Racial/ethnic and Socioeconomic Differences in Screening Toddlers for Autism Spectrum Disorders Using the M-CHAT

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Lauren E. Herlihy, Ph.D.

University of Connecticut, 2014

Universal screening of toddlers for autism spectrum disorder (ASD) in pediatric practice is recommended to potentially reduce racial/ethnic and socioeconomic disparities in timing of diagnosis. Early diagnosis of ASD has been associated with higher parent education and income but not with ethnicity in some studies, while others report that economically disadvantaged children and African American and Latino children are diagnosed later or not at all (Fombonne, 2003; Fountain, King, & Bearman, 2011; Liptak et al., 2008). Screening for ASD may currently be more common among lower income and minority children (Arunyanart et al., 2012). The current sample of 18,669 children was drawn from screening sites at the University of Connecticut (n = 9587, 51.4%) or Georgia State University (n = 9082, 48.6%). Socioeconomic status (SES) was estimated by Census Tract median income data. Most analyses compared children in the Majority group (White children; n= 6169, 68.9%) and the Minority group (all other racial/ethnic groups; n= 2789, 31.3%). Small but significant disparities by race/ethnicity, controlling for median income, were observed in child age at M-CHAT screening, age at M-CHAT Follow-up Interview (FUI), and time from M-CHAT to FUI. Black/African American and Latino children were screened and followed up at later ages, but not evaluated later, perhaps due to differential attrition. Minority and lower income children also had higher scores on the M-CHAT, but Majority and higher income children had higher scores on the M-CHAT FUI. Minority and lower income children screened positive more frequently on certain individual M-CHAT items, including all reverse-scored items, while Majority children screened positive more
frequently on certain M-CHAT FUI items. Finally, positive predictive value (PPV) of the M-CHAT and M-CHAT FUI procedure did not differ by race/ethnicity, in contrast to previous studies. In conclusion, standardized screening procedures employed in the current study largely eliminated disparities in screening, follow-up, and evaluation for ASD in toddlers. Item response patterns also differed by both race/ethnicity and SES, underscoring the need for vigilance and support for parent understanding of M-CHAT items in pediatric practice.
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APPROVAL PAGE

Doctor of Philosophy Dissertation

Racial/ethnic and Socioeconomic Differences in Screening Toddlers for Autism Spectrum Disorders Using the M-CHAT

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Table of Contents

Introduction ......................................................................................................................... 1
  Epidemiological Studies of ASD Prevalence ................................................................. 3
  The ASD Screening Mandate and Socio-demographic Differences ......................... 13
  The Current Study ........................................................................................................ 18
  Hypotheses .................................................................................................................... 18

METHODS .......................................................................................................................... 20
  Participants ....................................................................................................................... 20
  Instruments ...................................................................................................................... 22
  Census Tracts .................................................................................................................. 23
  Procedure ....................................................................................................................... 26

RESULTS ............................................................................................................................ 29
  Hypothesis 1 .................................................................................................................. 30
  Hypothesis 2 .................................................................................................................. 35
  Hypothesis 3 .................................................................................................................. 37

DISCUSSION ....................................................................................................................... 38
  Hypothesis 1 .................................................................................................................. 39
  Hypothesis 2 .................................................................................................................. 43
  Hypothesis 3 .................................................................................................................. 48
  Conclusions ..................................................................................................................... 49
  Limitations and Future Directions ............................................................................. 50

TABLES ............................................................................................................................... 54
  Table 1. Comparison of main variables of interest by site ......................................... 54
Tables 2a & 2b. Descriptives and multiple regression models ..............................55
Table 2c. Correlations for multiple regressions .................................................56
Table 3. Descriptives for ANCOVAs by racial/ethnic group- timing of screening ....57
Table 4. Descriptives for ANCOVAs by racial/ethnic group- score .........................58
Table 5. ANCOVAs for outcome variables by racial/ethnic group, controlling for median income ..........................................................59
Table 6. Attrition characteristics ......................................................................60
Table 7. Screen positive participants by racial/ethnic group on M-CHAT items .......61
Table 8. Screen positive participants by racial/ethnic group on FUI items ..............62
Table 9. Hierarchical regressions predicting individual item responses from racial/ethnic group, controlling for median income ........................................63
Table 10. Chi-square data for PPV comparisons ..................................................65

FIGURES ........................................................................................................66
Figure 1. Participant flow chart for screening procedures ....................................66
Figure 2. Mean age at M-CHAT screening, at FUI, and at evaluation by ethnicity ......67

REFERENCES ..................................................................................................68

APPENDICES ..................................................................................................73
A. M-CHAT ....................................................................................................73
B. M-CHAT FUI ............................................................................................74
Disparities in access to mental healthcare for children in the United States have long been discussed, whereas this discussion is relatively recent in the study of Autism Spectrum Disorder (ASD). In their 2010 review, Alegria and colleagues defined a health service disparity as "differences in treatment or access not justified by the differences in health status or preferences of the groups" (pp.760). Others have defined "health gradients," or the association between wealth and disease, such that the wealthier a person is, the less likely he/she is to experience disease or early mortality. (King & Bearman, 2011). Health gradients are believed to arise and persist because people with more resources can devote more of those resources to their health, and because wealthy and educated people are disproportionately able to take advantage of technological and medical advances that create opportunities for better health (King & Bearman, 2011). Overall, African American and Latino children, when compared to non-Latino white children in the U.S., reportedly have the greatest unmet need for mental health services, and the services they receive are often of inferior quantity and quality. These children are underserved across multiple areas of mental healthcare, including prevention, access, quality of treatment, and treatment outcomes (Alegria, Vallas, & Pumariéga, 2010). One ASD-specific study based on the National Children's Health Survey found that being African American or Latino, or having a family income less than 100% of the poverty level was associated with decreased access to medical services generally, while having Medicaid or State Children's Health Insurance Program was linked with better access to some services (Liptak et al., 2008).

Another recent study of mental healthcare access for children in the United States compared children with private versus public (i.e., Medicaid) insurance in terms of the rates of 20 common health conditions, including general developmental delays and ASD (Bethell et al., 2011). Compared with privately-insured children, the prevalence, severity, and complexity of
mental health concerns were systematically greater for the children who were publically insured after adjusting for variations in demographic and socioeconomic factors. Developmental screening by parent-report measure was reported by 20% of parents of children ages 10-76 months, and parents of publically-insured children were more likely to have participated in such screening than privately-insured children (Bethell et al., 2011). Notably, the authors found higher prevalence of risk for developmental delay (Adjusted odds ratio (OR): 32.7 vs. 22.1), developmental delay that affects learning (OR: 5.8 vs. 2.3), and ASD (OR: 1.5 vs. 0.9) for publically-insured children compared to privately-insured children. These differences may reflect greater participation of pediatricians in practices that serve publically-insured children in screening for mental health and developmental concerns, rather than true differences in rates of delays in the population at large. One effort to reduce these disparities at the federal level came in the form of the Early Periodic Screening, Detection, and Treatment (EPSDT) mandate, which requires states to deliver medically necessary mental health services for children covered by Medicaid (Alegria, Vallas, & Pumariega, 2010). This mandate trains primary care providers on tools, referral procedures, and consultation to enhance their first-line provision of mental health services to high-risk populations. Screening for ASD in underserved populations of children falls squarely within the EPDST mandate and represents a foundation for the impetus to provide universal screening in pediatric practice for children who otherwise may never be referred for ASD diagnostic services. The current study aims to examine differences by race/ethnicity and socioeconomic status (SES) in age of screening and screener performance using one such screening tool for ASD, the Modified Checklist for Autism in Toddlers (M-CHAT; Robins, Fein, Barton & Green, 2001).
Epidemiological Studies of ASD Prevalence and Socio-demographic Differences

As the prevalence rate of ASD in the U.S. has risen, more attention has been paid to the impact of these well-known disparities in pediatric mental healthcare on screening, early identification, and treatment for ASD. ASDs are characterized by serious and pervasive impairments in communication and social interaction, and the presence of restricted interests and repetitive behaviors (APA, 2000). The Centers for Disease Control (CDC) recently stated that nearly one in 88 children in the United States is identified with an ASD (CDC, 2012). The CDC considers ASD to be the second most common serious disability (after intellectual disability), and a group of conditions worthy of public health attention due to its impact on children, their families, and their communities (CDC, 2012). While ASD is known to occur in all racial/ethnic and socioeconomic groups in the United States (CDC, 2012; Shattuck et al., 2009; Mandell et al., 2009), reports of differences in its prevalence have been conflicting (e.g., Fombonne, 2003).

The vast majority of studies examining comparisons of ASD diagnosis by race/ethnicity and socioeconomic factors have been broader studies aimed at estimating prevalence. Only one recent review of the influence of racial/ethnic and socioeconomic factors on ASD prevalence and diagnosis has been published (Fombonne, 2003), which included epidemiological surveys of ASD internationally, including nine studies published since the author's previous review in 1999. It is important to note that the majority of studies reviewed were conducted in European countries such as the United Kingdom and France, where the racial/ethnic and socioeconomic composition of communities is likely very different from those in the United States. Wide variations in the prevalence of ASD among minority or immigrant groups in these surveys were reported, with some finding increased prevalence among Afro-Caribbean immigrants and others finding no difference between ethnicities in the same geographical area (Fombonne, 2003).
Additionally, four studies conducted in 1980 showed associations between autism diagnosis and social class or parental education, whereas all studies conducted after this date showed no association. In this review Fombonne (2003) pointed out that studies of ASD prevalence have long been plagued by wide variations in methodology, including diagnostic instruments employed, if any; the use of diagnostic criteria that have changed over time, including a lack of criteria in diagnostic manuals prior to 1982; small sample sizes, especially for minority racial/ethnic groups; and the paucity of data examining negative cases in ascertainment studies to determine rates of missed cases.

More recent studies of disparities in ASD prevalence in the U.S. have employed three main methodologies and datasets: the National Survey of Children's Health (NSCH), the Autism and Developmental Disabilities Monitoring (ADDM) network, and Medicaid insurance claim review. The NSCH is a nationally representative random-digit-dial telephone survey including households from all 50 states, with interviews conducted in English, Spanish, and four Asian languages (Schieve et al., 2012). ASD status was ascertained for one child age 3-17 in each home by parent responses to the following questions: "Were you ever told by a doctor or other health care provider that your child had autism, Asperger's disorder, pervasive developmental disorder, or another autism spectrum disorder?" and "Does your child currently have autism or ASD?" (Schieve et al., 2012). The NSCH methodology and ASD-associated findings are limited by the exclusive parent-report nature of ASD case ascertainment and symptom severity; these reports are not verified by record review or direct assessment. Additionally, these studies do not elicit responses from parents of children under the age of three by design, and may therefore underestimate prevalence increases in underserved groups in recent years following the push for early screening and identification. Finally, although evaluation data were abstracted, a wide
variety of measures and administrations were likely included and there is no way to ensure standardization of diagnostic procedures in these studies.

NSCH Methodology

The first report of data from NSCH included survey year 2003 and examined associations between child race/ethnicity and family poverty status and ASD diagnosis, and also survey questions related to access to healthcare (Liptak et al., 2008). The data presented were weighted to produce nationally representative estimates of the non-institutionalized ASD prevalence for children in 2003. Liptak and colleagues (2008) found that the prevalence of ASD was lower for Latinos (26/10,000) than for non-Latinos (51/10,000), comparable rates for Whites and African Americans, and that the lowest preschool rate of autism occurred in children whose family income was at less than 100% of the poverty level (16/10,000). Parents in this lowest income group and Latino parents also rated their child's ASD as more severe. The authors concluded that there is a failure to diagnose ASD early in economically disadvantaged children and that less severe ASD is likely under-diagnosed in economically disadvantaged and racial/ethnic minority children (Liptak et al., 2008).

A study of the 2007 NCSH data examined point-prevalence of ASD and the association of socio-demographic factors and current or past ASD diagnosis (Kogan et al., 2009). In an overall sample of 78,037 children the authors found a weighted point prevalence (frequency of diagnosis in a defined population at a single point in time) of 110 per 10,000 for ASD. They found that non-Latino African American children and multiracial children had significantly lower odds of ever having an ASD diagnosis than non-Latino white children, but that prevalence for Latino children was only slightly lower than non-Latino white children (Kogan et al., 2009). Additionally, parents with less than 12 years of education were more likely to report moderate to
severe symptoms for their child with ASD. While prevalence rates among racial/ethnic groups remain conflicted, this second study confirms the increased severity of ASD for children from lower SES families and subsequently the likely under-diagnosis of this disorder in its less severe forms.

Further study of the 2007 NCSH dataset explored the prevalence of ASD for racial/ethnic minority children by comparing children in two-parent households who had at least one immigrant parent to those children who had two American-born parents (Schieve et al., 2012). The authors prefaced this study by stating that limited studies in Europe and Australia found some increased risk for ASD in children whose parents were immigrants, while a single contrasting study from California found that ASD prevalence was significantly lower among children of mothers born in Mexico (Schieve et al., 2012). The study compared non-Latino White children (6.7% of whom had at least one foreign-born parent) to Latino children (69.2% of whom had at least one foreign-born parent). The authors found that, in comparison to non-Latino white children with at least one American-born parent, Latino children with one or both parents foreign-born had significantly lower ASD prevalence (adjusted prevalence ratio= 0.2), while rates were comparable for Latino children with American-born parents (Schieve et al., 2012). Latino foreign-born parents were also found to be less educated and lower income than all other groups and had the lowest percentages of family-centered care and care within a medical home. The authors cautioned that based on these data, important subgroups exist within the broad term "Latino" depending on parental nativity, and that these differences influence prevalence of ASD and access to medical care (Schieve et al., 2012).

ADDM Methodology
The second major data source and methodology for studies of ASD prevalence in the literature, ADDM, is an active surveillance system that estimates the prevalence of ASD among children 8 years old whose parents/guardians reside within 14 ADDM sites in the U.S. (Baio, 2012). ADDM does not rely on family or professional reporting of ASD diagnosis, instead, information is obtained from the child’s evaluation records to determine presence of ASD symptoms at any time from birth to the end of the year when the child turns eight. Evaluations by professional providers in multiple community sites are abstracted from records and then reviewed by trained clinicians to determine ASD case status (Baio, 2012). A child meets surveillance case definition for ASD if record exists of the child displaying behaviors consistent with DSM-IV TR criteria for Autistic Disorder, Asperger's Syndrome, or PDD-NOS; some of these ASD diagnoses would be explicitly documented in the record, while others did not have documented ASD classification but had indication in the record of social and communication deficits consistent with ASD (Mandell et al., 2009; Thomas et al., 2012). These data are frequently combined with other sources (NCHS, U.S. Census) to access household median income and overall population estimates, for example. Limitations to the ADDM methodology include a lack of SES data on specific individuals, for example family-reported income or parental education. Bias may also result from the potentially greater likelihood of missing records in low SES areas that leads to systematic exclusion of cases that may influence overall results.

Mandell and colleagues (2009) reported on a sample of 2568 children aged 8 years old (all born in 1994) from the ADDM network who met surveillance criteria for ASD. Logistic regression controlling for random effects by site estimated the association between race/ethnicity and documented ASD, adjusting for gender, birth weight, IQ, and maternal education. Children
who were African American (OR= .79), Latino (OR= .76), or Other race/ethnicity (OR= .65) were less likely than White children to have documented ASD (Mandell et al., 2009). This disparity persisted for African American children regardless of IQ, and was concentrated for children of other ethnicities when IQ was lower than 70. Additionally, children whose mothers had at least some college education were more likely to be diagnosed with ASD than children whose mothers had less than a high school diploma (Mandell et al., 2009).

A subsequent study by Durkin and colleagues (2010) examined a sample of 3680 children 8 year old children with ASD in 2002 and 2004. The sample was divided into SES tertiles (low, middle, and high), weighted for the number of 8 year olds estimated to be living in the census block group, and then census block groups were ranked based on their values on three SES indicators: percentage of families with children that had incomes above federal poverty level, percentage of adults over 25 with a bachelor's degree, and median household income (Durkin et al., 2010). Compared to all 8 year old children in the study areas, those with ASD were less likely to reside in areas classified as impoverished and more likely to live in areas with higher adult educational attainment and median household income. Prevalence of ASD increased in a dose-response manner with increasing SES for all three indicators (Durkin et al., 2010). In contrast to Mandell and colleague's (2009) findings, the authors of this study found no evidence of this gradient in prevalence of ASD with co-occurring cognitive impairment, but strong evidence of gradient when there is no co-occurring cognitive impairment (i.e., in milder cases of ASD). The authors offer their findings, in conclusion, as support of the hypothesis in epidemiological studies that the associations between SES and ASD prevalence are a result of ascertainment bias; as parent education and wealth increase, the chance that a child will receive an accurate diagnosis also increases.
More recent reports using ADDM network data have compared prevalence rates across study sites. Using a sample of 3820 children meeting ASD case criteria upon clinician review who represented the population of 8 year olds in the U.S. in 2008, Baio (2012) reported an overall estimated prevalence of 11.3 cases per 1,000 (1 in 88). Data in this sample were stratified by two factors highly associated with final case status: information source (education type source only, health type source only, or both types of sources) and the presence or absence of either an ICD-9 code for ASD or autism special education eligibility. Importantly and predictably, prevalence varied by state, with New Jersey, Arizona, and Utah having the highest, and Alabama the lowest, prevalence rates of ASD (Baio, 2012). Across all sites, non-Latino Whites (12 per 1000) had greater prevalence than non-Latino African Americans (10.2 per 1000), who had greater prevalence than Latino children (7.9 per 1000). Combined estimates indicated a 16% increase in ASD prevalence among non-Latino Whites, 42% increase in non-Latino African Americans, and 29% increase among Latino children over the study period (Baio, 2012). The author concluded that these disparities in prevalence estimates reflect under-ascertainment among racial/ethnic minority children, but that these gaps appear to be closing in many states.

