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Original Article

Validation of the Indonesian Version of *Modified Checklist for Autism in Toddlers*: a diagnostic study

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Abstract

Background Autism is a developmental disorder for which early detection in toddlers is recommended because of its increased prevalence. *The Modified Checklist for Autism in Toddlers* (M-CHAT) is an easy-to-interprete tool that can be filled out by parents. It has been translated into the Indonesian language but needs to be validated.

Objective To evaluate the diagnostic validity of the Indonesian version of M-CHAT in detection of autism spectrum disorder in Indonesia.

Methods A diagnostic study was conducted at Sanglah Hospital, Denpasar, Bali, from March 2011 to August 2013. Pediatric outpatients aged 18 to 48 months were included. The Indonesian version of the M-CHAT tool was filled by parents. Autism assessment was done according to the *Diagnostic and Statistical Manual of Mental Disorders,* 4th edition (DSM-IV-TR). The assessment results were analyzed with the MedCalc program software, in several steps: (i) reliability of M-CHAT; (ii) description, distribution, and proportion to determine the characteristics of the subjects of research; and (iii) validity of M-CHAT compared to the gold standard DSM-IV-TR by a receiver operating characteristic curve and several area under the curve cut-off points, in order to assess the sensitivity, specificity, positive predictive value, negative predictive value, and positive and negative likelihood ratio, accompanied by the 95% confidence interval of each value.

Results The Indonesian version of M-CHAT in toddlers had 82.35% sensitivity and 89.68% specificity, using the cut-off point of more than 6 failed questions.

Conclusion The Indonesian version M-CHAT translated by Soetjiningsih has optimal diagnostic validity for detection of autism in toddlers. **[Paediatr Indones. 2020;60:160-6; doi: http://dx.doi.org/10.14238/pi60.3.2020.160-6]**.

Keywords: *M-CHAT; autism; screening; validity*

Autism is a severe disorder of development, affecting children below 36 months of age. Autism often goes undetected in toddlers, especially in urban children with low socio-economic status.[1,2] To our knowledge, there have been no studies reporting autism prevalence in Indonesia. A Bandung (West Java) study reported that 20–30% of children below five years of age have symptoms of delayed development.[3] According to a 2009 report from the Indonesian Autism Foundation, there were more than 102 therapeutic centers and 13 schools for autism in Indonesia.[4]

From 2006, the *American Academy of Pediatrics* (AAP) has recommended using the algorithm for developmental surveillance and screening for early identification of autism spectrum disorder (ASD), because it allows early intervention, etiologic investigation, and counseling regarding the risk of recurrence.[5] Of the ASD screening tools, the *Checklist for Autism in Toddlers*

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(CHAT) was designed specifically as a level 1 screening tool. It is available at no cost to practitioners for use in primary care and only requires 5 minutes to complete the questionnaire. Because of its low sensitivity, Robins modified the CHAT to the *Modified Checklist for Autism in Toddlers* (M-CHAT) to better identify children at risk for any ASD.[5] The M-CHAT is more cost- and time-efficient than other tools. It only requires about 5-10 minutes for parents to complete the survey, with 23 yes/no items that are easy to understand. The M-CHAT can be used to screen children aged 18 to 48 months. In the United States, community- and clinical-based studies on M-CHAT reported 85% of sensitivity and 93-100% of specificity.[1,5-7]

The M-CHAT was translated into the Indonesian language by Soetjiningsih, with permission from the author. This Indonesian version of M-CHAT has been widely used in Indonesia, but M-CHAT use and validity has not been reported. Hence, this study was conducted to evaluate the diagnostic validity of the Indonesian version of M-CHAT for detection of ASD in Indonesia.

Methods

This cross-sectional study was conducted in the Child Growth and Development Clinic of Sanglah Hospital, Denpasar, Bali, from March 2011 to August 2013. Children aged 18 to 48 months whose parents brought them to the clinic and agreed to participate were included in this study. We excluded children with global inability in language expression or verbal communication (because of hearing loss or palatoschisis), and those with global motor deficits or cognitive delays such that they could not pass the cognitive/developmental assessment (for example, cerebral palsy, hydrocephalus, or other severe congenital deformities).

Estimation of sample size was calculated by a single proportion sample method, with P=80%, α=0.05, Zα=1.96, d=30%, and the 4.8% proportion of children with ASD aged 18 to 48 months who came to the Child Growth and Development Clinic of Sanglah Hospital by 2009.[8] A total of 143 subjects, the minimum required sample size, were included in this study.

