

The Validity of the Modified Checklist for Autism in Toddlers, Revised with Follow-Up (M-CHAT-R/F) Thai Version as the Autism Screening Application: A Pilot Study

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Background: Autism spectrum disorder (ASD) is a neurodevelopmental disorder where symptoms first appear during the first two years of life. Early screening and diagnosis are the keys to identifying toddlers with ASD so that early intervention could be recommended. The Modified Checklist for Autism in Toddlers, Revised with Follow-up (M-CHAT-R/F) is a worldwide ASD screening instrument with adequate validity, which is used to screen ASD in toddlers between the ages of 16 and 30 months.

Objective: To compute the sensitivity and specificity of the Thai version of the M-CHAT-R/F on the Autism Screening application (AS app) among children ranging from 16 to 30 months of age.

Materials and Methods: The permission to translate M-CHAT-R/F into Thai and place it on an AS app on the computer website, on iOS, and on Android smartphones/tablets was granted. The forward translation of M-CHAT-R/F to Thai and the back translation into English were conducted by the language experts. The content was proofed and edited by two Child and Adolescent Psychiatrists and by one Developmental Pediatrician. The final Thai version of the M-CHAT-R/F was placed in the AS app and was used in the pilot study, which consisted of 15 toddlers with ASD and 15 toddlers with typical development. The screening results from the AS app were compared to the diagnoses from either Child and Adolescent Psychiatrists or Developmental Pediatricians to calculate the sensitivity and specificity.

Results: The number of female(s) and male(s) among typical toddlers and toddlers with ASD were 1/14 and 2/13. The mean ages were 16 (SD 0)/26 (SD 4.31) and 23 (SD 9.90)/29.08 (SD 1.71) months old. The Thai M-CHAT-R/F gave the sensitivity and specificity of 100% at the cutoff score of 6 or greater from the full score of 20.

Conclusion: The AS app had a high level of validity at the cutoff score of 6 or greater.

Keywords: Application; Screening; Autism; Toddlers; Thai

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Autism spectrum disorder (ASD) is a neurodevelopmental disorder, which is characterized by impairment in social interaction and communication,

often accompanied with repetitive/restricted behaviors^(1,2). ASD affects the individual's abilities of social function⁽³⁾, quality of life, and their family life⁽⁴⁾. ASD is a lifelong condition, in which the symptoms can appear early during the first two years of life⁽⁵⁾. The average age that ASD was diagnosed has been found to be three years of age⁽⁶⁾. The diagnosis of ASD discovered in a patient at the age of two by an experienced professional, was found to be reliable and stable⁽⁷⁾.

Since birth, all the children have had their development monitored. The detection of early signs or symptoms of ASD by parents or by a medical doctor is the key to get the child into early intervention programs, which, may prevent problems from occurring later in life⁽⁶⁾. To create an autism-friendly

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environment around the affected individuals, it is necessary to obtain an early diagnosis and acquire the appropriate information⁽⁸⁾. Screening tools for ASD have been developed. Around the world, the Modified Checklist for Autism in Toddlers is a tool that is being used, and it has been revised with a follow-up (M-CHAT-R/F). It can lower the age that children can be diagnosed with ASD and thereby, increase the time available for early intervention⁽⁹⁾. The present study aimed at calculating the sensitivity and specificity of the Thai version of the M-CHAT-R/F on the Autism Screening application (AS app) for the parents seeking to screen their children between the ages of 16 and 30 months old.

Materials and Methods

The present study was a cross-sectional validity study conducted between July 2017 and June 2018, after receiving approval from the Ethics Committee of Khon Kaen University (HE591359).

M-CHAT-R/F

M-CHAT-R/F is a 2-stage parent-report screening tool utilized to assess the risk for ASD in toddlers. The M-CHAT-R/F contained 20 items, which ask 'YES' or 'NO' questions about ASD symptoms. The M-CHAT-R/F, which has a total score of 20, must be completed in its entirety. For children, who have been screened as 'positive', it is strongly recommended that the Follow-up form being used. This is particularly important for those children, whose scores were in the mid-range or scores of 3 to 7. The Follow-up form contains all the same items as the M-CHAT-R, but the 'YES' or 'NO' answers have been replaced by 'Pass' or 'Fail'.

