are shown as row percentages except where noted (Row N and Maximum Column N).

\*Indicates a significant association ( $P < .05$ ) between the characteristic listed in the first column and M-CHAT positivity or ASD positivity, respectively.

†Preterm labor, preterm premature rupture of membranes, abruption, cervical insufficiency.

a child was classified as GMFCS level 5 if he or she had no self-mobility. Because ASD cannot be validly diagnosed in children with severe motor impairments, children with no self-mobility at age 10 years were excluded from diagnostic consideration of ASD.

### Sensory Impairments

Parents were asked to provide information about their child's vision and hearing at ages 2 and 10 years. A child was considered to have visual impairment if the parent reported that the child was legally blind in at least one eye or if the child was receiving treatment or had surgery for lazy eye, strabismus, squinting, or crossed eyes. A child was considered to have hearing impairment if the parent reported that the child used

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