Finally, two state-specific studies utilized methods similar to the ADDM network studies to examine the association between socioeconomic status, race/ethnicity, and ASD prevalence estimates. Thomas and colleagues (2012) examined a sample of 586 children with ASD in four counties in New Jersey that participated in ADDM case ascertainment. SES was estimated using median household income associated with 2000 Census tract. Prevalence was higher in White (12.5/1000) and Asian (14.0/1000) non-Latinos than in African American non-Latinos (9.0/1000) and Latinos (8.5/1000), but race/ethnicity did not predict ASD diagnosis in multivariate models (Thomas et al., 2012). Prevalence was also higher in census tracts with
median income over $90,000 (17.2/1000) than in tracts with median income below $30,000 (7.1/1000), with a prevalence ratio of 3.5 (Thomas et al., 2012). Additionally, in higher income tracts, number of evaluations was higher and median age of diagnosis lower (41 months (12-104 month range) for high income vs. 56 months (27-101 months) (Thomas et al., 2012). An association between ASD severity and income was also found in this study; prevalence of ASD with mild impairment increased with increasing income. Finally, Jarquin and colleagues (2011) reported on ASD cases identified using MADDSP, an ongoing surveillance system similar to ADDM methodology for monitoring developmental disabilities among 8 year old children living in Atlanta, Georgia. Overall, 1273 children met surveillance criteria for ASD, and the prevalence of ASD among non-Latino African American children was lower than for non-Latino white children (Jarquin, Wiggins, Schieve, & Van Naarden-Braun, 2011). Odds of eligibility for ASD-related educational services without a diagnosis was 50% greater for African American than for White children, though this association was no longer significant after accounting for SES. African American children were more likely to have Autistic Disorder (AD) and to have co-occurring intellectual disability than White children, again supporting the idea that more severe cases of ASD in underrepresented groups are frequently identified (Jarquin et al., 2011). The authors concluded that the greater proportion of African American children with more severe ASD may not reflect lower SES (this was controlled for) but instead limited community awareness of milder ASD.

Medicaid Record-Review Methodology

Other studies of differences in prevalence have looked at Medicaid records, which estimate ASD prevalence in a given area using rates of service use and reimbursement for Medicaid insurance. This methodology is limited by the inclusion of only those children who are
eligible or receiving Medicaid; this excludes children who are privately insured or uninsured. Additionally, these children are largely older than three years old, and data may be unavailable about earlier ASD diagnosis if these services were not billed through Medicaid. Finally, individual-level SES variables and ASD diagnostic evaluation data were not standardized, as data were reviewed included only insurance claims, not actual evaluations and reports by parents.

Philadelphia Medicaid specialty mental health claims identified 406 children who received at least two Medicaid claims in 1999 for AD, who were born between January 1983 and May 1996 and were no older than 3 at the time data collection began (Mandell, Listerud, Levy, & Pinto-Martin, 2002). Claims were used to identify the date of first mental health visit, first receipt of AD diagnosis, and the number of visits occurring between these dates. White children received their first AD diagnosis at 6.3 years of age, compared to 7.9 years of age for African American children, and 8.8 years for Latino children (Mandell et al., 2002). Once in treatment, African American children required three times the number of visits over a period of time three times as long as White children before receiving an AD diagnosis. A follow-up study on an overlapping sample of Medicaid-eligible children with AD found that African-American children were 2.6 times less likely than White children to have received that diagnosis on their first specialty care visit (Mandell, Ittenbach, Levy, & Pinto-Martin, 2007). Common first diagnoses included ADHD in both groups, and Conduct Disorder in African American children. In a more recent study by Mandell and colleagues (2010), national Medicaid claims from 2002-2004 were used to identify age of diagnosis and characteristics of children younger than 10 with a diagnosis of any ASD. A national total of 28,722 Medicaid-enrolled children newly diagnosed with an ASD were identified. The authors reported that Asian children were diagnosed earlier than
children in other racial and ethnic groups, and that these differences were much more pronounced for "other spectrum disorders" than for AD (Mandell et al., 2010). Children eligible for Medicaid through the income category were diagnosed earlier than those eligible through disability, foster care, or other reasons, although this difference decreased over time and children in the poorest counties in this study were diagnosed at the youngest ages. This is in contrast with previous studies with similar methodology and also studies with disparate methodology conducted on the same birth cohort.

Similar studies in California examined data from birth and diagnostic records for all children born in California between 1992 and 2000 (N= 4,906,926), 18,731 of whom were diagnosed with autism (King & Bearman, 2011). Multilevel models examining the association between individual- and community-level SES and autism diagnosis found that having older, more educated parents increased risk for autism (King & Bearman, 2011). Being on Medicaid at the time of birth was associated with decreased risk of autism in general, but these results could be further differentiated by neighborhood economic conditions: a child born on Medicaid and living in a wealthier neighborhood was, on average, about 250 percent more likely than a child living in a poorer neighborhood to be diagnosed with ASD (King & Bearman, 2011). The authors concluded that the strength of this positive SES gradient was less among later birth cohorts as diagnoses became increasingly prevalent and knowledge about the disorder diffused widely, and that the economic composition of a community mattered most when prevalence rates are rising. Finally, a follow-up study of 17,185 children with diagnosis of AD born in California between 1992 and 2001 and enrolled with California Department of Developmental Services was conducted by Fountain, King, and Bearman (2011). Child characteristics associated with later age of diagnosis with AD included minority race/ethnicity, lower parental education, the child's
mother being born outside of the U.S., and having the child's delivery paid for by Medicaid (Fountain, King, & Bearman, 2011). The effect of parental education on age of diagnosis remained robust over time. At the community level higher property value (wealthier community) was associated with earlier age at diagnosis, although modeling suggests that this effect of community economic resources is disappearing as prevalence increases and early diagnosis becomes more common (Fountain, King, & Bearman, 2011). The authors concluded that there is a persistent gap in the age of diagnosis between high and low SES children that has shrunk but not disappeared over time.

The ASD Screening Mandate and Socio-demographic Differences

The American Academy of Pediatrics (AAP) recommended screening all children for ASD in pediatric practice at both 18 and 24 months (Johnson & Myers, 2007). The AAP suggested that this universal practice would help reduce racial/ethnic and socioeconomic disparities in timing of diagnosis and referral for evaluation services that are presumed to underlie the differential prevalence rates expounded upon in the epidemiological literature review in the previous section. Early diagnosis of ASD has been associated with higher parent education and income but not with ethnicity in some studies, while others report that economically disadvantaged children and African American children are the least likely to be diagnosed under age six (Fombonne, 2003; Fountain, King, & Bearman, 2011; Liptak et al., 2008; Rosenberg, Landa, Law, Stuart, & Law, 2011). Rosenberg and colleagues (2011) found that even for families who are not impoverished, African American and multiracial toddlers were diagnosed significantly later than Asian and White toddlers.
Importance of ASD Screening in Reducing Bias

The use of formal screening tools in addition to routine surveillance for symptoms of ASD in pediatric practice has been found to increase the effectiveness of identifying children with ASD (Robins, 2008; Beeger, El Bouk, Boussaid, Terwogt, & Koot, 2009). Perhaps the mechanism by which standardized screening reduces these disparities is a reduction in the use of spontaneous clinical judgment alone, when clinicians may be more inclined to dismiss symptoms of ASD and other disorders in minorities as cultural differences (Beeger et al., 2009; Aklin & Turner, 2006). A 2003 study by Sices and colleagues utilized an experimental randomized block design to examine physician referral bias based on several clinical vignettes describing developmental delays in young children. The authors found differences in the likelihood that a physician would hypothetically refer a child for further evaluation and services based on child gender and physician gender, but not based on parent expression of concerns. Importantly, physicians were no more likely to refer children whose parents voiced developmental concerns than children whose parents were not concerned, despite considerable evidence in the literature that parental report of developmental concerns can be highly valid and accurate (Sices et al., 2003). The authors suggested that the practice of repeated, routine screening for ASD by pediatricians should reduce some of these biases at the extremely important step of referral for further evaluation of developmental delays and treatment.

In their review, Barton and colleagues (2011) suggested several factors that may contribute to these disparities in screening: barriers due to limited English language proficiency, cultural differences in interpretation of early symptoms of ASD, and differential attendance of well-child visits. Roux and colleagues (2012) additionally indicated four major barriers to implementing universal developmental and ASD screening in medical settings as recommended
by AAP: inconsistent access to preventative care and a medical home, low prevalence of screening by healthcare providers, especially for non-English speaking families, frequent use of non-standardized screening procedures, and inconsistent referrals for further evaluation when screening flags potential problems. A more recent study of implementation of screening practices in pediatric care suggests that screening may actually be more routine among practices serving Medicaid-insured and racial/ethnic minority children. Survey-based research was used to determine factors associated with pediatrician compliance with AAP screening recommendations for a) developmental screening at 9, 18 and 24 or 30 months, b) screening when concerns are raised at a surveillance visit, c) autism screening at 18 and 24 months (Arunyanart et al., 2012). The authors found that 30-45% of pediatricians reported never using standardized developmental screening at suggested intervals or when concerns are raised, and 59.8% of pediatricians screened for autism at 18 month visit, 50.2% at 24 month visit (Arunyanart et al., 2012). Additionally, differences were reported in screening rates by patient population; pediatricians were more likely to screen for developmental delay if they served a population that was more than 50% racial/ethnic minority or more than 30% Medicaid-insured, but less likely to screen for ASD in the latter case (Arunyanart et al., 2012). These physician studies indicate that efforts have been made to implement routine, universal screening for ASD in order to reduce bias that is associated with disparities in screening and diagnosis, but that not all physicians or practices have followed suit.

Most recently, Zuckerman and colleagues (2013) surveyed 267 primary care pediatricians in California about their ASD screening practices in white versus Latino children. The authors found that only 10% of pediatricians provided Spanish-language screening for general developmental delays and for ASD, and that only 29% offered Spanish ASD screening
(Zuckerman et al., 2013). Pediatricians had more difficulty assessing ASD risk for Spanish-speaking Latino children than for white children, even when recommended ASD screening was conducted or the pediatrician had greater than 25% Latino patients. The most frequent barrier to ASD identification in Latinos was access to developmental specialists.

A Novel Approach to Reducing Barriers to Screening for ASD

While the majority of the responsibility for universal screening for ASD has been placed on pediatricians, Roux and colleagues (2012) took a novel approach to reducing some of these barriers to access to developmental and ASD screening in California. The authors implemented the 2-1-1 Los Angeles County Developmental Screening Project (2-1-1), utilizing an existing resource for many underserved parents (52% of callers with young children have monthly income of less than $1000 and are publically insured or uninsured). Parents of children ages birth to five years old who called 2-1-1 in Los Angeles county for other information were offered the opportunity to participate in developmental screening over the phone using the PEDS (for general development) and the M-CHAT (ASD-specific symptoms; Roux et al., 2012). Referrals were made immediately for screen-positive children to Head Start, publicly-available diagnostic evaluation, or specialty medical care. Parents remained on the phone during these referrals so they could learn the self-advocacy process and the outcome of these referrals in the community was tracked. Participants included parents of 2896 children ages birth to five who were screened over the phone; of these, 28.2% of children screened with the PEDS were high-risk, indicating need for further evaluation, and of the children were screened with the M-CHAT, 21.2% had elevated risk for ASD (Roux et al., 2012). The authors concluded that the prevalence of high risk for developmental delay and ASD identified through the screenings, prevalence of pre-existing
developmental concerns, and large numbers of children who were not receiving any intervention at all signal unmet needs and underscore the utility of universal screening in this population.

**Preliminary Studies of M-CHAT Screening and Sociodemographic Differences**

A recent study by Scarpa and colleagues (2013) examined psychometric properties of the M-CHAT screener for ASD in a diverse, low-income sample in rural Virginia screened at their 18- and 24-month well-child pediatric visits. Participants were invited to return for additional diagnostic testing if children screened positive on the M-CHAT (n=21, 4.6%), but the standard M-CHAT follow-up interview was not administered. The authors found overall unacceptable internal consistency and reliability for the items on the M-CHAT in their sample, especially for low-income and less educated parents (Scarpa et al., 2013). For the combined sample of both screen-positive and screen-negative cases, children of parents with any education beyond high school failed a significantly higher number of M-CHAT items than children of parents who did not complete high school, but there were no significant differences by race/ethnicity, Spanish versus English language version of the M-CHAT, or income (Scarpa et al., 2013). Screen-positive responses to specific items also differed by race/ethnicity and maternal education. The authors concluded that future studies should examine differences in performance on the M-CHAT among ethnic groups in the United States, citing an unpublished preliminary study that found the screen positive rate on the M-CHAT in a Hispanic population to be nearly twice the rate of other studies (Scarpa et al., 2013). The authors go on to suggest that differential performance on the M-CHAT may indicate that certain screener items do not carry the same cultural meaning in some minority populations, that these populations have more difficulty obtaining early diagnosis despite early signs being observed by parents, or simply that parents of
these populations are not completing the forms correctly for various reasons (i.e., reading level, language issues).

Previous studies from our lab have reported racial/ethnic disparities in age of screening and timing of follow-up for toddlers, but no differences in rates of ASD versus other diagnoses (Herlihy et al., 2010; Troyb et al., 2008). We also found racial/ethnic differences in response patterns, with minority parents being more likely to endorse reverse-scored items on the M-CHAT, but were unable to control for SES in these analyses. These performance differences largely disappeared on the M-CHAT FUI, during which more information is gathered from parents about at-risk responses over the phone. Additionally, a study of children who presented for ASD evaluation after screening positive on the M-CHAT found significant but very small differences in age at evaluation based on minority versus non-minority race/ethnicity, controlling for SES (Herlihy et al., in press). While previous studies found that racial/ethnic minority and economically disadvantaged children had more severe symptom presentation at the time of their diagnosis with ASD, we found very small effect sizes for differences in a child’s presentation at the time of evaluation. This sample represented a portion of the larger screening sample used in the current study and demonstrated clear benefits of standardized, early screening for ASD in the reduction of disparities by SES and race/ethnicity observed in previous research.

The Current Study

The current study is the first of its kind to directly address the utility of the M-CHAT and its companion, the M-CHAT Follow-up Interview (FUI) among racial/ethnic minority and low income children. Additionally, the study explored patterns of responding to individual items on the screener as a potential source of the previously observed racial/ethnic differences in rate of
diagnosis. Due to a lack of individual-level SES indicators available in the current dataset, we chose to estimate SES based on neighborhood-level household median income associated with each family's census tract. These methods have been robustly employed in many of the epidemiological studies reviewed previously in this section and allow us to partial out the potential effect of SES on observed racial/ethnic differences in screener performance. The following hypotheses are offered:

**Hypotheses**

1. Children of racial/ethnic minority parents (after controlling for neighborhood-level SES) and children from lower SES neighborhoods will be older at the time of screening and experience longer delays in phone follow-up and time to evaluation than children of non-minority parents and children from higher SES neighborhoods. Differences by race/ethnicity will also be observed in M-CHAT and M-CHAT FUI total score.

2. Differences in individual item performance on the M-CHAT and M-CHAT FUI will be observed based on parent’s race/ethnicity and neighborhood-level SES. For example, children from low income families will screen positive more frequently on reverse-scored.

3. Positive predictive value (PPV) of the combined M-CHAT and M-CHAT FUI procedure for diagnosing ASD will differ by race/ethnicity, with the Minority racial/ethnic group having lower PPV.
METHODS

Participants
The study drew from a larger sample of M-CHAT screening data collected over a period of about 10 years from 1999 to 2008 at two sites: the University of Connecticut (UConn) in Storrs, CT and Georgia State University (GSU) in Atlanta, GA. These participants overlap very closely with a recently published study from our research group examining the psychometric properties of the M-CHAT (Chlebowski et al., 2013). Participants represent the full range of communities from rural to suburban to major urban centers; UConn participants resided in CT, southwestern MA, and RI while GSU participants primarily resided in the metro Atlanta, GA area. Children included in the current sample from both sites were screened with the M-CHAT at their pediatrician’s office between the ages of 16 months and 30 months, 30 days, most commonly during the course of an 18- or 24-month well-child visit. Additionally, participants were required to have valid and complete address data for inclusion, as this information was used to geocode census tract and subsequently household median income data, and also complete date of birth and date of administration of the M-CHAT.