The scoring algorithm for M-CHAT-R is as follows:

For most items, 'YES' is the typical response, while 'NO' is an at-risk response. However, for Items 2, 5, and 12, the scores have been reversed, which means that 'NO' is the typical response and 'YES' is the at-risk response. To score the M-CHAT-R, the number of at-risk responses is added up by following the algorithm below:

Total score of 0 to 2: The score represents a low risk, and No Follow-up is needed. The child is screened negative. If the child was younger than two years old, it is advised to rescreen the child at 24 months, or after three months has elapsed from the first assessment, and if developmental surveillance or other tools suggested risk for ASD, refer as needed.

Total score 3 to 7: The score represents a moderate

risk. Administer the M-CHAT-R Follow-up items correspond to the at-risk responses. Only those items, which were scored at-risk, need to be completed. If two or more items continued to be at-risk, immediately refer the child for the following, (a) an early intervention and (b) a diagnostic evaluation.

Total score 8 to 20: The score represents a high risk. It is not necessary to complete the M-CHAT-R Follow-up. Bypass the Follow-up and immediately refer the child for (a) an early intervention and (b) a diagnostic evaluation.

The sensitivity and specificity at the M-CHAT-R scoring of 3 with follow-up of 2 were 85.40% and 99.30%, respectively⁽⁹⁾.

Translation of M-CHAT-R/F

The translation was permitted by the original developer⁽⁹⁾. The translation process started with the translation of the English version into Thai by utilizing the following experts: two Child and Adolescent Psychiatrists, one Developmental Pediatrician, and one Developmental Nurse. All the experts met together for a session to review their translations and to select the best one where the agreement was obtained from at least three of the four translators. This was to make the primary Thai version. The two other psychiatrists, who were fluent in the English language, translated the primary Thai version back into English. The primary Thai version and the back translation version (English) were reviewed by the other panel of experts consisting of two Child and Adolescent Psychiatrists and one Developmental Pediatrician. The contents, which obtained agreement from at least two of the three reviewers, were collected. This was to make the final Thai version of the M-CHAT-R/F, which was able to retain the meaning of the original M-CHAT-R/F.

The Autism Screening application

The AS app was built by the medical authors (the Child and Adolescent Psychiatrists, the Developmental Pediatrician, the Psychiatrist, and the Developmental Nurse) and by two university lecturers in the field of Computer Engineering (an Associate Professor and an Assistant Professor). The name of the mobile app was “คัดกรองออทิสซึม”. App “คัดกรองออทิสซึม” (Figure 1) consisted of six parts. Part 1. The interface: The app ran on iOS, android, and on the website platform and could be installed from each storage platform. Part 2. The startup screen: Access to the app did not require disclosure of an individual's most personal or private information. Parents were able to gain access



Figure 1. The Autism screening application.

to the app as a guest. Part 3. The demographic data: To proceed to the screening part, the information that was needed consisted of a nickname, address, gender, date of birth, and the birth order of the child among the other sister(s) and brother(s). Part 4. The M-CHAT-R/F screening: This section contained 20 ASD questions in the Thai language. The authors were permitted to enclose a drawn picture, which delineated the intent of each question. The answer to each of the questions was either 'YES' or 'NO'. To receive the results, before leaving the screening part, the app warned the parents not to leave any question unanswered. In other words, every question had to be answered. Part 5. The results: The scoring program is designed to automatically score the 'YES' and 'NO' responses and to score the total of the at-risk items. The parent would receive the computation score result from the app along with a suggestion note (see the details above). Part 6. Education: This part contained education for parents to stimulate their child's development and the locations of nearby governmental clinics: the Pediatric Developmental Clinic and the Child and Adolescent Psychiatry Clinic.

Participants

Controls: The control group was composed of 15 toddlers ranging in age from 16 to 30 months old brought to the Well-Child Clinic at the Faculty of Medicine, Khon Kaen University's Srinagarind Hospital. The controls had to pass the regularly used Developmental Surveillance Form (DSF). The DSF was utilized and completed by the attending

pediatrician when the toddlers were 9 months, 18 months, and 24 to 30 months old. The DSF has four domains of development, fine motor, gross motor, speech, and language development. The controls were required to pass the four domains. During the period of the present research, the parents of the toddlers with consecutive normal development were asked to participate in the present study. The agreement, which was made with the parents after completing the informed consent, was that, the parents were asked to complete the AS app.