This study was undertaken in the following three phases: (i) translation, back translation, cultural adaptation, and a short pilot study to obtain the final Indonesian version of M-CHAT to be used in Indonesia; (ii) the reliability study; and (iii) the validity study.

The M-CHAT questionnaire was translated into the Indonesian language by Soetjiningsih with guidance that, rather than being literal, the translation should had semantic, linguistic, and cultural equivalence. The resulting version was then back-translated by a native English speaker who was bilingual, and sent to the original authors to compare it to the original M-CHAT. After several exchanges of opinion with the original author and making certain amendments, the Indonesian version of the M-CHAT questionnaire was approved by the original author. The Indonesian language M-CHAT questionnaire consists of 6 critical questions and 17 other questions, total 23 questions.

The reliability study of M-CHAT was done to evaluate the variability of the instrument and observer (parents). Our reliability study included 15 parents from the Child Growth and Development Clinic of Sanglah Hospital without inclusion nor exclusion criteria. The Indonesian version of M-CHAT was administered to the parents twice, at the first visit and at a visit 1 month later.

The reliability test for the Indonesian version of M-CHAT was done by calculating the coefficient of test-retest (intraobserver) reliability, in which 15 parents participated. This study used Bland-Altman curve as parameter of reliability test.[9]

Parents were accompanied by a resident familiar with the content of the questions in the Indonesian M-CHAT, so that they could request an explanation if needed. The authors were not directly involved in this aspect of the study in order to remain blinded to the parents' answers. Completed questionnaire was collected and Bland-Altman analysis was carried out (M-CHAT1). The first result then will be compared with the result of second analysis which was done one month later (M-CHAT2).

Children of both genders aged 18-48 months who visited our clinic with parents were screened for inclusion. Subjects' parents provided written informed consent. All subjects were evaluated by the authors using the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV-TR) criteria from the *Centers for Disease Control and Prevention*

(CDC) methodology. The ASD cases were identified and systematically defined using the DSM-IV-TR criteria from CDC. The authors were blinded to the M-CHAT results. The results of the M-CHAT and DSM-IV-TR assessments were merged by way of the research subject identity forms.

All collected data were entered and analyzed by the *MedCalc program software*, in several steps: (i) reliability of M-CHAT; (ii) description, distribution, and proportion to determine the characteristics of the study subjects; and (iii) validity of M-CHAT compared to the gold standard DSM-IV-TR by a receiver operating characteristic (ROC) curve and several area under the curve (AUC) cut-off points, in order to assess the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and positive and negative likelihood ratio (LR), accompanied by the 95% confidence interval of each value.

The study was approved by the Medical and Health Research Ethics Committee of Universitas Udayana Medical School/Sanglah Hospital, Denpasar.

Results

A total of 175 children were screened for this study. We excluded 32 children with global developmental delays. A Bland-Altman plot (**Figure 1**) revealed the systematic distinction between measurements and identify possible outliers. Mean difference was the estimation of bias and standard deviation from difference of random fluctuations around the mean. This study was clinically important because the difference was within the range of SD 1.96. The P value obtained from this study was <0.001 with 95%CI -0.725 to 0.725 (SD 1.31). Blant-Altman plot determined whether language in the Bahasa MCHAT questionnaire represented language that intelligible by respondens (parents). If the plot was between +1.96 and -1.96, the study could be continued. If the plot was scattered beyond the SD 1.96, the Bahasa in the MCHAT translated quiesionnaire should be improved first so it can be equally understood by all the respondens.

The characteristics of subjects are presented in **Table 1**. Of 143 study subjects, the median age was 33 months, ranging from 18-48 months. More boys participated than girls, with a ratio of 1.9:1. Subjects' nutritional status was mostly well-nourished (94.4%),

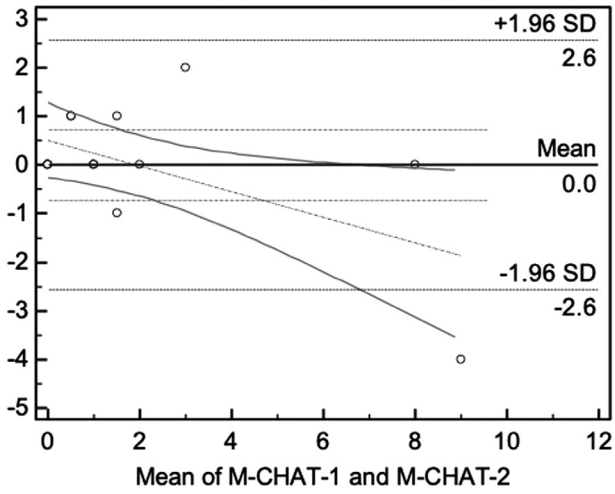

Figure 1. Bland-Altman curve

with only 5.6% malnourished. Most fathers (74.8%) did not have a college education, nor did mothers (80.4%). Only 19.6% of mothers completed university. Using the DSM-IV-TR, we identified 17 (11.9%) children with autism.