The current dataset included 18,669 children, with 9587 (51.4%) from the UConn site and 9082 (48.6%) from the GSU site (See Table 1 for demographic data by screening site). Of these, race/ethnicity data were available for 8958 (48.0%). It is important to note that race/ethnicity data were collected at UConn beginning in June 2007 and at GSU in June 2006. Missing ethnicity data for children screened after these dates indicate parents who chose to leave this item blank on the questionnaire, as opposed to having no opportunity to report race/ethnicity prior to these dates. For analyses using median income only as a predictor, the full sample of children was used, while the subsample of 8959 was used for comparisons by race/ethnicity.
Participants in the current study represented the full range of estimated median household incomes and significant racial ethnic diversity. Of those participants for whom race/ethnicity data were collected, 6169 were White (68.9%), 1175 were Black/African American (13.1%), 545 were Hispanic/Latino (6.1%), 343 were Asian (3.8%), and 726 were Other or Biracial (8.1%). To maximize power in some analyses, race/ethnicity was coded into a bivariate variable with White children in the ethnic Majority category (n = 6169, 68.9%) and children from all other racial/ethnic categories in the ethnic Minority category (n = 2789, 31.3%). In terms of gender, 9423 (50.5%) children were male and 9001 (48.2%) were female; child gender data were missing for the remaining 1.3%. The majority of caregivers who completed the M-CHAT were mothers (87.8%).

Of the 18,669 children screened with the M-CHAT at both sites, 1630 (8.7%) screened positive. Of the screen-positive children who had race/ethnicity data available (n = 835) 414 were White (49.6%), 189 were Black/African American (22.6%), 109 were Hispanic/Latino (13.1%), 55 were Asian (6.6%), and 68 were Other/Biracial (8.1%). Attrition at this stage in the study included 388 of the screen-positive children who did not receive the M-CHAT Follow-Up Interview (M-CHAT FUI; see below) 27 because the parent refused, 88 because the family could not be contacted, and 35 because of researcher error.

Consequently, 1242 received the M-CHAT FUI and 262 (21.1%) continued to screen positive. Of the 198 FUI screen-positive children who had race/ethnicity data available 126 were White (63.6%), 32 were Black/African American (16.2%), 21 were Hispanic/Latino (10.6%), 5 were Asian (2.5%), and 14 were Other/Biracial. Of those who screened positive on the M-CHAT FUI, 147 children participated in the free developmental and diagnostic evaluation. Attrition was represented at this stage of the study for the following reasons: 65 children did not participate in
the evaluation because the parent refused, 22 did not participate because the family moved or could not be contacted, 15 met exclusionary criteria for the evaluation due to an existing sensory/motor deficit or ASD diagnosis. For the remainder of non-completers, no data were available. (See Figure 1 for a flow chart). Additionally, 39 children participated in the evaluation who did not screen positive on the M-CHAT FUI: 14 screened positive on a large number of M-CHAT items and were therefore immediately evaluated, 14 passed the M-CHAT but were evaluated due to their pediatrician red-flagging them with autism-specific concerns, and 11 were evaluated at UConn because the participant screened negative on the M-CHAT but screened positive on an additional screener used for a short period of time. It is important to note that those children who were red-flagged or screened positive on the additional screener will be excluded from analyses looking at age of FUI, age of evaluation, and trajectory from M-CHAT screening to evaluation because they did not follow the traditional participant flow through the study.

**Instruments**

*Modified Checklist for Autism in Toddlers* (M-CHAT; Robins, Fein, & Barton, 1999; Robins et al., 2001)

The Modified Checklist for Autism in Toddlers (M-CHAT) is a 23-item parent report questionnaire in a yes/no format designed to screen for behaviors seen in toddlers with ASD (Robins et al., 2001). The M-CHAT was adapted from the Checklist for Autism in Toddlers (CHAT- Baron-Cohen, Allen, & Gillberg, 1992; Baron-Cohen, Cox, & Baird, 1996). Four of the items are intended to be answered “no” instead of “yes” in order to reduce response bias. Six items were identified as “critical items” in the original publication of the M-CHAT (Robins et
al., 2001); they are thought to best predict a subsequent ASD diagnosis. A “screen positive” on
the M-CHAT requires a score of 2 of these 6 critical items failed, or 3 items failed total;
therefore, a screen-positive child’s total score ranges from 2 to 23. Internal reliability of the M-
CHAT was found to be adequate for the entire checklist and the 6 critical items (α = .85 and α =
.83 respectively) in the original study sample (Robins et al., 2001) and in a subsequent
replication study (α = .85 and α = .83; Kleinman et al., 2008). In the same study, the positive
predictive value (PPV) for receiving an ASD diagnosis of the M-CHAT screener was found to be
0.36, with a 95% confidence interval of 0.31 to 0.40. It is important to note that the 2001 sample
was composed of both low-risk (pediatrician-screened) and high-risk (already referred for Early
Intervention) participants, which influenced PPV. The M-CHAT screener can be found in
Appendix A.

*M-CHAT Follow-up Interview* (M-CHAT FUI; Robins, Fein, & Barton, 1999):

Children who screen positive on the M-CHAT received a scripted phone follow-up in which
each item failed on the screener was reviewed. The M-CHAT FUI has the same scoring as the
M-CHAT; children who fail 2 of 6 critical items or 3 items total are thought to screen positive.
Toddlers who continued to screen positive after this follow-up were offered a free developmental
and diagnostic evaluation at their respective University site. Use of the M-CHAT FUI increases
the PPV for ASD diagnosis to 0.74, with a 95% confidence interval of 0.68 to 0.80 (Kleinman et
al., 2008). The M-CHAT FUI can be found in Appendix B.

**Census Tracts**

Census tracts refer to geographical groupings within zip code areas created by the U.S. Census
Bureau (U.S. Census Bureau, 2000, <http://factfinder.census.gov) that are thought to reflect
housing areas with relatively homogeneous characteristics, such as median income and
percentage of residents living below the poverty line. In the absence of individual-level indicators of SES (i.e., household income, maternal education), recent epidemiological studies of health conditions as diverse as cancer (e.g., Shebl, Capo-Ramos, Graubard, McGlynn, & Altekruse, 2012), alcoholism (e.g., McKinney, Chartier, Caetano, & Harris, 2012) and ASD (e.g., Thomas et al., 2011) have utilized the census tract technique to compare outcomes directly by SES level, and also as a control variable when looking at racial/ethnic disparities.

In the current study, the address the parent provided at the time of screening with the M-CHAT was used to determine census tract and subsequently median income. For a small subset of children ($n=350, 1.9\%$) census tract and median income data were geocoded based on their most recent mailing address available through the larger study, rather than their residence at the time of screening, because these data were unavailable from the initial address. Median income estimates for these few children may therefore be inexact for their parents' income at the time of screening. Major analyses were subsequently compared when these children's data were included versus excluded and no significant differences emerged. Due to the large period of time over which M-CHAT screening data were collected, two different U.S. Census data collection referents were used: U.S. Census 2000 for data collected prior to 2006, and U.S. Census 2010 for data collected in 2006 or later.

Geocoding used the ArcGIS 10.1 (published by ESRI) program. An Excel spreadsheet was geocoded using ArcGIS 10.1’s address locator named “USA Geocoding Service,” which compared an address from the spreadsheet of interest with this address locator. If the address from the input table matched, it created a point at the address’s location. Geocoding created a layer of points that are placed in a specific location based on the address. As ArcGIS geocoded each address, it categorized each address as “Matched,” “Tied,” or “Unmatched” and assigned a
score, ranging from 0-100, indicating how well the address matched. Addresses that are “unmatched” do not have points created or placed on the map; and their status indicates a variety of issues, including an address that no longer exists, spelling errors, a post office box, or an address that is newer than ArcGIS’s address locator. Census tract boundaries were downloaded from the National Historical GIS (Main Page: http://www.nhgis.org; Data Finder: https://data2.nhgis.org/main). Tract boundaries for Census Years 2000 and 2010 were downloaded as a shapefile (.shp; the default file type for ArcGIS). Median Household Income data for Census Years 2000 and 2010 was also downloaded from NHGIS. Data for Year 2000 came from the actual census, while Year 2010 data came from the 2006-2010 American Community Survey. These tables were then joined to the census tract boundary shapefiles using a unique ID join field provided by NHGIS. A spatial map then joined attributes of different GIS layers together based on their location; in this case, the attributes of the census tracts (census tract number, median household income) were attached to the points that represent the specific addresses of the participants.

Furthermore, median household income data for Census Year 2000 \( (n=7076, \text{37.9}\% \text{ of total sample}) \) were adjusted to reflect the cumulative rate of inflation in the U.S. between 2000 and 2010, in order to combine these data with income data for Year 2010. Rate of inflation was drawn from the Bureau of Labor Statistics for the U.S. (www.bls.gov/cpi) Consumer Price Index, which produces data on monthly changes in the prices paid by consumers for a representative basket of goods and services, averaged over a given year. The cumulative inflation rate from 2000 to 2010 was 26.63\%, and therefore median income estimates from Census Year 2000 were transformed by an increase of 26.6\% (i.e., a reported income of $10,000 in 2000 was transformed to $12,663 in 2010 dollars). Finally, for logistic regressions, median income data were re-coded.
in units of $10,000 per year (i.e. a median income of $45,250 was coded as 4.5250) in order to make units of change more meaningful, as an increase of $1 per year is less meaningful than an increase of $10,000 per year.

Procedure

The Institutional Review Boards at the UConn and GSU approved this study. Children entered this study through screening at their 18- and/or 24-month well-child visit to a pediatrician. Research staff at GSU or UConn provided pediatricians with consent forms, M-CHAT screeners, and demographic sheets, and instructed them to give them to parents of all children ages 16-30 months attending well-child visits. For pediatric practices, this typically coincided with the 18- or 24-month well-child visit. These forms were also available in Spanish at the UConn site only; however, these data were excluded in the current study. Parents could decline to participate at any time by leaving the demographic and M-CHAT forms blank. Attrition at this point of the study was difficult to ascertain, as providers did not consistently keep track of these refusals. The demographic sheet included child and parent’s name, relationship to the child, child’s date of birth and sex, date of screening, and contact information including full address. This form was later amended to collect race/ethnicity data (at UConn in June 2007, at GSU in June 2006). At UConn parents were asked to check one or more of the following categories for their own race/ethnicity: White, Black or African American, American Indian or Native American, Asian or Pacific Islander, Native Hawaiian, Other. Additionally, they checked “yes” or “no” in response to the question “Are you Hispanic/Latino?” and had the option to write in their race/ethnicity if they chose “Other.” At GSU parents wrote in their
ethnicity in response to an open-ended question and it was coded by researchers. Ethnicity data are available for 8,959 of the total sample of 18,672 toddlers.

Providers sent these demographic forms and M-CHAT screeners to the study site, where they were scored. Parents whose children screened positive on the M-CHAT received the M-CHAT FUI over the phone in English or Spanish, conducted by research staff. Attrition at this point occurred when staff members were unable to contact the family, determined that the parent’s dominant language was something other than English or Spanish, and when parents declined to participate. If the child continued to screen positive on the M-CHAT FUI, the family was offered a free developmental evaluation for ASD-specific concerns. Parents were free to refuse this evaluation, and children were excluded from the evaluation if they had significant sensory (e.g., blindness) or motor (e.g., paralysis) deficits that would preclude the use of standardized measures. Participants who did not have transportation were provided with free taxi service to the study site or, less commonly, were offered the evaluation in their homes.

The developmental evaluation, conducted by a licensed Psychologist or a Developmental-Behavioral Pediatrician and a doctoral student in Psychology or a related discipline, included the following standardized measures: the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994) Toddler Research Version and various unpublished versions of this measure, the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, & DiLavore, 1997), the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988), the Mullen Scales of Early Learning (Mullen, 1994), and the Vineland Adaptive Behavior Scales or its revision, the Vineland-II (Vineland; Sparrow, Balla, & Cicchetti, 1984; Sparrow, Cicchetti, & Balla, 2005). ASD diagnoses were assigned using DSM-IV-TR criteria supplemented by cut-off scores on the ADOS and/or ADI, and were based on the
“gold standard” of clinical judgment (see Klin, Carter, & Sparrow, 1997). Evaluations for Spanish-speaking families were conducted by research staff who were fluent in Spanish; the use of interpreters was not required.

**Power Analysis**

The overall sample size for the current study ($N = 18,669$) provided sufficient power (power = .80, alpha = .05) to detect small effects (Cohen’s $d > .2$, $r < .1$) for multiple regression and simple correlation. The sample for whom ethnicity data were available ($n = 8958$) also provided sufficient power (power = .80, alpha = .05) to detect small effects (Cohen’s $d > .2$, $r < .1$) for multiple regression and simple correlation (Cohen, 1988).
RESULTS

Due to the existence of subgroups in the current sample by screening site, comparisons between UConn participants and GSU participants were conducted on measures of interest. Significant mean differences emerged for: estimated family median income ($\text{M}_{\text{UConn}} = 74,182.28 \text{[SD}= 26,539.02\text{], M}_{\text{GSU}} = 76,257.78 \text{[SD}= 30,821.22\text{]; } t(17,227.34)= -4.79, p<.001, d = .07\text{), age at M-CHAT (M}_{\text{UConn}} = 20.32 \text{months [SD}= 3.01\text{], M}_{\text{GSU}} = 20.67 \text{months [SD}= 3.12\text{]; } t(18,517.15)= -7.68, p<.001, d = .11\text{), M-CHAT total score (M}_{\text{UConn}} = .92 \text{[SD}= 1.59\text{], M}_{\text{GSU}} = .83 \text{[SD}= 1.37\text{]; } t(18,512.51)= 4.12, p<.001, d = .06\text{), and total time elapsed from M-CHAT screening to evaluation (M}_{\text{UConn}} = 3.27 \text{months [SD}= 2.23\text{], M}_{\text{GSU}} = 4.18 \text{months [SD}= 3.24\text{]; } t(183)= -2.26, p=.025, d = .32\text{). These significant differences between sites represent small effects (Cohen's d), but were nonetheless entered in to regression equations as covariates. No differences emerged on age at M-CHAT FUI, FUI score, time elapsed from M-CHAT screening to M-CHAT FUI, time elapsed from M-CHAT FUI to evaluation, or age at evaluation by site. Therefore, UConn and GSU samples were combined for the main analyses of this paper.

Additionally, race/ethnicity and estimated family median income were confounded, as expected. Median incomes for each racial/ethnic group in the current study were, on average: $79,270.51 (\text{SD}= 27,644.58) for the White/Majority group, $52,250.89 (\text{SD}= 20,300.32) for the Black/African American group, $55,709.17 (\text{SD}= 25,549.54) for the Hispanic/Latino group, $77,836.75 (\text{SD}= 28,585.67) for the Asian group, and $67,170.17 (\text{SD}= 25,042.67) for the Other/Biracial group. Therefore, family median income was used as a covariate in all analyses comparing groups based on race/ethnicity. Descriptive statistics for other major variables of interest are presented by racial/ethnic group in subsequent sections.
Hypothesis 1

Multiple Regression

To test the hypothesis that minority status predicts a child’s age at screening and follow-up, and delays in follow-up and evaluation (dependent variables), hierarchical multiple regressions were conducted, controlling for household median income (estimated from Census Tracts according to the procedures above) and screening site. In each hierarchical multiple regression, in step 1, median income and screening site were the independent variables; in step 2, Minority versus Majority status was entered into the step 1 equation (See Tables 2a and 2b). For these analyses, Minority versus Majority status referred to the comparison of White (Majority) participants to Minority participants (all remaining racial/ethnic groups combined).

Minority status was found to be a significant predictor of child age at M-CHAT screening ($R^2 = .017$, $ΔR^2 = .004$, $F(3, 8605)= 50.59$, $p<.001$), age at M-CHAT FUI ($R^2 = .048$, $ΔR^2 = .026$, $F(3, 646)= 10.81$, $p<.001$), and time elapsed from M-CHAT to M-CHAT FUI ($R^2 = .038$, $ΔR^2 = .016$, $F(3, 646)= 8.51$, $p<.001$). In each case, participants in the Minority racial/ethnic group were older at the time of screening (.61 months older on average) and follow-up (1.75 months older on average), and experienced longer time elapsed between the two procedures (1.02 more months elapsed on average; see means in Table 2a). Family median income alone was also negatively correlated with child age at M-CHAT ($r = -.088$, $p<.001$), age at M-CHAT FUI ($r = -.142$, $p<.001$), and time elapsed between M-CHAT and M-CHAT FUI ($r = -.129$, $p=.001$), indicating that children from lower income families were also older at screening and follow-up, and experienced longer time elapsed between the two procedures (See Tables 2b & 2c).

Minority status was not a significant predictor of child’s age at evaluation ($p = .512$), or time elapsed between M-CHAT FUI and evaluation ($p = .355$); however, the direction of these
nonsignificant effects was the same. A trend emerged for total time elapsed from M-CHAT screening to evaluation by race/ethnicity, with Minority children experiencing longer time on average (.81 months) than Majority children ($R^2 = .048, \Delta R^2 = .007, F (3, 145)= 2.46, p = .065$). Median income alone was negatively correlated with time from M-CHAT screening to evaluation as well, indicating that lower income children took longer to pass from screening to evaluation ($r = -.175, p = .016$). Median income was not significantly correlated with either age at evaluation or time elapsed from M-CHAT FUI to evaluation (See Tables 2b & 2c).