Cases: The toddlers, who ranged in age from 16 to 30 months old from north-eastern Thailand, had been brought by their parents or had been referred by a physician to either visit the Child Developmental Clinic or the Child and Adolescent Psychiatry Clinic at the Faculty of Medicine, Khon Kaen University's Srinagarind Hospital. The purpose was to screen for ASD. To be a part of the present study, they had to have missed at least one or more milestones in DSF and the attending Pediatrician was also concerned. The exclusion criteria were 1) the parents did not agree for their children to participate in the research, and 2) the children had a significant loss of hearing or of vision or other neurological disorders such as cerebral palsy, phenylketonuria, tuberous sclerosis, neurofibromatosis, and seizure disorders, or a history of severe head trauma or stroke, feeding problems or malnutrition, prematurity, autoimmune disorders, anemia, diseases of the endocrine system, cardiovascular system, the pulmonary system, the liver, or the kidneys, and those, who had a severe intellectual disability. During the study period, the parents of those consecutive toddlers with a positive DSF were asked to participate in the present study. After giving their informed consents, the parents were asked to complete the AS app. Fifteen toddlers, who had scored more than 2 on the AS app, were required.

After completing the AS app, both the controls and the cases met either with a Child and Adolescent Psychiatrist or a Child Developmental Pediatrician so that each child could be evaluated using the Diagnostic and Statistical Manual of Mental Disorders: Fifth Edition (DSM-5) to determine if a diagnosis of ASD could be found. Both the Child and Adolescent Psychiatrist and the Child Developmental Pediatrician had been using the DSM-5 criteria for more than five years and were accustomed to it. Both were blind to the M-CHAT-R/F results. The diagnoses of ASD, which made either by the Child and Adolescent Psychiatrist or the Child Developmental Pediatrician, were the gold standard.

Measures

The screening results for ASD from the Thai version of the M-CHAT-R/F on the AS app were compared with the clinical diagnoses of ASD conducted by the clinicians.

Statistical analysis

The data from the 30 toddlers, including 15 toddlers with typical development and 15 toddlers with ASD, were analyzed by using Stata, version 10.1 (StataCorp LP, College Station, TX, USA; Khon Kaen University copyright). Genders and ages were presented in percentages. The authors determined the criterion validity of the Thai version of the M-CHAT-R/F by assessing the psychometric properties at various cutoff scores. Comparison between the results from the Thai version of the M-CHAT-R/F screening and the results from the clinical diagnoses yielded the following values, sensitivity, specificity, specificity classified, and likelihood ratios. To determine the best cutoff score, The Youden's index was also calculated.

Results

Thirty participants including 50% with typical development and 50% having been diagnosed with ASD, with 27 males (90%) and three females (10%) were included in this study. Their ages ranged from 16 to 30 months old. Twenty-six of the participants (86.67%) were older than 24 months old. The mean ages (standard deviation, SD) of all participants, those with typical development, and those diagnosed with ASD, were 26.80 (4.54), 25.33 (4.89), and 28.27 (3.75) months, respectively. The female/male ratios among the typical toddlers and those toddlers with ASD were 1/14 and 2/13, respectively and the mean ages (SD) were 16 (0)/26 (4.31) and 23 (9.90)/29.08 (1.71) months old, respectively (Table 1).

The analysis of the M-CHAT-R/F Thai version on the AS app was conducted to determine the appropriate cutoff score. The authors found that at the score of 1 or greater, the sensitivity was 100% and the specificity was 73.33%, while at the score of 6 or greater, both the sensitivity and specificity were at 100%. The Youden's index at the score of 6 or greater was 1, which indicated the best cutoff score (Table 2). Thus, these data points suggested that the appropriate cutoff score should be at a score of 6 or greater.

Then the diagnostic testing of the Thai version of the M-CHAT-R/F at the score of 6 or greater was calculated. The sensitivity, specificity, positive predictive value, and negative predictive value are shown in Table 3.