The cut-off M-CHAT score was determined by the intersection between sensitivity and specificity for the AUC and the coordinates of the ROC curve.[10,11] The AUC values evaluated were from 50%, the worst rating, up to 100%, the best value.[11] The ROC curves showed that the M-CHAT score of the study (**Figures 2** and **3**), had a good diagnostic value because the curve was far above the 50% line and closer to 100%. The AUC were 91.2% (95%CI 85.2% to 95.3%) for M-CHAT critical questions and 93.7% (95%CI 88.3% to 97.1%) for M-CHAT total questions (P<0.001).

The cut-off point was established clinically and statistically in accordance with the clinical expectations and interests,[11] by the ROC curve coordinates. The diagnostic value for the critical items of M-CHAT at various cut-off points revealed that the best validity was achieved if failure occurred on more than 1 question of the six critical questions on the Indonesian version of M-CHAT (sensitivity 82.35% and sensitivity 91.27%).

The AUC revealed that the best validity for the total M-CHAT questions was if failure occurred on 5 or more out of 23 questions (sensitivity 88.24% and specificity 85.71%). The diagnostic values for the critical and total items of the Indonesian version of

Table 1. Characteristics of subjects

Characteristics	Autism (DSM-IV-TR) (n = 17)	Total (N = 143)
Sex, n (%)		
Male	14	94 (65.7)
Female	3	49 (34.3)
Median age (range), months	38 (29 to 48)	33 (18 to 48)
Nutritional status, n (%)		
Malnourished	1	8 (5.6)
Well-nourished	15	127 (88.8)
Overweight	1	8 (5.6)
Maternal education, n (%)		
Elementary	0	13 (9.1)
Junior high	5	27 (18.9)
Senior high	10	75 (52.4)
University	2	28 (19.6)
Paternal education, n (%)		
Elementary	0	14 (9.8)
Junior high	4	26 (18.2)
Senior high	10	67 (46.8)
University	3	36 (25.2)

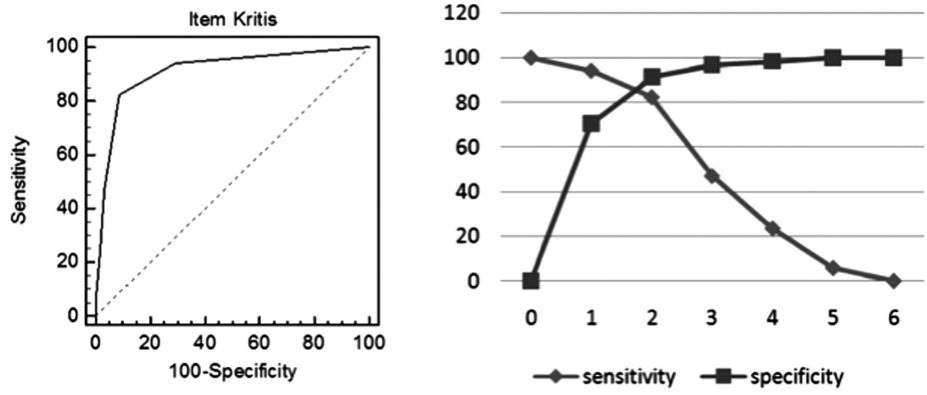

Figure 2. ROC curve and AUC cut-off for critical questions of M-CHAT

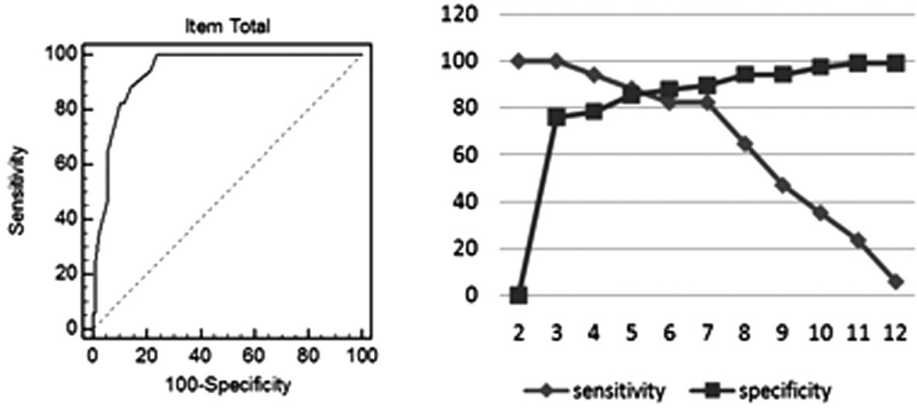

Figure 3. ROC curve and AUC cut-off for total questions of M-CHAT

M-CHAT at various cut-off points are shown in **Table 2** and **Table 3**, respectively.