Additionally, minority status (controlling for household median income and screening site) was explored as a predictor of child’s total score on the M-CHAT and M-CHAT FUI; higher scores on each measure are more indicative of autism-specific concerns, with a clinical cut-off of 3 screen-positive items. These regressions were run on both the full sample of children with ethnicity data and also on the screen-positive only sample for each measure, as including scores from the screen negative sample will skew the total score data toward zero. Minority status was a significant predictor of M-CHAT total score in the total screening sample ($R^2 = .028, \Delta R^2 = .012, F(3, 8605)= 82.44, p<.001$), and M-CHAT total score was negatively correlated with family median income ($r = -.116, p<.001$). The direction of these effects indicate that children from the Minority group and children from lower income families had higher M-CHAT total scores on average (See Tables 2b & 2c). However, the opposite effect was observed for M-CHAT total score in the M-CHAT screen positive sample; children from the Majority group had higher scores on average ($R^2 = .021, \Delta R^2 = .003, F(3, 789)= 5.58, p = .001$). Similarly, children from higher income families had higher M-CHAT total scores in this subsample ($r = .115, p = .001$).
Minority status was also a significant predictor of M-CHAT FUI total score in the overall screening sample ($R^2 = .034$, $\Delta R^2 = .008$, $F(3, 678) = 8.02$, $p < .001$), with children in the Majority group receiving higher M-CHAT FUI scores on average than those in the Minority group. Additionally, median income was positively correlated with M-CHAT FUI total score ($r = .159$, $p < .001$), with children from higher income families receiving higher scores. In the subsample of children who screened positive on the M-CHAT FUI racial/ethnic Minority status was not a significant predictor of M-CHAT FUI score ($p = .326$). A trend emerged in the correlation between M-CHAT FUI score and median income in this subsample, with higher income children receiving higher M-CHAT FUI scores on average ($r = .106$, $p = .073$).

**ANCOVA**

Hypothesis 1 was examined in further detail by conducting univariate ANCOVAs comparing the racial/ethnic groups described previously (i.e., White, Black, Latino, Asian, and Other/Biracial), with family median income as a covariate, on outcome measures of interest. Descriptive statistics for these variables, along with $F$-tests for both median income and race/ethnicity can be found in Tables 3 and 4. It is important to note that for two major analyses the assumption of homogeneity of slopes was violated due to a significant interaction effect between racial/ethnic group and family median income. Therefore, for differences in age at M-CHAT and differences in M-CHAT total score, ANCOVAs were invalid but descriptive statistics by racial/ethnic group are presented (see Table 5). For all analyses, post-hoc contrasts between the White/Majority and Asian or Other/Biracial groups were nonsignificant.

Significant differences in mean age at M-CHAT FUI emerged between racial/ethnic groups ($F(4) = 13.43$, $p < .001$, $\eta_p^2 = .077$; Table 5). This represented a medium effect and explained 7.7% of the variance in age at M-CHAT FUI. Post-hoc contrasts comparing the
White/Majority racial/ethnic group to all others indicated that Black/African American children received the FUI at significantly older ages than White children (+1.97 months difference; \(p<.001\)), as did Hispanic/Latino children (+3.79 months; \(p<.001\)). Family median income was not a significant contributor to this effect (\(p = .959\)). Significant differences also emerged by racial/ethnic group for time elapsed from M-CHAT screening to M-CHAT FUI (\(F(4) = 6.43, \ p<.001, \ \eta^2_p = .038\)). This represented a small effect and explained 3.8% of the variance in time elapsed. Post-hoc contrasts again indicated that Black/African American children experienced longer time elapsed to follow-up than White children (+1.08 months; \(p = .005\)), as did Hispanic Latino children (+1.92 months; \(p<.001\)). Family median income was not a significant contributor to this effect (\(p = .222\)).

Child age at evaluation did not differ significantly by racial/ethnic group (see Table 5; \(p = .185\)). Time elapsed from M-CHAT FUI to evaluation also returned a nonsignificant ANCOVA overall (\(p = .354\), however, a significant contrast emerged such that Black/African American children experienced longer time elapsed than White children (+1.07 months, \(p = .047\)). Finally, significant differences in overall time elapsed from M-CHAT screening to evaluation were observed by race/ethnicity (\(F(4) = 3.86, \ p = .005, \ \eta^2_p = .085\)). This represented a medium effect and explained 8.5% of the variance in time elapsed. Post-hoc contrasts indicated that Black/African American children experienced the cumulative effect of longer elapsed time than White children (+2.32 months; \(p<.001\)). The trajectory for each racial/ethnic group as they progress from screening to follow-up to evaluation can be observed in Figure 2.

Finally, comparisons were made by race/ethnicity on M-CHAT total score and M-CHAT FUI total score (see Table 4). As mentioned previously, the ANCOVA for M-CHAT total score by race/ethnicity was invalid due to a significant interaction effect for median income and
race/ethnicity violating the assumption of homogeneity of slopes. The ANCOVA for M-CHAT FUI total score by race/ethnicity was nonsignificant ($p = .406$), however, a significant effect of median income was observed for this score ($F(1) = 5.23, p = .023, \eta^2_p = .008$). This small effect was reported previously, indicating that children from higher income families received higher scores on the M-CHAT FUI.

**Analysis of Attrition**

To aid in the interpretation of discrepancies by racial/ethnic group in child ages and time elapsed between screening procedures reported previously, an analysis of those participants who experienced attrition was conducted. Attrition was first examined for those participants who screened positive on the M-CHAT but did not participate in the M-CHAT FUI (see Method for more information about attrition at this point). Characteristics of M-CHAT FUI noncompleters by Majority versus Minority race/ethnicity are reported in Table 6. Pearson Chi-square comparison of M-CHAT FUI completers to noncompleters based on Majority versus Minority race/ethnicity returned significant results ($\chi^2 (1)= 7.55, p=.006$), with a greater number of minority participants represented in the noncompleter group. Additional $t$-test comparisons of noncompleters by race/ethnicity indicated that Minority noncompleters were significantly lower income than Majority noncompleters ($t (153)= 4.28, p<.001$; see Table 6), a reflection of the confounding of race/ethnicity and income in the overall sample. A trend also emerged for racial/ethnic Majority noncompleters to have higher M-CHAT total scores ($t (163) = -0.15, p= .084$).

Attrition was also examined for those participants who screened positive on the M-CHAT FUI but did not participate in the free, developmental and diagnostic evaluation they were offered (see Method for more information about attrition at this point). Characteristics of
evaluation noncompleters by Majority versus Minority race/ethnicity are also reported in Table 6. Pearson Chi-square comparison of evaluation completers to noncompleters based on Majority versus Minority race/ethnicity returned nonsignificant results ($\chi^2(1) = .424$, $p = .515$). Additional $t$-test comparisons of noncompleters by race/ethnicity indicated that Minority noncompleters were again significantly lower income than Majority noncompleters ($t (53) = 3.38$, $p = .001$; see Table 6). A trend also emerged for racial/ethnic Minority noncompleters to be older at the time of M-CHAT FUI than Majority noncompleters ($t (20.95) = -1.81$, $p = .084$).

**Hypothesis 2**

The second hypothesis predicted differences in individual item performance on the M-CHAT and M-CHAT FUI based on parent’s race/ethnicity and neighborhood-level SES. To test this hypothesis, logistic regressions were conducted separately for each of the 23 items on the M-CHAT and the 23 corresponding items on the M-CHAT FUI, predicting the log odds of a failing response on the item from child’s race/ethnicity (ethnic Minority versus ethnic Majority), controlling for median household income. The number and percentage of Minority versus Majority participants who screened positive on each M-CHAT item can be found in Table 7, while the same data for each M-CHAT FUI item can be found in Table 8. Hierarchical regression model results for each M-CHAT and M-CHAT FUI item are presented in Table 9. For these logistic regressions, household median income was transformed into $10,000 increments in order to represent a more interpretable unit increase in log odds than $1 increments.

For the M-CHAT screening questionnaire, significant differences by ethnicity were observed for the following items: 1 (Does your child enjoy being swung, bounced on your knee, etc?), 3 (Does your child like climbing on things, such as up stairs?), 8 (Can your child play properly with small e.g. cars or blocks without just mouthing, fiddling, or dropping them?), 10
(Does your child look you in the eye for more than a second or two?), 11 (Does your child ever seem oversensitive to noise?), 17 (Does your child look at things you are looking at?), 18 (Does your child make unusual finger movements hear his/her face?), 20 (Have you ever wondered if your child is deaf?), 21 (Does your child understand what people say?), 22 (Does your child sometimes stare at nothing or wander with no purpose?), and 23 (Does your child look at your face to check your reaction when faced with something unfamiliar?). In each case, the item was more likely to be failed by Minority ethnicity participants (see $\beta$ values in Table 9).

In contrast, on the M-CHAT FUI, ethnic Majority children were significantly more likely than ethnic Minority children to fail the following items: 2 (Does your child take an interest in other children?), 5 (Does your child ever pretend, for example, to talk on the phone or take care of a doll or pretend other things?), and 22 (Does your child sometimes stare at nothing or wander with no purpose?). These results are also presented in Table 9.

Median income was a significant predictor of scores on M-CHAT items 1, 8, 10, 11, 17, 18, 20, 22, and 23. For every $10,000 increase in median income, log odds of failing each item decreased by the proportion represented by the $\beta$ values in Table 5. This indicated that children from higher income families were less likely to fail these items. Median Income was a significant predictor of M-CHAT FUI items 1, 6, 7, 9, 13, 19, and 21. For every $10,000 increase in median income, log odds of failing Item 1 decreased by .285, indicating that children from higher income families were less likely to fail this item. The opposite pattern was observed for the remaining M-CHAT FUI items; for every $10,000 increase in median income, log odds of failing each item increased by the proportion represented by the $\beta$ values in Table 9.
Hypothesis 3

The final hypothesis stated that positive predictive value (PPV) of the combined M-CHAT and M-CHAT FUI procedure for diagnosing ASD will differ by race/ethnicity, with the Minority racial/ethnic group having lower PPV. PPV refers to the proportion of screen-positive cases that are true positives. Chi-square tests were employed to calculate and compare PPV of the M-CHAT and M-CHAT FUI together by comparing Majority versus Minority children who received ASD versus other diagnoses, among those who screened positive on the M-CHAT and FUI (see Table 10). First, comparison was made for Majority versus Minority children with ASD diagnoses being the true positive condition and all other diagnoses the false alarm condition. Overall PPV for the M-CHAT and FUI was .46, with .43 for Majority children and .52 for Minority children. The PPV difference between Majority and Minority groups was not significant (Pearson $\chi^2 = 1.45$, $df=1$, $p=.228$). A final comparison designated all developmental delays, including ASD, as the true positive condition and no diagnosis/typical development as the false alarm condition. Overall PPV for this sample was .83, with .80 for Majority children and .89 for Minority children. This difference between Majority and Minority PPV was also not significant (Pearson $\chi^2 = 2.40$, $df=1$, $p=.122$).
DISCUSSION

The American Academy of Pediatrics (AAP) recommends screening all children for ASD in pediatric practice at both 18 and 24 months (Johnson & Myers, 2007). The AAP suggested that this universal practice would help reduce the racial/ethnic and socioeconomic disparities in timing of diagnosis and referral for evaluation services that are presumed to underlie differential prevalence rates for ASD found in the epidemiological literature. Early diagnosis of ASD has been associated with higher parent education and income but not with ethnicity in some studies, while others report that economically disadvantaged children and African American children are the least likely to be diagnosed under age six, and Latino children are the least likely to carry an ASD diagnosis (Fombonne, 2003; Fountain, King, & Bearman, 2011; Liptak et al., 2008; Rosenberg, Landa, Law, Stuart, & Law, 2011). Paradoxically, screening for developmental delays and ASD may actually be more common among lower income children (i.e., those who have public health insurance) and minority children (Arunyanart et al., 2012), as a result of Medicaid requirements.

A single previous study of the utility of the M-CHAT screener (without the M-CHAT FUI) indicated that the overall internal consistently and reliability of the screener’s items was poor overall and especially for lower income and less educated respondents (Scarpa et al., 2013). Scarpa and colleagues also noted that parents with a higher level of education provided screen-positive responses to a greater number of M-CHAT items than less educated parents (parents who attained any level of education beyond high school versus parents who did not complete high school), and that screen positive rates for individual M-CHAT items also differed by education level, with less educated parents (no high school diploma) more likely failing reverse scored items. Additionally, the authors indicated that minority race/ethnicity influenced the
likelihood of screening positive on certain items (Scarpa et al., 2013). Previous, unpublished work from our research group also indicated that minority race/ethnicity parents were more likely to provide screen-positive responses to the reverse scored items that majority race/ethnicity parents, but that these differences largely disappeared when parents were administered the M-CHAT FUI (Troyb et al., 2008).

The current study was the first of its kind to directly address the utility of the M-CHAT and its companion, the M-CHAT FUI among racial/ethnic minority and low-income children in a very large sample of low-risk toddlers. Additionally, the study explored patterns of responding to individual items on the screener as a potential source of the previously observed racial/ethnic differences in rate of diagnosis. SES for each participant who completed the screener was based on neighborhood-level household median income associated with the family's census tract and was used both as a direct predictor and to control for the potential effect of SES on observed racial/ethnic differences in screener performance.

**Hypothesis 1**

The first hypothesis stated that children of racial/ethnic minority parents (after controlling for neighborhood-level SES and site of screening) and children from lower SES neighborhoods will be older at the time of screening and experience longer delays in phone follow-up and time to evaluation than children of non-minority parents and children from higher SES neighborhoods. This hypothesis was mostly upheld by the current findings, however, effect sizes and mean differences tended to be small. Minority race/ethnicity, controlling for median household income, was a significant predictor of child’s age at M-CHAT screening, with Minority children and children from lower income families being screened at later ages. While this delay in age of screening persisted, even in this population of children who were part of a
standardized, routine screening study at their pediatrician’s office, the difference of less than one month is likely not clinically significant. Interestingly, M-CHAT age could not be examined by more specific racial/ethnic groups due to a significant interaction effect between race/ethnicity and median income. This indicates that the effect of median income on M-CHAT age is not predictably similar between different racial/ethnic groups.

Second, Minority race/ethnicity, controlling for median income and screening site, was also a significant predictor of child’s age at M-CHAT FUI, with Minority and lower income children receiving follow-up at later ages. Black/African American children and Hispanic/Latino children in particular were followed-up significantly later than White children. It is important to note that these analyses excluded the population of Latino children screened whose parents’ native language is Spanish, indicating that the later age of follow-up for their screening was not due to language barriers or to the lack of availability of bilingual staff. While we are not able to assess the exact reasons for this significant lag time in follow-up for Latino and Black children in the current study, having to wait longer for follow-up to a positive screen on the M-CHAT may have clinical significance, especially as this tool is translated for use in general pediatric practice without structured support from research staff. Delays in follow-up may translate directly to delays in access to diagnostic assessment for ASD, which in turn influences timeliness of entry into ASD-specific early intervention.

Minority race/ethnicity, controlling for median income and screening site, and median income alone were also found to predict time elapsed from M-CHAT screening to M-CHAT FUI, with Minority and lower income children experiencing longer times. Specifically, Black/African American and Hispanic/Latino children had longer elapsed time on average than White children. A similar trend (though not significant) emerged for total time elapsed from M-
CHAT screening to evaluation, with Minority children experiencing longer total time spent in these procedures. Median income was a significant predictor of this variable, with lower income children experiencing longer time elapsed between screening and evaluation.

Surprisingly, child age at evaluation and time elapsed from M-CHAT FUI to evaluation were not significantly different by race/ethnicity, despite increasing disparities throughout the screening and follow-up process. This is in contrast to the existing body of literature reviewed earlier in this document on disparities in diagnosis of ASD. Evidence for these disparities was conflicting, but generally indicated that Latino and African American children, when compared to White children, had lower odds of ever having an ASD diagnosis (Kogan et al., 2009), were less likely to have a documented diagnosis of ASD in their medical record (Mandell et al., 2009), were older at age of first ASD diagnosis (Mandell et al., 2002, Mandell et al., 2010, Fountain, King, & Bearman, 2011) and, specifically for African American children, required a greater number of visits to healthcare providers before they obtained the ASD diagnosis (Mandell et al., 2002). One study found similar results; Thomas and colleagues (2012) found that although prevalence of ASD across ADDM study sites was higher for White and Asian children than for African American and Latino children, race did not predict diagnosis in multivariate models. Importantly, an analysis of differential attrition, one potential explanation for the lack of a consistently increasing disparity in age at screening, follow-up, and evaluation, and time spent progressing through these stages, found greater attrition for Minority participants only at the M-CHAT FUI stage, and few descriptive differences that would explain this effect.

Additionally, median income alone did not predict child age at evaluation. This is in contrast to the consistent findings in the literature that children from lower income families and/or who have less educated parents have the lowest rate of autism diagnosis in the preschool
years (Liptak et al., 2008), are less likely to be diagnosed with ASD (maternal education below a high school diploma- Mandell et al., 2009; income correlation with mild ASD- Thomas et al., 2012), and receive fewer evaluations and a higher median age of diagnosis (Thomas et al., 2012). Interestingly, King and Bearman (2011) found, in a sample of children in California whose births were paid for by Medicaid, that children living in wealthier neighborhoods were 250% more likely to have an ASD diagnosis than those living in poorer neighborhoods. While the rate of ASD diagnosis was not directly assessed in the current study, the lack of association between age at evaluation and median income may represent a birth-cohort effect as King and Bearman (2011) suggested in their paper: the gradients in ASD diagnosis by SES indicators have appeared to decrease over time, supposedly as awareness about the diagnosis in a community improves and access to diagnostic evaluation improves as well. Methods employed in the current study can explain this difference from prior studies for several reasons. First, the current study procedures, such as providing transportation to the study site, inherently reduced barriers to screening and evaluation for ASD for low-income children and families. Additionally, ours was not a representative epidemiological sample, nor one based on record review as in the previous studies, and therefore represented ideal conditions in the current public health climate, rather than a retrospective look at low-income children’s ability to access these services using existing infrastructure.