Table 1. The demographic data of the participants

	ASD	Typical development
Age (months); mean [SD]	25.33 [4.89]	28.87 [3.75]
Sex; n (%)		
Male	14 (93.33)	13 (86.67)
Female	1 (6.67)	2 (13.33)
Primary caregiver; n (%)		
Mother	12 (80)	13 (86.67)
Father	0 (0.00)	0 (0.00)
Grandmother	2 (13.33)	2 (13.33)
Grandfather	1 (6.67)	0 (0.00)
Living area; n (%)		
Urban	5 (33.33)	13 (86.67)
Rural	10 (66.67)	2 (13.33)
Birth condition; n (%)		
Normal	15 (100)	15 (100)
Physical examination; n (%)		
No gross neurological deficits	15 (100)	15 (100)
Presenting symptoms; n (%)		
Reduced eye contact	15 (100)	0 (0.00)
Delayed language	15 (100)	0 (0.00)
Repetitive motor movement	3 (20.00)	0 (0.00)

ASD=autism spectrum disorder; SD=standard deviation

Each item of the Thai version of the M-CHAT-R/F was statistically analyzed. High sensitivity and specificity were found in Item 16 with sensitivity and specificity at 100%, and in Item 9 with sensitivity at 93.3% and specificity at 100%. However, because Item 4, with a sensitivity of 13.3% and specificity of 73.3%, and Item 13 with a sensitivity of 13.3% and a specificity of 100%, the results showed less effective screening (Table 4).

Discussion

In the present study, almost all the participants with clinically diagnosed ASD had first been diagnosed at an age older than two years old and all were boys, which aligns with the previous studies^(6,10). ASD symptoms appear during the developmental period, while symptoms can be detected in the early stage, especially within the first two years. Studies support that ASD might be able to be diagnosed under the age of two years by experienced professionals^(7,11), but at first, the parents are the key people to detect or to suspect symptoms. Effective ASD screening might enhance their capability to bring the children at risk of ASD to be diagnosed more quickly.

The Thai version of the M-CHAT-R/F demonstrated high sensitivity and specificity, and the Youden's index was 1. To summarize, a score of

Table 2. The sensitivity, specificity, specificity classified, likelihood ratios (LR), and Youden's index of the Thai version of the M-CHAT-R/F score on the AS app at the different cutoff points (n=30)

Cutoff points	Sensitivity	Specificity	1-specificity	Specificity classified	LR+	LR-	Youden's index
≥0	100%	0.00%	0.00%	50.00%	1.0000	-	0.00
≥1	100%	73.33%	26.67%	86.67%	3.7500	0.0000	0.73
≥6	100%	100%	0.00%	100%	-	0.0000	1.00
≥9	93.33%	100%	0.00%	96.67%	-	0.0667	0.93
≥11	66.67%	100%	0.00%	83.33%	-	0.3333	0.67
≥12	53.33%	100%	0.00%	76.67%	-	0.4667	0.53
≥13	46.67%	100%	0.00%	73.33%	-	0.5333	0.47
≥14	13.33%	100%	0.00%	56.67%	-	0.8667	0.13
≥17	0.00%	100%	0.00%	50.00%	-	1.0000	0.00
>17	100%	0.00%	0.00%	50.00%	1.0000	-	0.00

Table 3. The psychometric properties of the M-CHAT-R/F when the cutoff score=6

TP	FN	FP	TN	Sensitivity (95% CI)	Specificity (95% CI)	PPV	NPV
15	0	0	15	100 (78.2 to 100)	100 (78.2 to 100)	100	100

TP=true positive; FN=false negative; FP=false positive; TN=true negative; PPV=positive predicted value; NPV=negative predicted value; CI=confidence interval

Table 4. The sensitivity and specificity of the Thai version of the M-CHAT-R/F for each item