The value of the likelihood ratio is varying from zero to infinity. A strong positive result of diagnostic test provides positive LR >6, while a strong negative result will gives the negative LR <0.2.10,12 Table 3 shows that at the >6 item failure cut-off point with 82.35% sensitivity and 89.68% specificity, the positive LR was 7.98 and negative LR was 0.2, which fulfilled the above criterion.

Table 2. Diagnostic values of critical M-CHAT items compared to the gold standard at various cut-off points

Cut-off	Sensitivity, % (95%CI)	Specifity , % (95%CI)	PPV, % (95%CI)	NPV, % (95%CI)	Positive LR, % (95%CI)	Negative LR, % (95%CI)
>0	94.12 (71.3 to 99.9)	70.63 (61.9 to 78.4)	30.2 (18.2 to 44.5)	98.9 (94.0 to 100)	3.21 (2.4 to 4.3)	0.083 (0.01 to 0.6)
>1	82.35 (56.6 to 96.2)	91.27 (84.9 to 95.6)	56.0 (34.9 to 75.6)	97.5 (92.7 to 99.5)	9.43 (5.1 to 17.3)	0.19 (0.07 to 0.5)
>2	47.06 (23.0 to 72.2)	96.83 (92.1 to 99.1)	66.7 (34.9 to 90.1)	93.1 (87.4 to 96.8)	14.82 (5.0 to 44.0)	0.55 (0.3 to 0.9)

Table 3. Diagnostic values of total M-CHAT items compared to the gold standard at various cut-off points

Cut-off	Sensitivity, % (95%CI)	Specifity , % (95%CI)	PPV, % (95%CI)	NPV, % (95%CI)	Positive LR, % (95%CI)	Negative LR, % (95%CI)
>3	94.12 (71.3 to 99.9)	78.57 (70.4 to 85.4)	37.2 (23.0 to 53.3)	99.0 (94.6 to 100)	4.39 (3.1 to 6.3)	0.0075 (0.01 to 0.5)
>4	88.24 (63.6 to 98.5)	85.71 (78.4 to 91.3)	45.5 (28.1 to 63.6)	98.2 (93.6 to 99.8)	6.18 (3.9 to 9.8)	0.14 (0.04 to 0.5)
>5	82.35 (56.6 to 96.2)	88.10 (81.1 to 93.2)	48.3 (29.4 to 67.5)	97.4 (92.5 to 99.5)	6.92 (4.1 to 11.7)	0.2 (0.07 to 0.6)
>6	82.35 (56.6 to 96.2)	89.68 (83.0 to 94.4)	51.9 (31.6 to 71.7)	97.4 (92.6 to 99.5)	7.98 (4.6 to 14.0)	0.2 (0.07 to 0.6)
>7	64.71 (38.3 to 85.8)	94.44 (88.9 to 97.7)	61.1 (35.7 to 82.7)	95.2 (89.8 to 98.2)	11.65 (5.2 to 25.9)	0.37 (0.2 to 0.7)

Discussion

The autism prevalence at the Child Growth and Development Clinic, Sanglah Hospital, Bali, was 9.7% for children aged 18-48 months. After excluding children with global delayed development, the prevalence rose to 11.9%. In a population-based study, a previous study reported a prevalence of 2.66%.[5] A previous study estimated an ASD prevalence of 8.5 per 1,000 children aged 3 to 5 years in the United States.[13] Research on the 14 sites in the United States revealed a prevalence of 11.3 per 1,000 children aged 8 years.[14] A community-based study in South Korea noted an ASD prevalence of 2.64% (95%CI 1.91 to 3.37) in children aged 7-12 years.[15] A study conducted two stages of community-based studies in Spain and reported prevalences of 0.92% and 0.29% of children aged 18-36 months.[16]

We found more autism in boys than in girls, with ratio of 4.7:1. Our finding was similar to that of a 2008 surveillance study in the US which reported a ratio of 5:1.[14] Eldin *et al.*[17] studied children aged 18 to 124 months in 9 Arabic countries, and reported 84.4% boys and 15.6% girls in their autism subjects (5.4:1).