Unique methods employed in the current study, such as the providing transportation for families who are unable to travel

Total score on the M-CHAT and M-CHAT FUI were also compared by race/ethnicity, in both the total sample and the screen positive sample for each measure. Minority and low income
children had higher M-CHAT scores on average in the total screening sample. However, in the M-CHAT screen positive sample, higher income and Majority children received higher scores on average. Differences by racial/ethnic group could not be explored further with ANCOVAs due to the significant interaction between race/ethnicity and median income. For the M-CHAT FUI total score, Majority and higher income children had higher scores in the overall M-CHAT FUI sample. This effect was not significant in the M-CHAT FUI screen positive subsample, however, there was a trend for higher scores among children from higher income families. These findings replicate previous reports of data from subsections of this study sample that indicated Minority race/ethnicity parents were more likely to fail a greater number of items on the M-CHAT, but that this difference largely disappeared after items were explained in greater detail over the phone in the M-CHAT FUI (Troyb et al., 2008). Additionally, Scarpa and colleagues (2013) found that in a combined screen positive/screen negative sample (indicating performance on the M-CHAT), parents with educational attainment beyond high school failed a significantly greater number of items than parents who did not complete high school, while there were no differences by race, income, or administration of the Spanish versus English version of the M-CHAT. While we did not measure parental education in the current study, our proxy measure of SES, median income, returned results in the opposite direction; less wealthy parents failed a greater number of items on the M-CHAT, but the opposite effect occurred among those who screened positive and for the M-CHAT FUI.

**Hypothesis 2**

In our item-by-item analysis, differences in response emerged between Minority and Majority parents, and also by median income, thereby confirming this hypothesis. For the M-CHAT screener, all of following items were more likely to be failed by Minority parents, after
controlling for median income: 1, 3, 8, 11, 17, 18, 20, 21, 22, and 23. Scarpa and colleagues (2013), in a smaller sample of children screened with the M-CHAT, also found that Minority parents failed items 1, 11, and 18 more often. Our list of items included all four reverse-scored “foil” items on the M-CHAT, designed to reduce response bias from parents who might answer “yes” to all of the questions without reading them thoroughly. Reverse-scored items include 11 (Does your child ever seem oversensitive to noise? (e.g., plugging ears)), 18 (Does your child make unusual finger movements near his/her face?), 20 (Have you ever wondered if your child is deaf?), and 22 (Does your child sometimes stare at nothing or wander with no purpose?).

A small body of literature has examined group-based differences in responding to reverse-scored items on questionnaires. Whereas these studies mainly employed Likert scales and not questionnaires with a yes/no response format, the results may be applied to findings of the current study wherein minority participants and participants with lower SES are more likely to screen positive on reverse-scored items on the M-CHAT. Reverse-worded items are thought to have a heavier cognitive load than positively worded items, and to be more susceptible to differences in interpretation and understanding (Carlson et al., 2011). Carlson and colleagues (2011) found that the four reverse-scored items on the CES-D, which assess frequency of symptoms of depression using a 0 to 3 Likert scale, were less internally consistent than positively worded items, were associated with lower item-to-scale correlations, were more often answered atypically for the individual’s overall response pattern, and were negatively correlated with responses to psychometrically sound non-reversed items with similar content. Additionally, the rate of deviant responding on these items tended to inflate depression scores. In another study, responses to consumer research questionnaires were compared between Americans and East Asians (from Singapore, Thailand, Japan, and Korea), and the direction of item wording was
found to influence how East Asians respond (Wong, Rindfleish, & Burroughs, 2003). For the American group, reverse and forward worded items were largely equivalent, but the correlation between them was unacceptably low for East Asians. This bias was primarily attributed to the manner in which forward and reverse worded items are responded to (Wong, Rindfleish, & Burroughs, 2003). In the current study, reverse-scored items were not, in fact, reverse-worded. However, these items reflected “positive” symptoms of ASD, characterized by the presence of unusual behaviors rather than the absence of typical developmental milestones. These positive symptoms may be more difficult for parents to interpret or report on.

A second group of items that was more likely to be failed by Minority parents were those related to play: Items 1 (Does your child enjoy being swung, bounced on your knee, etc.?), 3 (Does your child like climbing on things, such as up stairs?), and 8 (Can your child play properly with small toys (e.g. cars or blocks) without just mouthing, fiddling, or dropping them?). It is possible that cultural differences in expectation about children’s play, especially physical play such as climbing and bouncing, are at work in the differential responses to these items, which are also not as directly related to the core symptoms of ASD in toddlers (e.g., Farver, Kim, & Lee, 1995). The remaining three items, 17 (Does your child look at things you are looking at?), 21 (Does your child understand what people say?), and 23 (Does your child look at your face to check your reaction when faced with something unfamiliar?) have apparently little in common.

A similar set of items on the M-CHAT screener were less likely to be failed by higher income parents than lower income parents: Items 1, 8, 10 (Does your child look you in the eye for more than a second or two?), 11, 17, 18, 20, 22, 23. This list again includes all four reverse-scored items, and though there is little research investigating SES differences in questionnaire responding, it is possible that lower income (and usually therefore less educated) parents may
have a more difficult time responding to the change in desired response format (answering no versus yes). Scarpa and colleagues (2013) compared M-CHAT responses based on parental educational attainment, another indicator of SES, and differential responses on items 15, 18, and 22 by education. They found that Item 15 was most often failed by parents with the highest level of education (any education beyond a high school diploma/GED), while items 18 and 22 were failed most often by parents without a high school diploma/GED and least often by parents with education beyond high school.

Assuming that neighborhood-level median income is highly correlated with level of educational attainment, we also looked into reading level of the individual items failed using the Flesch-Kincaid Grade Level Test feature of Microsoft Word as a potential explanation for the differences in responding observed. The Flesch-Kincaid Grade Level Test (Microsoft Word, 2010), estimates the U.S. grade level of reading to understand a document using an algorithm that combines the average sentence length (number of words/number of sentences) with the average number of syllables (number of syllables/number of words). While the overall grade level for the M-CHAT screener is 4.5 (indicating about a fourth-grade reading level), reading grade levels for individual items range from 0.0 (Item 16, Does your child walk?) to 9.0 (Item 7, Does your child ever use his/her index finger to point, to indicate interest in something?). This is a possible explanation for parents’ differential responding based on level of income to Items 8 (7.3 grade level; Can your child play properly with small toys (e.g. cars or blocks) without just mouthing, fiddling, or dropping them?) and 23 (7.6 grade level; Does your child look at your face to check your reaction when faced with something unfamiliar?). However, the remaining items (1, 10, and 17) all have a reading grade level of first or second grade and should therefore not differ based on the difficulty that less educated, lower income parents might have with
reading the items. Interestingly, items 10 and 17 assess eye contact and joint attention through
gaze shifting, which may be more difficult for parents with lower SES to assess if they have less
familiarity with or opportunity to observe their child’s gaze shifting. However, one study found
that frequency and persistence of joint attention was unrelated to race or SES in dyads with
typically developing infants (Farrant & Zubrick, 2011; Saxon & Reilly, 1999).

The M-CHAT FUI is a follow-up interview administered over the phone to parents with
additional explanation of the intended content of items failed on the M-CHAT paper-and-pencil
screener. Controlling for median income, racial/ethnic Majority parents were more likely than
Minority parents to screen positive on items 2 (Does your child take an interest in other
children?), 5 (Does your child ever pretend, for example, to talk on the phone or take care of a
doll or pretend other things?), and 22 (Does your child sometimes stare at nothing or wander
with no purpose?). This is in contrast to the pattern observed for M-CHAT screener responses
where Minority parents were more likely to fail all of the items that were significant. Items 2 and
5 reflect core symptoms of ASD in toddlers, delayed pretend play and lack of or lower interest in
peers (APA, 2000). It is possible that cultural differences in parents’ expectations of social
behavior in toddlers or differential opportunities for pretend play and play with peers may
underlie these differences in responding, even when controlling for the effect of neighborhood-
level SES.

Also on the M-CHAT FUI, parents with higher income were less likely to fail Item 1
(Does your child enjoy being swung, bounced on your knee, etc.) but more likely to fail items 6
(Does your child ever use his/her index finger to point, to ask for something?), 7 (Does your
child ever use his/her index finger to point, to indicate interest in something), 9 (Does your child
ever bring objects over to you (parent) to show you something?), 13 (Does your child imitate
you? (e.g., you make a face—will your child imitate it?), 19 (Does your child try to attract your attention to his/her own activity?), and 21 (Does your child understand what people say?). Items 7, 9, and 13 are critical items (thought to be most predictive of later ASD diagnosis if failed on the M-CHAT or M-CHAT FUI; Robins et al., 2008), while items 6, 19, and 21 are also face-valid core symptoms of ASD. While not borne out in differential rates of ASD diagnosis in this sample, it is therefore important to consider lower income parents’ awareness of and ability to raise concern about core symptoms of ASD, even using a structured follow-up phone interview, as they are less likely to endorse these symptoms than higher income parents and therefore their children may be missed with early screening. This is in line with the robust finding that lower income, less educated parents have children who are diagnosed later with ASD (Fountain, King and Bearman, 2011; Thomas et al., 2012), perhaps because they do not raise concerns with pediatricians about more subtle but important early symptoms such as those assessed with items 7 (pointing to indicate interest) and 19 (attracting attention to their own activity).

**Hypothesis 3**

The final hypothesis stated that positive predictive value (PPV) of the combined M-CHAT and M-CHAT FUI procedure for diagnosing ASD will differ by race/ethnicity, with the Minority racial/ethnic group having lower PPV. This hypothesis was not supported; the overall PPV comparing the ASD group to the group with all other diagnoses was .46, and there was no difference in PPV between racial/ethnic Minority children and Majority children. This is in contrast to previous studies that have reported significantly lower likelihood of racial/ethnic Minority children being diagnosed with ASD in comparison to White children (Fombonne, 2003; Fountain, King, & Bearman, 2011; Liptak et al., 2008; Rosenberg et al., 2011) and is possible
evidence of the importance of routine, standardized screening in reducing disparities in rate of ASD diagnosis in young children. Additionally, the PPV of the M-CHAT + M-CHAT FUI in differentiating between typically developing children and those who have some type of developmental delay, including ASD, who would benefit from early intervention was excellent (.83 overall, no difference by race/ethnicity).

Conclusions

Small but significant disparities by race/ethnicity, controlling for median income, were observed in child age at M-CHAT screening, age at M-CHAT FUI, and time elapsed from M-CHAT to FUI, with Black/African American and Hispanic/Latino children screened and followed-up at later ages, despite standardized screening procedures. However, these discrepancies did not persist to the provision of a free, developmental and diagnostic evaluation for ASD, perhaps due to differential attrition by race/ethnicity at the M-CHAT FUI phase.

Minority children, controlling for median income, and lower income children also had higher scores on the M-CHAT on average, but Majority and higher income children among those who ended up screening positive on the M-CHAT had higher scores. For the M-CHAT FUI, Majority children and higher income children had higher scores overall.

Parent responses to individual items on the M-CHAT also differed by race/ethnicity and by median income, with Minority and lower income children being more likely to screen positive on a number of items, including all four reverse-scored items. For the M-CHAT FUI, Majority children were more likely to screen positive on three items. Lower income children were more likely to screen positive on item 1, while higher income children were more likely to screen positive on a set of items, none of which was a reverse-scored item.
Finally, there were no significant differences in the PPV of the M-CHAT + M-CHAT FUI procedure based on racial/ethnic group, in contrast to previous studies indicating a decreased rate of ASD diagnosis among racial/ethnic Minority children. This likely reflects the highly standardized and expedient procedures for accessing diagnostic evaluation for all children in the current study, in spite of the small disparities in timing of screening and follow-up, and performance of individual M-CHAT items, based on race/ethnicity. In conclusion, the standardized screening procedures employed in the current study largely eliminated clinically significant disparities in screening, follow-up, and evaluation for ASD in toddlers. Important differences in item response patterns emerged by both race/ethnicity and SES, underscoring the need for vigilance and support for parent understanding of M-CHAT items in pediatric practice.

Limitations and Future Directions

Although the current study was the first of its kind to examine the utility of the M-CHAT and the M-CHAT FUI among racial/ethnic minority and low-income children in a very large sample of low-risk toddlers, certain limitations must be acknowledged. First, median income data used in the current study were extrapolated based on neighborhood-level census tract data from either the 2000 or 2010 census years and were not directly collected from participants. These data are therefore estimates and may not reflect a family’s exact income or be an accurate reflection of their socioeconomic status at the time of screening with the M-CHAT. However, these methods have been widely used in large-scale epidemiological work where SES data were not collected from individuals for a variety of reasons (See McKinney et al., 2012; Shebl et al., 2012; Thomas et al., 2011) and appear to be robust. The alternative, to conduct analyses based on race/ethnicity without controlling for some indicator of SES would have proven less informative overall. Additionally, for a small portion of the sample census tracts and median income data
were based on most current mailing address because the address at the time of screening was unavailable. However, we found no difference in our major analyses when this subsample was excluded. Future studies should examine differences in the screening process and responses to individual item in samples where SES data, either family income or maternal education level, were collected directly by parent report along with screening data.

A second limitation of the current study was the use of a heterogeneous racial/ethnic Minority group in some analyses, which combined all groups other than White individuals. Despite the large sample size employed in the current study, the small number of participants representing certain racial/ethnic groups (i.e. Asian, Other/Biracial) necessitated the combination of these groups for major analyses. While this is common practice in research of this kind, we are aware that important variation in response styles to the M-CHAT, in interpretation of individual items, and in PPV of the M-CHAT could be masked by the combination of disparate groups into a single comparison group. This is especially true because income was so different across the groups, with families in the Asian and Other/Biracial groups having higher incomes. Whenever possible, analyses were also examined by more specific racial/ethnic groupings. Future studies should seek to examine the efficacy of the M-CHAT screener in specific racial/ethnic Minority populations and possibly employ parent focus groups to better understand the patterns of differential timing of screening and follow-up and differential item responses in various groups.

Thirdly, it is important to note that the Hispanic/Latino group in the current study consisted of only those parents who completed the English-language version of the M-CHAT screener and whose child participated in a diagnostic evaluation in English. Our sample of Spanish-speakers who followed the same study procedures was excluded from the current study.
because their trajectory through the screening process and diagnostic evaluation procedures were significantly different from those participants who spoke English. While this limits the validity of the current findings to English-speaking Hispanic/Latino populations in the United States, the decision to examine Spanish-speakers separately is supported by very recent research that differentiates between recently immigrated Spanish-speaking populations and Hispanic/Latino populations born in the U.S. and/or who speak English (e.g., Schieve et al., 2012). Future studies will make direct comparison of Spanish-speaking respondents to the M-CHAT Spanish translation and to English-speaking Hispanic/Latino participants to determine if there are disparities based on language proficiency or level of acculturation to results of screening for ASD using the M-CHAT.

Additionally, the current study combined two large datasets from screening sites at the University of Connecticut and Georgia State University. These datasets were combined in order to achieve the largest possible sample size for making comparisons, to include the largest sample of racial/ethnic Minority participants possible, and to sample from families living in the entire range of settings, from large cities, to greater metropolitan areas, to suburbs and rural towns. While this diversity in terms of participant race/ethnicity and living situation is an asset, there are likely differences between Georgia and Connecticut in the socioeconomic landscape that may have an unknown impact on our results. When directly assessed, significant differences emerged by screening site, therefore, screening site was entered as a covariate in regression analyses. However, these differences represented very small effects that are likely not clinically significant and therefore the benefit of a large, diverse sample outweighed the possible heterogeneity of our findings. Future studies should seek to screen a representative population of each state to determine if there are systematic differences in pediatric care practice, for example, that
contribute to widely different rates or efficiency of screening for ASD in toddlers, or to differences in how participants interpret and response to individual items on the M-CHAT.

Finally, the screening procedures employed in the current study were standardized and included significant research staff support to pediatric practices to move participants through the screening, follow-up, and evaluation process. In fact, pediatric practices were responsible for distributing and collecting the paper-and-pencil questionnaire from parents of toddlers who attended pediatric visits between the ages of 16-30 months, whereas University staff from each site was responsible for screener scoring, follow-up, and diagnostic evaluations. Therefore, the very small disparities by race/ethnicity and SES found in the current study should not be considered equivalent to what might be anticipated from the traditional avenues by which toddlers come to be diagnosed with ASD. Future studies should be translational in nature, examining the effectiveness of the M-CHAT and M-CHAT FUI as administered by pediatric practice staff entirely, and the efficacy of existing systems for diagnostic evaluation referrals. This will offer further evidence in support of using standardized, routine screening for ASD in toddlers as a means for reducing racial/ethnic and socioeconomic disparities in access to diagnosis and hopefully early intervention.
### Comparison of main variables of interest by site

<table>
<thead>
<tr>
<th>Variable</th>
<th>UConn</th>
<th>GSU</th>
</tr>
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<tr>
<td>Median Income (adjusted 2010 dollars)</td>
<td>$74,178.28 (26,539.02)</td>
<td>$76,257.78 (30,821.22)</td>
</tr>
<tr>
<td>Age at M-CHAT (months)</td>
<td>20.32 (3.01)</td>
<td>20.67 (3.12)</td>
</tr>
<tr>
<td>M-CHAT Total Score</td>
<td>.92 (1.59)</td>
<td>.83 (1.37)</td>
</tr>
<tr>
<td>Time elapsed M-CHAT to Eval</td>
<td>3.27 (2.23)</td>
<td>4.18 (3.24)</td>
</tr>
</tbody>
</table>
### Table 2a.