Items	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
1 If you point at something across the room, does your child look at it? (FOR EXAMPLE, if you point at a toy or an animal, does your child look at the toy or animal?)	73.3	100	100	100
2 Have you ever wondered if your child might be deaf?	40	100	100	62.5
3 Does your child play pretend or make-believe? (FOR EXAMPLE, pretend to drink from an empty cup, pretend to talk on a phone, or pretend to feed a doll or stuffed animal?)	66.7	100	100	75
4 Does your child like climbing on things? (FOR EXAMPLE, furniture, playground equipment, or stairs)	13.3	73.3	33.3	45.8
5 Does your child make unusual finger movements near his or her eyes? (FOR EXAMPLE, does your child wiggle his or her fingers close to his or her eyes?)	33.3	100	100	60
6 Does your child point with one finger to ask for something or to get help? (FOR EXAMPLE, pointing to a snack or toy that is out of reach)	80	100	100	83.3
7 Does your child point with one finger to show you something interesting? (FOR EXAMPLE, pointing to an airplane in the sky or a big truck in the road)	80	100	100	83.3
8 Is your child interested in other children? (FOR EXAMPLE, does your child watch other children, smile at them, or go to them?)	73.3	100	100	78.9
9 Does your child show you things by bringing them to you or holding them up for you to see - not to get help, but just to share? (FOR EXAMPLE, showing you a flower, a stuffed animal, or a toy truck)	93.3	100	100	93.8
10 Does your child respond when you call his or her name? (FOR EXAMPLE, does he or she look up, talk or babble, or stop what he or she is doing when you call his or her name?)	60	100	100	71.4
11 When you smile at your child, does he or she smile back at you?	40	100	100	62.5
12 Does your child get upset by everyday noises? (FOR EXAMPLE, does your child scream or cry to noise such as a vacuum cleaner or loud music?)	66.7	100	100	75
13 Does your child walk?	13.3	100	100	53.6
14 Does your child look you in the eye when you are talking to him or her, playing with him or her, or dressing him or her?	80	100	100	83.3
15 Does your child try to copy what you do? (FOR EXAMPLE, wave bye-bye, clap, or make a funny noise when you do)	86.7	100	100	88.2
16 If you turn your head to look at something, does your child look around to see what you are looking at?	100	100	100	100
17 Does your child try to get you to watch him or her? (FOR EXAMPLE, does your child look at you for praise, or say "look" or "watch me"?)	80	100	100	83.3
18 Does your child understand when you tell him or her to do something? (FOR EXAMPLE, if you do not point, can your child understand "put the book on the chair" or "bring me the blanket"?)	66.7	100	100	75
19 If something new happens, does your child look at your face to see how you feel about it? (FOR EXAMPLE, if he or she hears a strange or funny noise, or sees a new toy, will he or she look at your face?)	73.3	100	100	78.9
20 Does your child like movement activities? (FOR EXAMPLE, being swung or bounced on your knee)	26.7	100	100	57.7

6 or greater on the Thai version of the M-CHAT-R/F on the AS app would be considered perfect⁽¹²⁾ in its predictive accuracy for ASD. The cutoff score was lower than the high-risk group, with a score of 8 to 20, in the original version⁽⁹⁾. These results arose from the fact that the case group in the present study had overt ASD symptoms and straight away sought medical diagnosis, which differed from the validity of the original version in which all toddlers were screened at their well-child visits. Additionally, the M-CHAT-R/F, which was used at two stages of screening, showed good sensitivity and specificity if the total score in the initial screening was 3 and if it was 2 in the follow-up⁽⁹⁾. The Thai version of the M-CHAT-R/F did not do the Follow-up score.

The authors carried out an analysis of each item and found that high sensitivity and specificity were found in Item 16: "If you turn your head to look at something, does your child look around to see what you are looking at?" and in Item 9: "Does your child show you things by bringing them to you or holding them up for you to see – not to get help, but just to share?". These two items were asking about social interactions and reciprocity, which are the important symptoms of ASD according to the DSM-5 criteria. Item 13: "Does your child walk?" and Item 4: "Does your child like climbing on things?" showed a low sensitivity in the Thai version. These two question items were understood by most of the participant's parents, indicating that their children could walk and that they liked to climb even though being more active at an earlier age can indicate the risk of having ASD symptoms^(13,14).

The limitations of the present study were its small sample size and the fact that the comparison was between children with ASD and children with typical development. A small sample size may cause a high value of sensitivity and specificity. Further studies should be conducted on larger groups and applied in the Well-Child Clinic or in a community that more closely resembles real-life situations. The authors should do two stage screening research as the original M-CHAT-R/F. Furthermore, public health education should focus on the signs of ASD and its early symptoms or on other neurodevelopmental disorders so that the parents can have an early and reliable scale to determine whether their child's development is progressing in a typical manner.

Conclusion

The Thai version of the M-CHAT-R/F on AS app was developed and has shown high level of the

sensitivity and specificity at the cutoff score of 6 or greater.

What is already known on this topic?

ASD is a neurodevelopmental disorder that chronically affects the social skills and behaviors of the individual. Early detection of ASD allows the child to receive early intervention and to gain a better prognosis.

What this study adds?

The AS app containing the Thai version of the M-CHAT-R/F is a good instrument that allows the parents to screen their toddlers between the ages of 16 and 30 months for ASD by themselves. The application allows for convenient access to the screening.

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Conflicts of interest

No potential conflicts of interest were reported by the authors.

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