The best age for autism screening in children is still debated. The AAP recommended autism screening for all children aged 18 to 24 months.[18] Firstly, M-CHAT was used to screen autism for children aged 16 to 30 months. Robins[19] included 4,797 children aged 14 to <27 months in her study. Also, a Thai study included 48 children aged 18 to 36 months.[20] In addition, another study included 18,989 children aged 16 to 30 months in their study.[18] Several longitudinal studies screened children at an early age, then reevaluated them at 2 to 4 years old. The authors concluded that M-CHAT validity was high, although the children had reached >30 months of age.[19]

The ROC curve for M-CHAT showed the

best sensitivity when failing seven or more items of M-CHAT, similar to results from previous study.[5] However, another study reported 87% sensitivity and 94% specificity for the Thai language M-CHAT with failure criteria cut-off of 8 or more questions.[20]

The earlier study found 85 to 87% of sensitivity and 93 to 99% of specificity, with 80% positive predictive value and 99% negative predictive value. Another study resulted in a 95-99% sensitivity and 95-99% specificity.[21] Aakre[22] noted that the M-CHAT has been available in Spain, Turkey, China and Japan.

The Spanish M-CHAT had good sensitivity (100%), specificity (98%), and NPV (100%), as well as moderate PPV (35%) if failure occurred on more than 1 question of critical question or more than 2 question of total question.[16] The Arabic M-CHAT had 86% sensitivity, 80% specificity, and good PPV (88%).[17] In addition, a study modified the Chinese language CHAT-23 and M-CHAT questions into a new version of 15 questions, with 100% sensitivity and 96.5% specificity if failing of 5 or 6 of 15 questions.[23] We used the Indonesian version of M-CHAT translated by Soetjiningsih and found 82.35% sensitivity (95%CI 56.6 to 96.2%) and 89.68% specificity (95%CI 83.0 to 94.4%) if failing more than 6 of 23 questions (**Table 3**).

The likelihood ratio is a semi-quantitative measurement of assessing a diagnostic test that reveals how big a diagnostic procedure will change the possibility of a disease that is calculated from sensitivity and specificity of a diagnostic test.[12] This ratio expresses the magnitude of the likelihood that ill patients would have a certain diagnostic test result divided by the possibility of well patients having the same test results.[10] The positive LR >6 and the negative LR <0.2 in a study indicates that the Indonesian M-CHAT is a good instrument because it can change the hypothesis against the probability of disease of pre-test to post-test.[12] Our LRs for a cut-off of failing >6 items were 7.98 (95%CI 4.6 to 14.0) for positive LR and 0.2 (95%CI 0.07 to 0.6) for negative LR.

Pre-test probability is the likelihood of a person having a disease prior to diagnostic test, also defined as the prevalence of the disease based on clinical and demographic characteristics.[10] The prevalence of our study was 9.7%. After excluding children with global developmental delay, the prevalence was 11.9%.

Screening instruments need high sensitivity to exclude a disease diagnosis for normal results. For conditions with a low prevalence, a test with high specificity is more important than one with high sensitivity.[10] Using a cut-off of >6 items of the total M-CHAT items, specificity was good at 89.68%. The specificity was higher than sensitivity (**Table 3**), indicating that the Indonesian version of M-CHAT is a suitable screening tool for autism.

The pre-test odds of this study were calculated from probability divided with (1-probability), resulting 0.135. The post-test odds is the multiplication value of pretest odds with positive LR, i.e. 1.078. Thus, the post-test probability according to Bayes theory could be calculated, i.e., the post-test odds divided with (1+post-test odds), amounting to 51.87%.

The limitations of our study was that we did not perform CHAT evaluation on the subjects which suspected with the M-CHAT, as some other studies did, we directly performing DSM-IV-TR on the first visit. In addition, this study was not community based, so the community-based autism prevalence remains unknown. This research needs to be continued with a larger sample size for a higher level of precision and narrower validity.

In conclusion, the Indonesian version of M-CHAT translated by Soetjiningsih is a suitable screening tool for autism. It has optimal diagnostic validity in detection of autism for failure criteria of more than 6 of 23 questions, with 82.35% sensitivity and 89.68% specificity. Of 6 critical M-CHAT questions, a failure of two or more had 82.35% sensitivity and 91.27% specificity. As such, the tool can be applied to children aged 18 to 48 months whose parents fill the form directly. If the result of the screening reveals suspected autism, parents are advised to seek expert opinion.

Conflict of Interest

None declared.

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