**Descriptives for multiple regressions**

<table>
<thead>
<tr>
<th></th>
<th>Overall Mean (SD)</th>
<th>Majority Mean (SD)</th>
<th>Minority Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age M-CHAT</strong></td>
<td>20.26 (3.07)</td>
<td>20.27 (2.98)</td>
<td>20.88 (3.24)</td>
</tr>
<tr>
<td><strong>Time M-CHAT to FUI</strong></td>
<td>2.80 (2.86)</td>
<td>2.32 (2.13)</td>
<td>3.44 (3.43)</td>
</tr>
<tr>
<td><strong>Age FUI</strong></td>
<td>23.58 (4.40)</td>
<td>22.76 (3.57)</td>
<td>24.51 (5.02)</td>
</tr>
<tr>
<td><strong>Time FUI to Eval</strong></td>
<td>1.94 (1.97)</td>
<td>1.86 (2.08)</td>
<td>2.09 (1.77)</td>
</tr>
<tr>
<td><strong>Age Eval</strong></td>
<td>25.28 (4.07)</td>
<td>25.20 (3.99)</td>
<td>25.45 (4.27)</td>
</tr>
<tr>
<td><strong>Time M-CHAT to Eval</strong></td>
<td>3.56 (2.57)</td>
<td>3.29 (2.52)</td>
<td>4.10 (2.62)</td>
</tr>
<tr>
<td><strong>M-CHAT Total Score</strong></td>
<td>0.86 (1.56)</td>
<td>0.71 (1.47)</td>
<td>1.18 (1.70)</td>
</tr>
<tr>
<td><strong>M-CHAT Total (Screen +)</strong></td>
<td>4.52 (2.64)</td>
<td>4.80 (2.97)</td>
<td>4.25 (2.23)</td>
</tr>
<tr>
<td><strong>FUI Total Score</strong></td>
<td>1.92 (2.94)</td>
<td>2.35 (3.22)</td>
<td>1.45 (2.53)</td>
</tr>
<tr>
<td><strong>FUI Total (Screen +)</strong></td>
<td>5.66 (3.22)</td>
<td>5.81 (3.34)</td>
<td>5.39 (2.99)</td>
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</table>

### Table 2b.

**Multiple regressions predicting child age at M-CHAT, M-CHAT FUI, and evaluation, and M-CHAT and M-CHAT FUI total scores**

<table>
<thead>
<tr>
<th>Regression Model</th>
<th>R²</th>
<th>ΔR²</th>
<th>F</th>
<th>df</th>
<th>p</th>
<th>Med. Income</th>
<th>Site</th>
<th>Minority/Majority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age M-CHAT</td>
<td>0.017</td>
<td>0.004</td>
<td>50.591</td>
<td>3, 8605</td>
<td>&lt;.001</td>
<td>-0.065</td>
<td>0.07</td>
<td>0.066</td>
</tr>
<tr>
<td>Time M-CHAT to FUI</td>
<td>0.038</td>
<td>0.016</td>
<td>8.509</td>
<td>3, 646</td>
<td>&lt;.001</td>
<td>-0.073</td>
<td>-0.043</td>
<td>0.129</td>
</tr>
<tr>
<td>Age FUI</td>
<td>0.048</td>
<td>0.026</td>
<td>10.813</td>
<td>3, 646</td>
<td>&lt;.001</td>
<td>-0.048</td>
<td>-0.081</td>
<td>0.162</td>
</tr>
<tr>
<td>Time FUI to Eval</td>
<td>0.023</td>
<td>0</td>
<td>1.09</td>
<td>3, 646</td>
<td>&lt;.001</td>
<td>-0.056</td>
<td>0.123</td>
<td>0.019</td>
</tr>
<tr>
<td>Age Eval</td>
<td>0.016</td>
<td>0.001</td>
<td>0.771</td>
<td>3, 646</td>
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<td>-0.032</td>
<td>-0.121</td>
<td>0.031</td>
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<tr>
<td>Time M-CHAT to Eval</td>
<td>0.048</td>
<td>0.007</td>
<td>2.46</td>
<td>3, 646</td>
<td>0.065</td>
<td>-0.121</td>
<td>0.096</td>
<td>0.088</td>
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<td>M-CHAT Total Score</td>
<td>0.028</td>
<td>0.012</td>
<td>82.443</td>
<td>3, 8605</td>
<td>&lt;.001</td>
<td>-0.075</td>
<td>-0.053</td>
<td>0.111</td>
</tr>
<tr>
<td>M-CHAT Total (Screen +)</td>
<td>0.021</td>
<td>0.003</td>
<td>5.578</td>
<td>3, 789</td>
<td>0.001</td>
<td>0.076</td>
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<td>-0.059</td>
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<td>FUI Total Score</td>
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<td>0.008</td>
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<td>-0.093</td>
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<td>0.001</td>
<td>1.162</td>
<td>3, 8605</td>
<td>0.326</td>
<td>0.08</td>
<td>-0.081</td>
<td>-0.024</td>
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Table 2c.

*Correlations for multiple regressions*

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<th>Med. Income</th>
<th>Site</th>
<th>Minority/ Majority</th>
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<td></td>
<td>r</td>
<td>p</td>
<td>r</td>
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<tr>
<td>Age M-CHAT</td>
<td>-0.088</td>
<td>&lt;.001</td>
<td>0.07</td>
</tr>
<tr>
<td>Time M-CHAT to FUI</td>
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<td>&lt;.001</td>
<td>-0.032</td>
</tr>
<tr>
<td>Age FUI</td>
<td>-0.129</td>
<td>0.001</td>
<td>-0.069</td>
</tr>
<tr>
<td>Time FUI to Eval</td>
<td>-0.084</td>
<td>0.158</td>
<td>0.135</td>
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<tr>
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<td>0.016</td>
<td>0.129</td>
</tr>
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<td>-0.071</td>
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<td>FUI Total (Screen +)</td>
<td>0.106</td>
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Table 3.

**Descriptives for ANCOVAs by racial/ethnic group for timing of screening**

<table>
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<tr>
<th>Outcome variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-CHAT Age (months)</td>
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<td>5948</td>
<td>20.27</td>
<td>2.98</td>
<td>16.00 - 30.66</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1114</td>
<td>21.10</td>
<td>3.31</td>
<td>16.00 - 30.46</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>523</td>
<td>21.25</td>
<td>3.42</td>
<td>16.00 - 30.98</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>330</td>
<td>20.33</td>
<td>3.04</td>
<td>16.00 - 30.00</td>
</tr>
<tr>
<td></td>
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<td>20.45</td>
<td>2.99</td>
<td>16.00 - 30.00</td>
</tr>
<tr>
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<td>3.08</td>
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</tr>
<tr>
<td>FUI Age (months)</td>
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<td>22.76</td>
<td>3.57</td>
<td>16.85 - 36.00</td>
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<td>24.73</td>
<td>5.10</td>
<td>16.00 - 43.00</td>
</tr>
<tr>
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<td>L</td>
<td>73</td>
<td>26.55</td>
<td>5.51</td>
<td>16.89 - 41.87</td>
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<td>A</td>
<td>44</td>
<td>23.09</td>
<td>4.05</td>
<td>18.00 - 32.69</td>
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<tr>
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<td>22.28</td>
<td>3.45</td>
<td>18.00 - 34.00</td>
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<td>4.40</td>
<td></td>
</tr>
<tr>
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<td>2.13</td>
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</tr>
<tr>
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<td>B</td>
<td>137</td>
<td>3.40</td>
<td>3.79</td>
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</tr>
<tr>
<td></td>
<td>L</td>
<td>73</td>
<td>4.24</td>
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</tr>
<tr>
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<td>A</td>
<td>44</td>
<td>2.97</td>
<td>2.49</td>
<td>0 - 11.00</td>
</tr>
<tr>
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<td>O/B</td>
<td>53</td>
<td>2.24</td>
<td>1.88</td>
<td>0 - 9.23</td>
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<tr>
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<td>2.80</td>
<td>2.86</td>
<td></td>
</tr>
<tr>
<td>Eval Age (months)</td>
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<td>118</td>
<td>25.28</td>
<td>4.06</td>
<td>17.00 - 37.00</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>26</td>
<td>26.76</td>
<td>4.25</td>
<td>20.00 - 34.00</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>14</td>
<td>26.28</td>
<td>4.45</td>
<td>19.93 - 35.00</td>
</tr>
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<td></td>
<td>A</td>
<td>5</td>
<td>23.80</td>
<td>3.27</td>
<td>21.00 - 29.00</td>
</tr>
<tr>
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<td>O/B</td>
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<td>23.55</td>
<td>4.06</td>
<td>19.00 - 29.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>173</td>
<td>25.44</td>
<td>4.13</td>
<td></td>
</tr>
<tr>
<td>Time elapsed FUI to Eval (months)</td>
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<td>100</td>
<td>1.82</td>
<td>2.04</td>
<td>0 - 15.00</td>
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<tr>
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<td>2.89</td>
<td>2.62</td>
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<td>2.13</td>
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<td>1.52</td>
<td>0.98</td>
<td>.51 - 3.00</td>
</tr>
<tr>
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<td>1.43</td>
<td>.16 - 4.90</td>
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<td>2.06</td>
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<tr>
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<td>118</td>
<td>3.31</td>
<td>2.46</td>
<td>.33 - 16.00</td>
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<tr>
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<td>5.63</td>
<td>4.17</td>
<td>.48 - 13.00</td>
</tr>
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<td>L</td>
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<td>1.92</td>
<td>.48 - 7.59</td>
</tr>
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<td>1.30 - 4.00</td>
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<td>1.14</td>
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<td>2.79</td>
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</tbody>
</table>

*Note. W: White, B: Black/African American, L: Hispanic/Latino, A: Asian, O/B: Other/Biracial*
Table 4.

**Descriptives for ANCOVAs by racial/ethnic group for screener score**

<table>
<thead>
<tr>
<th>Outcome variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>M-CHAT Total Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>5948</td>
<td>0.71</td>
<td>1.47</td>
<td>0 - 19</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1114</td>
<td>1.26</td>
<td>1.82</td>
<td>0 - 18</td>
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<td></td>
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<td>1.41</td>
<td>1.80</td>
<td>0 - 11</td>
</tr>
<tr>
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<td>A</td>
<td>330</td>
<td>1.22</td>
<td>1.51</td>
<td>0 - 11</td>
</tr>
<tr>
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<td>0.87</td>
<td>1.45</td>
<td>0 - 12</td>
</tr>
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<td>0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FUI Total Score</td>
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<td></td>
</tr>
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<td>W</td>
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<td>3.22</td>
<td>0 - 19</td>
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<td>2.78</td>
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<td>1.63</td>
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<td>0.96</td>
<td>1.93</td>
<td>0 - 10</td>
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<tr>
<td></td>
<td>O/B</td>
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<td>1.51</td>
<td>2.46</td>
<td>0 - 12</td>
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<td>682</td>
<td>1.92</td>
<td>2.94</td>
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</table>

*Note.* W: White, B: Black/African American, L: Hispanic/Latino, A: Asian, O/B: Other/Biracial
Table 5.

**ANCOVAs for outcome variables by racial/ethnic group, controlling for median income.**

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>Median Income</th>
<th>Ethnicity</th>
<th>Contrasts</th>
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<td>4</td>
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</tr>
<tr>
<td>FUI Age (months)</td>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>Time M-CHAT to FUI (months)</td>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>Evaluation age (months)</td>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>Time FUI to Eval (months)</td>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>Time M-CHAT to Eval (months)</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>M-CHAT Total Score</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>FUI Total Score</td>
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<td>4</td>
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<table>
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<th>p</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
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<td>&lt;.001</td>
<td>4</td>
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<td>0.007</td>
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</tr>
<tr>
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<td>ns</td>
<td>0.959</td>
<td>4</td>
<td>13.43</td>
<td>0.077</td>
<td>&lt;.001</td>
<td>B &gt; W ($p &lt; .001$)</td>
</tr>
<tr>
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<td>1.50</td>
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<td>0.222</td>
<td>4</td>
<td>6.43</td>
<td>0.038</td>
<td>&lt;.001</td>
<td>B &gt; W ($p = .005$)</td>
</tr>
<tr>
<td>1</td>
<td>0.05</td>
<td>ns</td>
<td>0.831</td>
<td>4</td>
<td>1.57</td>
<td>ns</td>
<td>0.185</td>
<td>B &gt; W ($p &lt; .001$)</td>
</tr>
<tr>
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<td>0.15</td>
<td>ns</td>
<td>0.696</td>
<td>4</td>
<td>1.11</td>
<td>ns</td>
<td>0.354</td>
<td>B &gt; W ($p = .047$)</td>
</tr>
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<td>ns</td>
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<td>4</td>
<td>3.86</td>
<td>0.085</td>
<td>0.005</td>
<td>B &gt; W ($p &lt; .001$)</td>
</tr>
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<td>1.00</td>
<td>ns</td>
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<td>ns</td>
</tr>
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</table>

**Note.** $\S$ANCOVA invalid due to significant interaction between ethnicity and median income variables.
Table 6.

Attrition characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Noncompleters of M-CHAT FUI</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Majority</td>
<td>Minority</td>
<td>df</td>
<td>t</td>
</tr>
<tr>
<td>Median Income</td>
<td>$70,435.55 (29,937.60)</td>
<td>$52,321.06 (22,444.37)</td>
<td>153</td>
<td>4.28</td>
</tr>
<tr>
<td>M-CHAT Age (months)</td>
<td>20.92 (3.18)</td>
<td>20.96 (3.23)</td>
<td>163</td>
<td>-0.154</td>
</tr>
<tr>
<td>M-CHAT Total Score</td>
<td>4.68 (3.25)</td>
<td>3.96 (2.10)</td>
<td>101.11</td>
<td>1.599</td>
</tr>
</tbody>
</table>

Noncompleters of Evaluation

| Variables                      | Majority                      | Minority    | df | t   | p   |
|-------------------------------|-------------------------------|-------------|--------------|---------------|
| Median Income                 | $65,849.62 (261,723.1)        | $43,790.27 (194,61.01) | 53 | 3.376 | 0.001 |
| M-CHAT Age (months)           | 20.63 (3.19)                 | 21.53 (3.97) | 56 | -0.951 | 0.346 |
| FUI Age (months)              | 22.16 (2.98)                 | 25.34 (7.05) | 20.95 | -1.814 | 0.084 |
| Time M-CHAT to FUI (months)   | 1.77 (1.69)                  | 3.51 (4.52) | 20.09 | -1.566 | 0.133 |
| M-CHAT Total Score            | 6.29 (4.07)                  | 6.13 (2.75) | 56 | 0.16 | 0.873 |
| FUI Total Score               | 5.26 (3.51)                  | 4.00 (2.32) | 56 | 1.513 | 0.136 |
### Table 7.

**Participants by racial/ethnic group who screened positive on M-CHAT items**

<table>
<thead>
<tr>
<th>Item #</th>
<th>Item content</th>
<th>Overall Sample</th>
<th>Screen Positive Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Screen Positive Maj. (%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Screen Positive Min. (%)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>M1</td>
<td>Enjoy being swung, bounced?</td>
<td>53 (42.4)</td>
<td>72 (57.6)</td>
</tr>
<tr>
<td>M2</td>
<td>Interest in other children?</td>
<td>82 (62.6)</td>
<td>49 (37.4)</td>
</tr>
<tr>
<td>M3</td>
<td>Like climbing on things?</td>
<td>27 (47.4)</td>
<td>30 (52.6)</td>
</tr>
<tr>
<td>M4</td>
<td>Enjoy playing peek-a-boo?</td>
<td>26 (50.0)</td>
<td>26 (50.0)</td>
</tr>
<tr>
<td>M5</td>
<td>Play pretend?</td>
<td>134 (71.3)</td>
<td>54 (28.7)</td>
</tr>
<tr>
<td>M6</td>
<td>Point to ask for something?</td>
<td>171 (64.0)</td>
<td>96 (36.0)</td>
</tr>
<tr>
<td>M7</td>
<td>Point to indicate interest?</td>
<td>166 (64.1)</td>
<td>93 (35.9)</td>
</tr>
<tr>
<td>M8</td>
<td>Play properly with small toys?</td>
<td>92 (44.0)</td>
<td>117 (56.0)</td>
</tr>
<tr>
<td>M9</td>
<td>Bring objects over to show?</td>
<td>86 (64.2)</td>
<td>48 (35.8)</td>
</tr>
<tr>
<td>M10</td>
<td>Look you in the eye?</td>
<td>82 (54.7)</td>
<td>68 (45.3)</td>
</tr>
<tr>
<td>M11</td>
<td>Oversensitive to noise?</td>
<td>1001 (60.8)</td>
<td>646 (39.2)</td>
</tr>
<tr>
<td>M12</td>
<td>Responsive smile?</td>
<td>11 (47.8)</td>
<td>12 (52.2)</td>
</tr>
<tr>
<td>M13</td>
<td>Does child imitate you?</td>
<td>243 (67.5)</td>
<td>117 (32.5)</td>
</tr>
<tr>
<td>M14</td>
<td>Respond to name?</td>
<td>53 (61.6)</td>
<td>33 (38.4)</td>
</tr>
<tr>
<td>M15</td>
<td>Looks to follow point?</td>
<td>115 (61.5)</td>
<td>72 (38.5)</td>
</tr>
<tr>
<td>M16</td>
<td>Does child walk?</td>
<td>72 (76.6)</td>
<td>22 (23.4)</td>
</tr>
<tr>
<td>M17</td>
<td>Look at what you're looking at?</td>
<td>72 (53.3)</td>
<td>63 (46.7)</td>
</tr>
<tr>
<td>M18</td>
<td>Unusual finger movements?</td>
<td>617 (48.5)</td>
<td>655 (51.5)</td>
</tr>
<tr>
<td>M19</td>
<td>Attract attention to activity?</td>
<td>314 (65.3)</td>
<td>167 (34.7)</td>
</tr>
<tr>
<td>M20</td>
<td>Wondered if child is deaf?</td>
<td>125 (53.9)</td>
<td>107 (46.1)</td>
</tr>
<tr>
<td>M21</td>
<td>Understand what people say?</td>
<td>72 (53.7)</td>
<td>62 (46.3)</td>
</tr>
<tr>
<td>M22</td>
<td>Stare at nothing or wander?</td>
<td>582 (51.2)</td>
<td>554 (48.8)</td>
</tr>
<tr>
<td>M23</td>
<td>Look to check your reaction?</td>
<td>228 (60.5)</td>
<td>149 (39.5)</td>
</tr>
</tbody>
</table>

<sup>a</sup> # Screen positive who were Majority race/ethnicity (% of screen positive who were Majority)

<sup>b</sup> # Screen positive who were Minority race/ethnicity (% of screen positive who were Minority)
### Table 8.

Participants by racial/ethnic group who screened positive on M-CHAT FUI items.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Item content</th>
<th>Overall Sample</th>
<th>Screen Positive Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Screen Positive Maj. (%)</td>
<td>Screen Positive Min. (%)</td>
</tr>
<tr>
<td>F1</td>
<td>Enjoy being swung, bounced?</td>
<td>7 (50.0)</td>
<td>5 (55.6)</td>
</tr>
<tr>
<td>F2</td>
<td>Interest in other children?</td>
<td>44 (74.6)</td>
<td>41 (74.5)</td>
</tr>
<tr>
<td>F3</td>
<td>Like climbing on things?</td>
<td>7 (3.6)</td>
<td>6 (60.0)</td>
</tr>
<tr>
<td>F4</td>
<td>Enjoy playing peek-a-boo?</td>
<td>6 (60.0)</td>
<td>5 (62.5)</td>
</tr>
<tr>
<td>F5</td>
<td>Play pretend?</td>
<td>47 (2.3)</td>
<td>39 (72.2)</td>
</tr>
<tr>
<td>F6</td>
<td>Point to ask for something?</td>
<td>86 (66.7)</td>
<td>72 (66.1)</td>
</tr>
<tr>
<td>F7</td>
<td>Point to indicate interest?</td>
<td>88 (67.7)</td>
<td>73 (64.6)</td>
</tr>
<tr>
<td>F8</td>
<td>Play properly with small toys?</td>
<td>41 (61.2)</td>
<td>34 (70.8)</td>
</tr>
<tr>
<td>F9</td>
<td>Bring objects over to show?</td>
<td>44 (65.7)</td>
<td>43 (67.2)</td>
</tr>
<tr>
<td>F10</td>
<td>Look you in the eye?</td>
<td>13 (61.9)</td>
<td>12 (63.2)</td>
</tr>
<tr>
<td>F11</td>
<td>Oversensitive to noise?</td>
<td>44 (55.7)</td>
<td>30 (68.2)</td>
</tr>
<tr>
<td>F12</td>
<td>Responsive smile?</td>
<td>3 (60.0)</td>
<td>3 (60.0)</td>
</tr>
<tr>
<td>F13</td>
<td>Does child imitate you?</td>
<td>45 (71.4)</td>
<td>41 (70.7)</td>
</tr>
<tr>
<td>F14</td>
<td>Respond to name?</td>
<td>32 (69.6)</td>
<td>29 (67.4)</td>
</tr>
<tr>
<td>F15</td>
<td>Looks to follow point?</td>
<td>54 (58.7)</td>
<td>48 (58.5)</td>
</tr>
<tr>
<td>F16</td>
<td>Does child walk?</td>
<td>19 (70.4)</td>
<td>13 (65.0)</td>
</tr>
<tr>
<td>F17</td>
<td>Look at what you're looking at?</td>
<td>33 (58.9)</td>
<td>30 (62.5)</td>
</tr>
<tr>
<td>F18</td>
<td>Unusual finger movements?</td>
<td>32 (53.3)</td>
<td>25 (61.0)</td>
</tr>
<tr>
<td>F19</td>
<td>Attract attention to activity?</td>
<td>46 (62.2)</td>
<td>40 (64.5)</td>
</tr>
<tr>
<td>F20</td>
<td>Wondered if child is deaf?</td>
<td>35 (63.6)</td>
<td>25 (59.5)</td>
</tr>
<tr>
<td>F21</td>
<td>Understand what people say?</td>
<td>33 (55.9)</td>
<td>30 (56.6)</td>
</tr>
<tr>
<td>F22</td>
<td>Stare at nothing or wander?</td>
<td>66 (63.5)</td>
<td>50 (67.6)</td>
</tr>
<tr>
<td>F23</td>
<td>Look to check your reaction?</td>
<td>48 (70.6)</td>
<td>40 (70.2)</td>
</tr>
</tbody>
</table>

a # Screen positive who were Majority race/ethnicity (% of screen positive who were Majority)

b # Screen positive who were Minority race/ethnicity (% of screen positive who were Minority)
Table 9.

Hierarchical regressions predicting individual item responses from racial/ethnic Minority versus Majority group, controlling for median income.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Model $\chi^2$</th>
<th>df</th>
<th>$p$</th>
<th>$\beta_{\text{Income}}$</th>
<th>$p$</th>
<th>$\beta_{\text{Ethnicity}}$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>78.99</td>
<td>2</td>
<td>&lt;.001</td>
<td>-0.278</td>
<td>&lt;.001</td>
<td>0.618</td>
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</tr>
<tr>
<td>F1</td>
<td>4.71</td>
<td>2</td>
<td>0.095</td>
<td>-0.285</td>
<td>0.048</td>
<td>-0.518</td>
<td>0.41</td>
</tr>
<tr>
<td>M2</td>
<td>5.19</td>
<td>2</td>
<td>0.075</td>
<td>-0.048</td>
<td>0.179</td>
<td>0.251</td>
<td>0.203</td>
</tr>
<tr>
<td>F2</td>
<td>11.16</td>
<td>2</td>
<td>0.004</td>
<td>0.055</td>
<td>0.327</td>
<td>-0.846</td>
<td>0.015</td>
</tr>
<tr>
<td>M3</td>
<td>10.41</td>
<td>2</td>
<td>0.005</td>
<td>-0.016</td>
<td>0.758</td>
<td>0.856</td>
<td>0.003</td>
</tr>
<tr>
<td>F3</td>
<td>0.495</td>
<td>2</td>
<td>0.781</td>
<td>-0.018</td>
<td>0.886</td>
<td>-0.475</td>
<td>0.499</td>
</tr>
<tr>
<td>M4</td>
<td>10.11</td>
<td>2</td>
<td>0.006</td>
<td>-0.111</td>
<td>0.078</td>
<td>0.562</td>
<td>0.074</td>
</tr>
<tr>
<td>F4</td>
<td>0.431</td>
<td>2</td>
<td>0.806</td>
<td>-0.066</td>
<td>0.631</td>
<td>-0.444</td>
<td>0.545</td>
</tr>
<tr>
<td>M5</td>
<td>1.89</td>
<td>2</td>
<td>0.389</td>
<td>-0.035</td>
<td>0.235</td>
<td>-0.176</td>
<td>0.318</td>
</tr>
<tr>
<td>F5</td>
<td>9.98</td>
<td>2</td>
<td>0.007</td>
<td>0.025</td>
<td>0.644</td>
<td>-0.859</td>
<td>0.009</td>
</tr>
<tr>
<td>M6</td>
<td>3.39</td>
<td>2</td>
<td>0.184</td>
<td>-0.011</td>
<td>0.634</td>
<td>0.216</td>
<td>0.123</td>
</tr>
<tr>
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<td>19.86</td>
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<td>0.148</td>
<td>0.001</td>
<td>-0.285</td>
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<tr>
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<td>2.81</td>
<td>2</td>
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<td>0.946</td>
<td>0.232</td>
<td>0.105</td>
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<tr>
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<td>23.52</td>
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<td>&lt;.001</td>
<td>0.157</td>
<td>&lt;.001</td>
<td>-0.329</td>
<td>0.177</td>
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<tr>
<td>M8</td>
<td>73.31</td>
<td>2</td>
<td>&lt;.001</td>
<td>-0.11</td>
<td>&lt;.001</td>
<td>0.909</td>
<td>&lt;.001</td>
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<td>2</td>
<td>0.313</td>
<td>0.011</td>
<td>0.835</td>
<td>-0.386</td>
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<td>M9</td>
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<td>2</td>
<td>0.313</td>
<td>0.029</td>
<td>0.365</td>
<td>0.288</td>
<td>0.141</td>
</tr>
<tr>
<td>F9</td>
<td>12.99</td>
<td>2</td>
<td>0.002</td>
<td>0.156</td>
<td>0.002</td>
<td>-0.182</td>
<td>0.553</td>
</tr>
<tr>
<td>M10</td>
<td>27.04</td>
<td>2</td>
<td>&lt;.001</td>
<td>-0.128</td>
<td>0.001</td>
<td>0.405</td>
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<tr>
<td>F10</td>
<td>0.148</td>
<td>2</td>
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<td>-0.001</td>
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<td>-0.186</td>
<td>0.727</td>
</tr>
<tr>
<td>M11</td>
<td>73.87</td>
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<td>-0.044</td>
<td>&lt;.001</td>
<td>0.362</td>
<td>&lt;.001</td>
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<tr>
<td>F11</td>
<td>3.91</td>
<td>2</td>
<td>0.142</td>
<td>-0.092</td>
<td>0.11</td>
<td>-0.483</td>
<td>0.091</td>
</tr>
<tr>
<td>M12</td>
<td>5.12</td>
<td>2</td>
<td>0.077</td>
<td>-0.03</td>
<td>0.733</td>
<td>0.953</td>
<td>0.047</td>
</tr>
<tr>
<td>F12</td>
<td>1</td>
<td>2</td>
<td>0.606</td>
<td>-0.196</td>
<td>0.361</td>
<td>-0.682</td>
<td>0.509</td>
</tr>
<tr>
<td>M13</td>
<td>2.7</td>
<td>2</td>
<td>0.259</td>
<td>-0.033</td>
<td>0.124</td>
<td>-0.001</td>
<td>0.991</td>
</tr>
<tr>
<td>F13</td>
<td>19.45</td>
<td>2</td>
<td>&lt;.001</td>
<td>0.174</td>
<td>0.001</td>
<td>-0.397</td>
<td>0.234</td>
</tr>
<tr>
<td>M14</td>
<td>3.71</td>
<td>2</td>
<td>0.157</td>
<td>0.04</td>
<td>0.313</td>
<td>0.461</td>
<td>0.056</td>
</tr>
<tr>
<td>F14</td>
<td>6.25</td>
<td>2</td>
<td>0.044</td>
<td>0.102</td>
<td>0.091</td>
<td>-0.385</td>
<td>0.304</td>
</tr>
<tr>
<td>M15</td>
<td>5.45</td>
<td>2</td>
<td>0.065</td>
<td>-0.017</td>
<td>0.556</td>
<td>0.324</td>
<td>0.05</td>
</tr>
<tr>
<td>F15</td>
<td>0.388</td>
<td>2</td>
<td>0.824</td>
<td>0.008</td>
<td>0.863</td>
<td>-0.125</td>
<td>0.644</td>
</tr>
<tr>
<td>M16</td>
<td>2.43</td>
<td>2</td>
<td>0.296</td>
<td>0.004</td>
<td>0.911</td>
<td>-0.362</td>
<td>0.158</td>
</tr>
<tr>
<td>F16</td>
<td>3.25</td>
<td>2</td>
<td>0.197</td>
<td>0.019</td>
<td>0.805</td>
<td>-0.704</td>
<td>0.14</td>
</tr>
<tr>
<td>M17</td>
<td>23.45</td>
<td>2</td>
<td>&lt;.001</td>
<td>-0.099</td>
<td>0.009</td>
<td>0.539</td>
<td>0.005</td>
</tr>
<tr>
<td>F17</td>
<td>1.02</td>
<td>2</td>
<td>0.601</td>
<td>0.035</td>
<td>0.553</td>
<td>-0.157</td>
<td>0.634</td>
</tr>
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</tr>
<tr>
<td>M18</td>
<td>362.65</td>
<td>2</td>
<td>&lt;.001</td>
<td>-0.132</td>
<td>&lt;.001</td>
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<td>&lt;.001</td>
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<tr>
<td>F18</td>
<td>3.43</td>
<td>2</td>
<td>0.18</td>
<td>-0.091</td>
<td>0.149</td>
<td>-0.541</td>
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<tr>
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<td>5.97</td>
<td>2</td>
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<td>-0.026</td>
<td>0.152</td>
<td>0.15</td>
<td>0.161</td>
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<tr>
<td>F19</td>
<td>10.16</td>
<td>2</td>
<td>0.006</td>
<td>0.153</td>
<td>0.02</td>
<td>0.146</td>
<td>0.621</td>
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<tr>
<td>M20</td>
<td>24.88</td>
<td>2</td>
<td>&lt;.001</td>
<td>-0.057</td>
<td>0.037</td>
<td>0.519</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>F20</td>
<td>4.71</td>
<td>2</td>
<td>0.095</td>
<td>0.069</td>
<td>0.227</td>
<td>-0.393</td>
<td>0.247</td>
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<tr>
<td>M21</td>
<td>12.71</td>
<td>2</td>
<td>0.002</td>
<td>-0.042</td>
<td>0.241</td>
<td>0.546</td>
<td>0.005</td>
</tr>
<tr>
<td>F21</td>
<td>5.02</td>
<td>2</td>
<td>0.081</td>
<td>0.126</td>
<td>0.024</td>
<td>0.22</td>
<td>0.495</td>
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<tr>
<td>M22</td>
<td>221.82</td>
<td>2</td>
<td>&lt;.001</td>
<td>-0.087</td>
<td>&lt;.001</td>
<td>0.728</td>
<td>&lt;.001</td>
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<tr>
<td>F22</td>
<td>10.1</td>
<td>2</td>
<td>0.006</td>
<td>-0.026</td>
<td>0.571</td>
<td>-0.759</td>
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<td>-0.071</td>
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<td>2</td>
<td>0.009</td>
<td>0.089</td>
<td>0.084</td>
<td>-0.508</td>
<td>0.108</td>
</tr>
</tbody>
</table>

\(^1\text{Model is Step 2 Model, representing the influence of Minority versus Majority ethnicity, controlling for income, on likelihood that item is failed}\)
### Table 10.

**Chi-square data on which positive predictive values were based**

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Majority</th>
<th>Minority</th>
<th>df</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>ASD$^a$</td>
<td>52</td>
<td>30</td>
<td>1</td>
<td>1.45</td>
<td>ns</td>
</tr>
<tr>
<td>All other dx</td>
<td>69</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASD + all DD$^b$</td>
<td>97</td>
<td>51</td>
<td>1</td>
<td>2.40</td>
<td>ns</td>
</tr>
<tr>
<td>TD/No dx$^c$</td>
<td>24</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* $^a$ASD includes Autistic Disorder, Pervasive Developmental Disorder-Not Otherwise Specified, and ASD-Low Mental Age. $^b$DD = Developmental Delay. $^c$TD = typically developing, No dx = subthreshold delays.
Figure 1.

Participant flow chart for screening procedures

N=18,669 (screened with M-CHAT)

1630 Screen Positive
- Participated in M-CHAT F/U
  - n=1242
  - Screen Positive n=262
  - No evaluation n=767
    - Parent refused n=65
    - No contact/Moved n=77
    - Excluded n=15

17,039 Screen Negative
- No M-CHAT F/U
  - n=388
  - Parent refused: n=27
  - Unable to contact: n=88
  - 25 received evaluation:
    - Red Flag n=14
    - Screen positive on Yale Screener n=11

Participated in Screening n=725
Figure 2.

*Mean age at M-CHAT screening, follow-up interview, and evaluation by racial/ethnic group*

![Graph showing mean age by ethnicity](image)

*Note.* Group means without controlling for median income. “Other” includes participants who identified as Other or Biracial race/ethnicity.
REFERENCES


Herlihy, L.E., Green, J., Hardy, S., Knoch, K., Dumont-Mathieu, T., & Barton et al., (2010). Demographic differences in age at screening but not age at evaluation for children screened with the M-CHAT. Poster presentation at the Annual Meeting of the International Neuropsychological Society. Boston, MA, USA.


71


APPENDICES

Appendix A

M-CHAT
University of Connecticut Department of Psychology

Please fill out the following about how your child usually is. Please try to answer every question. If the behavior is rare (e.g., you've seen it once or twice), please answer as if the child does not do it.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does your child enjoy being swung, bounced on your knee, etc.?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Does your child take an interest in other children?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Does your child like climbing on things, such as up stairs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Does your child enjoy playing peek-a-boo/hide-and-seek?</td>
<td></td>
<td></td>
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<tr>
<td>5. Does your child ever pretend, for example, to talk on the phone or take care of a doll or pretend other things?</td>
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<tr>
<td>6. Does your child ever use his/her index finger to point, to ask for something?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Does your child ever use his/her index finger to point, to indicate interest in something?</td>
<td></td>
<td></td>
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<tr>
<td>8. Can your child play properly with small toys (e.g. cars or bricks) without just mouthing, fiddling, or dropping them?</td>
<td></td>
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<tr>
<td>9. Does your child ever bring objects over to you (parent) to show you something?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Does your child look you in the eye for more than a second or two?</td>
<td></td>
<td></td>
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<tr>
<td>11. Does your child ever seem oversensitive to noise? (e.g., plugging ears)</td>
<td></td>
<td></td>
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<tr>
<td>12. Does your child smile in response to your face or your smile?</td>
<td></td>
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<tr>
<td>13. Does your child imitate you? (e.g., you make a face-will your child imitate it?)</td>
<td></td>
<td></td>
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<tr>
<td>14. Does your child respond to his/her name when you call?</td>
<td></td>
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<tr>
<td>15. If you point at a toy across the room, does your child look at it?</td>
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<tr>
<td>16. Does your child walk?</td>
<td></td>
<td></td>
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<tr>
<td>17. Does your child look at things you are looking at?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Does your child make unusual finger movements near his/her face?</td>
<td></td>
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<tr>
<td>19. Does your child try to attract your attention to his/her own activity?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Have you ever wondered if your child is deaf?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Does your child understand what people say?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Does your child sometimes stare at nothing or wander with no purpose?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Does your child look at your face to check your reaction when faced with something unfamiliar?</td>
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</tbody>
</table>

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Modified Checklist for Autism in Toddlers
(M-CHAT) Follow-Up Interview™

**May be used for research or clinical purposes, but please do not cite or distribute**

Acknowledgement: We thank Joaquin Fuentes, M.D. for his work in developing the flow chart format used in this interview.

The M-CHAT Follow-Up Interview can be downloaded free of charge from http://www2.gsu.edu/~psydlr

For more information, please contact Diana Robins (drobins@gsu.edu) or Deborah Fein (deborah.fein@uconn.edu).

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1. You reported that _________ does not enjoy being swung, bounced on your knee, etc.

   Is this still true?

   No

   Then s/he does enjoy being bounced or swung?

   No

   When you swing or bounce him/her, how does s/he react?

   Laughs or smiles
   Talks or babbles
   Requests more by holding out his/her arms

   Other (Describe):_____________________________________________________________

   If NO to all
   FAIL

   If YES to any specific examples

   PASS

   If other is clearly a positive response
2. You reported that ________ does not take an interest in other children. (Critical)

Is this still true?

No

Then your child does take an interest in other children?

Yes

No

Is he/she interested in children who are not his/her brother or sister?

Yes

No

When you are at the playground or supermarket, does your child usually respond to the presence of another child?

Yes

No

How does your child respond?

PASS

(Ask all)

NO to all

FAIL

If yes to any:

Plays with the other child
Talks to the other child
Aggressive behavior
Vocalizes
Looks at the other child
Smiles at the other child

If yes to any:

Docs s/hc (fill in responses given here- e.g. plays, talks, smiles, looks, or vocalizes) more than half of the time?

No

Yes

FAIL

PASS
3. You reported that _________ does not like climbing on things, such as up stairs.

Is this still true?

- No
  - Then s/he does like climbing on things?
    - Yes
    - No
      - Does he/she enjoying climbing on:
        - ... stairs? Yes □ No □
        - ... chairs? Yes □ No □
        - ... furniture? Yes □ No □
        - ... playground equipment? Yes □ No □
      - Yes to any
      - No to all
        - PASS
        - FAIL
4. You reported that _______ does not enjoy playing peek-a-boo / hide-and-seek.

   Is this still true?

   No

   Then your child does enjoy playing peek-a-boo or hide-and-seek?

   YES

   PASS

   NO

   YES

   Does your child like any games that involve a back-and-forth exchange with another person?

   Yes

   What does s/he do if you try to play a game like peek-a-boo or pat-a-cake (or example given) with him/her?

   Smiles/laughs
   Vocalizes pleasure
   Requests more verbally
   Requests more nonverbally

   Yes [ ] No [ ]
   Yes [ ] No [ ]
   Yes [ ] No [ ]
   Yes [ ] No [ ]

   If yes only to example(s) from above

   PASS

   If yes to examples from both

   What is more typical?

   Pass
   response

   Fail
   response

   Yes [ ] No [ ]
   Yes [ ] No [ ]
   Yes [ ] No [ ]
   Yes [ ] No [ ]
   Leaves situation if parent initiates

   If yes only to example(s) from above

   FAIL
5. You reported that ________ does not ever pretend, for example, to talk on the phone or take care of dolls, or pretend other things.

- Is this still true?
  - No
    - Then your child does pretend play?
      - Yes
        - Can you give me an example?
          - Yes
            - Does he/she ever play make believe?
              - Yes
                - If parent gives any examples listed, it is a pass.
              - No
                - If parent did not give any example listed: 
                  - PASS
          - No
            - If no, ask examples individually
              - Push a car on a pretend road ________
              - Does he/she put a toy pot on stove or stir imaginary food? ________
              - Pretend to vacuum or mow lawn ________
              - Feed self with a toy spoon or empty cup ________
              - Feed a doll with real or imaginary food?

  - Yes
    - Can you give me an example?
      - Yes
        - Does he/she ever play make believe?
          - Yes
            - If parent gives any examples listed, it is a pass.
          - No
            - If parent did not give any example listed: 
              - PASS
      - No
        - If parent did not give any example listed:
          - FAIL
6. You reported that __________ does not use his/her pointer finger to point, to ask for something.

- Is this still true?

  - No

    Then your child does use his/her pointer finger in order to ask for something?

    - Yes

      Points _______

    - No

- Yes

  If there is something your child wants that is out of reach, such as a cookie up on a counter, how does he/she get it?

  - Reaches for the object with the whole hand _______
  - Leads the parent to the object _______
  - Tries to get the object for him/herself
  - Asks for it _______

- If responds with any of the above:

  - If you said “Show me,” would he/she point at it?

    - Yes
    - No

PASS

FAIL
7. You reported that ______________ does not use his/her pointer finger to point, to indicate interest in something. (Critical)

- Is this still true?
  - No
  - Yes

  - Then your child does use his/her pointer finger in order to point to indicate interest in something? (Yes or No)

    - Yes
      - PASS

    - No
      - Does your child ever want you to see something interesting such as....... (Yes or No for each option)

      - ...an airplane in the sky
      - ...a truck on the road
      - ...a bug on the ground
      - ...an animal in the yard

      - If Yes:
        - How does your child draw your attention to it? Would he/she point with his/her pointer finger? (Yes or No)

          - Yes
            - Is this to indicate interest, not to get help? (Yes or No)

              - Yes
                - PASS

              - No
                - FAIL

          - No
            - FAIL
8. You reported that ________ does not play properly with small toys (e.g. cars or blocks) without just mouthing, fiddling, or dropping them.

- Is this still true?

  No
  - Then your child does know how to play properly with small toys?
    - Yes
      - Can you give me an example?
      - PASS
        - Stacks blocks
        - Does simple puzzles
        - Plays with cars/trucks
        - Plays with a shape sorter
        - Stacks rings on a stick
        - Nest cups inside each other
    - No
      - How does he/she play with toys?
      - FAIL
        - Puts toys in mouth
        - Thows toys
        - Doesn’t play with toys
        - Swallows pieces
        - Lines toys up
        - Carries one toy around the house
        - Stares at toys

- If yes only to example(s) from above
  - PASS
  - If yes to examples from both
  - What is more typical?
    - Pass response
    - FAIL
  - If yes to any example from above
    - Fail response
9. You reported that ________ does not bring objects over to you (parent) to show you something. (Critical)

   Is this still true?
   
   No
   
   Then your child does bring objects over to show you?
   
   Yes
   
   No
   
   Does your child sometimes bring you:
   
   A picture or toy just to show you? _____
   A drawing he/she has done? _____
   A flower he/she has picked? _____
   A bug he/she has found in the grass? _____

   If yes to any:
   
   Yes
   
   Is this just to show you, not to get help?
   
   Yes
   
   No
   
   No
   
   FAIL

   PASS
10. You reported that __________ does not look you in the eye for more than a second or two?

Is this still true?

No

Then your child does look you in the eyes for more than a second or two?

Yes

PASS

No

Yes

Does s/he look you in the eyes when s/he needs something? _____
When playing with you? _____
During feeding? _____
During diaper changes? _____
When you are reading him/her a story? _____

Yes only to one

Yes to two or more

PASS

No to all

FAIL

On a day when you are together all day, does he/she look you in the eyes at least 5 times?

Yes

FAIL

No

PASS

FAIL
11. You reported that __________ sometimes seems oversensitive to noise.

Is this still true?

No

Then your child does not seem oversensitive to noise?

No, he/she does not

PASS

Yes, he/she does

Yes

Does your child have a negative reaction to the sound of:
(ask as needed)....

A washing machine? ____
Babies crying? ____
Babies squealing or screeching? ____
Vacuum cleaner? ____
Sirens? ____
Traffic? ____
Doors slamming? ____
Loud music? ____
Telephone/doorbell ringing? ____
Noisy places such as the supermarket or restaurant? ____
Other (describe): ________________________________

If yes to two or more, continue:

How does your child react to (list noise that child does not like)?

PASS

FAIL

If yes only to examples from both:

Calmly covers ears ____
Expresses displeasure verbally ____

FAIL

Screams ____
Cries ____
Covers ears while upset ____

PASS

FAIL

If yes only to example(s) from above:

What is more typical?

Pass response

FAIL

If yes only to one:

PASS
12. You reported that ________ does not smile in response to your face or your smile.

Is this still true?

No

Then your child does smile in response to your face or your smile?

Yes

PASS

Ask specifically about below examples if parent does not give any

Smiles when parent smiles____
Smiles when parent enters the room____
Smiles when parent returns____

FAIL

What makes ________ smile?

Yes

FAIL

If yes only to example(s) from above

PASS

If yes to examples from both:

FAIL

Always smiling____
Smiles at favorite toy or activity____
Smiles randomly or at nothing in particular____
13. You reported that ________ does not usually imitate you. (Critical)

Is this still true?

No

Then your child does imitate you?

Yes

No

Yes

If yes to two or more

PASS

No

Does your child copy you if you:

- Stick out your tongue? [ ] Yes [ ] No
- Make a funny sound? [ ] Yes [ ] No
- Wave good bye? [ ] Yes [ ] No
- Clap your hands? [ ] Yes [ ] No
- Put your fingers to your lips to signal “Shhh”? [ ] Yes [ ] No
- Blow a kiss? [ ] Yes [ ] No

If yes to one or none

FAIL
14. You reported that _________ does not respond to his/her name when you call. (Critical)

Is this still true?

- No
  - Then your child does respond to his/her name?
    - Yes
      - If he/she is not doing anything particularly fun or absorbing, would he/she usually respond to his/her name being called?
        - No
          - PASS
        - Yes
          - PASS
    - No
      - If parent does not spontaneously respond, ask below examples
        - PASS
          - Looks up _________
          - Talks or babbles _________
          - Stops what he/she is doing _________
        - FAIL
          - No response _________
          - Seems to hear but ignores parent _________
          - Parent needs to be in child’s face _________
          - Responds only if touched _________
    - If yes only to example(s) from above
      - PASS
    - If yes to examples from both
      - Pass response
      - Fail response
      - What is more typical?
        - PASS
        - FAIL
        - If yes only to example(s) from above
15. You reported that if you point at a toy across the room, ________ does not look at it.
   (Critical)

   Is this still true?

   No
   Then your child does look at objects that you point to?

   Yes
   If you point at something, what does your child typically do?

   If parent does not spontaneously respond, ask below examples

   No
   Looks at object ________
   Points to it ________
   Looks and comments on object ________
   Looks if parent points and says “look!” ________

   Yes
   PASS
   If yes only to example(s) from above

   PASS
   If yes to examples from both
   Pass response
   What is more typical?
   Fail response

   FAIL
   Ignores parent ________
   Looks around room randomly ________
   Looks at parent’s finger ________

   FAIL
   If yes only to example(s) from above
16. You reported that your child does not walk.

Is this still true?

No

Then your child walks without holding on?

Yes

FAIL

No

PASS

Yes

FAIL
17. You reported that ________ does not look at things you are looking at.

Is this still true?

No

Then your child does look at things you are looking at?

Yes

No

PASS

If parent does not spontaneously respond, ask below examples

PASS

Looks at object you are looking at ______
Points to object ______
Looks around to see what you are looking at ______

FAIL

What does s/he do when you are looking at something?

FAIL

Ignores ______
Looks at parent’s face

If yes only to example(s) from above

PASS

What is more typical?

Pass response

FAIL

Fail response

If yes only to example(s) from above
18. You reported that __________ makes unusual finger movements near his/her face.

Is this still true?

No

Then he/she does not make any unusual finger movements?

No

Yes

Please describe these movements.

If parent does not spontaneously respond, ask below examples

PASS

Wiggles his/her fingers near his/her eyes
Holds hands up close to eyes
Holds hands off to the side of his/her eyes
Flaps hands near face
Other (describe)______________________________

If yes to any fail response

Does this happen more than twice a week?

No

Yes

FAIL

PASS

Looks at hands
Moves fingers when playing peek-a-boo

PASS

FAIL
19. You reported that __________ does not try to attract your attention to his/her own activity.

Is this still true?

No

Then he/she does try to attract your attention to his/her own activity?

Yes

No

Ask each item.

Does he/she....

Say "Look!" or "Watch me!"

Bring a toy or activity to show you (parent) ______

Look expectantly to get praise or comment ______

Keep looking to see if you're (parent) is looking ______

If yes to any or sometimes to two or more

PASS

If yes to none or sometimes to one or fewer

FAIL
20. Have you wondered if your child is deaf?

- **No**
  - Then you haven’t wondered if he/she is deaf?
    - **No**
      - PASS
    - **Yes I have**

- **Yes**
  - What led you to wonder that?
    - Did he/she frequently ignore sounds?
      - Did he/she often ignore people?
        - If no to second and third question
          - PASS
        - If yes to either second or third question
          - FAIL

*Ask all parents:*

Has your child’s hearing been tested? If YES, what were the results?

*Note results* _____ Hearing impaired _____ Hearing in normal range

*If hearing is impaired > PASS*

*Note: If parents report that they wondered about their child’s hearing only as part of a routine checkup > PASS*

*Note: Regardless of hearing test results, if child ignores sounds or people > FAIL*
21. You reported that _______________ does not understand what people say?

Is this still true?

No

Then he/she does understand what people

Yes

When the situation gives him/her a clue, can he/she follow a command? For example, when you are dressed to go out and you tell him/her to get his/her shoes...

If yes

If no or sometimes

If it is dinnertime and food is on the table, and you tell the child to sit down, will he/she come sit at the table?

Yes

When the situation does not give any clues, can he/she follow a command (e.g., “show me your shoe” without any gestures)? Use other examples as needed: “Bring me the book”; “Bring me my keys”.

No

FAIL

PASS

FAIL

PASS
22. You reported that __________ sometimes stares at nothing or wanders with no purpose.

Is this still true?

No

Then your child does not stare at nothing or wander with no purpose?

Yes

Can you give me some examples of this behavior?

(If not stated above) Does your child often stare off into space?

No

Yes

(If not stated above) Does he/she like to walk around the edges of the room instead of settling down with an activity?

Yes to either example

No to both examples

Does he/she do this behavior (fill in behavior parent indicated) often - at least several times per week?

Yes to either

No to both

Does he/she walk in circles (not in play to make self dizzy) often - at least several times per week?

Yes

Does he/she do this only when tired?

Yes

No

FAIL

PASS
23. You reported that __________ does not usually look at your face to check your reaction when faced with something unfamiliar and a little scary.

Is this still true?

No

Yes

Then he/she does look at your face to check your reaction when faced with something scary?

Yes

No

If your child hears an unfamiliar or scary noise, will he/she look at you before deciding how to respond?

Yes

No

Does your child look at you when someone new approaches?

Yes

No

Sometimes or probably looks at parent’s reaction __________

PASS

Probably does not look at parent’s reaction __________

FAIL

What does your child do when faced with something unfamiliar and a little scary?