Original Article

Screening Tests for Cognitive Impairment in Elderly Thai Adults: A Systematic Review

Suchanan Kanjanapong MD[1], Harisd Phannarus MD[1], Weerasak Muangpaisan MD, MPhil[1]

[1] Division of Geriatrics, Department of Preventive and Social Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand

Background: Elderly adults in Thailand are expected to represent 20% of the population in 2021. Screening tools are crucial in initiating cognitive assessments of elderly adults. Clinicians and researchers should select the tools best suited for the characteristics of their population. Several screening tools have been studied in elderly Thai adults over the past 30 years.

Objective: To review the data on the screening tests for cognitive impairment currently available in Thailand, and to assess their respective strengths and issues.

Materials and Methods: Seven electronic databases including MEDLINE, Embase, PsycINFO, Scopus, Google Scholar, and two specializing in Thai journals, which are ThaiJo and TDC-ThaiLIS, were searched. A hand-search of the reference lists was also undertaken. Two reviewers independently screened the articles, assessed their quality using the QUADAS-2 checklist, and extracted relevant data. Any discrepancies were resolved through discussion.

Results: Twenty-eight studies assessing 33 screening tests were included. The tests were categorized into three groups, multiple-task, single-task, and questionnaire-based tools. Six articles studied their accuracy in community-based populations, while the rest were conducted at tertiary-care centers. The highest sensitivities for dementia detection were demonstrated by the Chula Mental Test for the multiple-task assessment test, and the Clock-Drawing Test for the single-task cognitive test.

Conclusion: Various screening tests for cognitive impairment have been examined in the Thai population. The present study main observation was that many researchers did not clearly address their methodology and biases. Tackling these issues will ensure a high-quality methodology and validity of screening tests. Future studies should focus on either developing appropriate tools or adapting the existing tools to better suit elderly Thai adults.

Keywords: Aging; Cognition; Cognitive Test; Dementia; Screening

Received 16 February 2021 | Revised 14 May 2021 | Accepted 14 May 2021

J Med Assoc Thai 2021;104(9):1433-46

Website: http://www.jmatonline.com

Dementia, a syndrome caused by diseases of the brain, presents as disturbances in multiple higher cortical functions. Affected patients will gradually experience impairments of their memory, thinking processes, behavior, and ability to perform daily activities[1]. As the size of the aging population continues to grow, dementia is inevitably becoming one of the world's public health priorities[2]. In Thailand, the proportion of elderly adults is projected to represent 20% of the population in 2021, and by 2024, dementia is expected to affect more than 600,000 elderly Thai adults[3].

Mild cognitive impairment (MCI) is defined by a performance lower than the expected normative standard, along with preservation of functional ability[4]. It is often viewed as a transitional phase between healthy aging and dementia. The prevalence of MCI in elderly adults over 60 years of age ranges from 5% to 22%[5,6]. People with MCI possess a higher risk of developing dementia, with the transition rate to dementia ranging from 10% to 20% annually[7,8]. Growing public awareness of dementia and Alzheimer's disease is encouraging people to seek advice about their memory changes. Some research on cognitive training has been found to help patients to maintain their daily living functions[9]. However, numerous medications attempted to treat MCI have not succeeded[10].

Both MCI and dementia have a chronic and progressive nature. As 5% to 18% of cases with cognitive impairment are due to reversible causes[11], the early detection of cognitive impairment can

Correspondence to:

Muangpaisan W.

Division of Geriatrics, Department of Preventive and Social Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

Phone: +66-2-4197287, **Fax**: +66-2-4115034

Email: weerasak.mua@mahidol.ac.th

How to cite this article:

Kanjanapong S, Phannarus H, Muangpaisan W. Screening Tests for Cognitive Impairment in Elderly Thai Adults: A Systematic Review. J Med Assoc Thai 2021;104:1433-46.

doi.org/10.35755/jmedassocthai.2021.09.12332

lead to appropriate intervention and quality of life improvement[12]. The standard diagnostic process for cognitive decline comprises history-taking, physical examination, neuropsychological evaluation, laboratory investigations, and structural brain imaging[13]. Since most places have few experts and limited resources, comprehensive neuropsychological assessments cannot be offered as a routine practice. Hence, cognitive testing has become the option physicians need to be familiarized with.

Cognitive tests are commonly used for screening impairment and assessing progression. They are available in traditional formats such as paper-based and face-to-face options, as well as newer forms, such as computer-based tests. They can be grouped characteristically into two types, multiple-task and single-task cognitive tests. The multiple-task cognitive tests assess numerous cognitive domains and calculate a summary score. Examples are the Mini-Mental State Exam (MMSE), the Montreal Cognitive Assessment (MoCA), and the Addenbrooke's Cognitive Examination (ACE)[14-16]. The better-known single-task cognitive tests are the Clock-Drawing, the category fluency, and the verbal learning tests. Researchers worldwide have been studying how these various multiple-task and single-task cognitive tests perform in detecting MCI and dementia. Each research methodology has varied, and the study results need to be applied to appropriate clinical contexts. When applying the tests to their patients, practitioners must keep in mind how the test was developed and how to interpret the reference cutoff point.

Both novel and adapted screening tools for cognitive impairment have been available in Thailand for decades. Over the years, screening tests have been developed and validated in various settings and with different groups of participants. Although, the two previous studies attempted to review the Thai screening tests for cognitive impairment, neither was a systematic review[17,18]. The current systematic review aimed to comprehensively collect the screening tools available in Thailand and to examine their validity, strengths, and limitations when applied to the Thai population. With this information, clinicians will be better able to select valid and suitable screening tests for cognitive impairment for their uses.

Materials and Methods

The present research protocol was approved by the Siriraj Hospital Ethics Committee (EC 705/2562).

Search strategy

Drawing upon the databases of MEDLINE, Embase, PsycINFO, Scopus, Google Scholar, and two specializing in Thai journals, the authors searched for the relevant articles published between January 1989 and April 2020. The articles were identified by searching published titles and abstracts, using keywords containing dementia or Alzheimer's or Cogniti* or cognitive impairment or cognitive dysfunction or cognitive disorders, and screen or measure or test tool or instrument or assessment, and Thai or Thailand. Studies published in English or Thai were included. Furthermore, the authors conducted a hand search and consulted personal contacts to identify additional studies. Moreover, the authors utilized a list of recommended publications specifically prepared for us by experts in the field or from reference lists. The search strategy is illustrated in Figure 1.

Eligibility and selection criteria

Each identified screening test was classified as an assessment, measurement, or screening tool. To be included in the present systematic review, each study had to meet all the following criteria, 1) included participants aged 60 years and above, 2) involved an accuracy study of cognitive screening tools and questionnaires used for the detection of cognitive impairment, Alzheimer's disease, or dementia, and 3) was conducted on the Thai population.

Studies were excluded if their index tests were categorized as full neuropsychological battery testing, the index tests were intended to be administered by a specialist such as a neuropsychologist or neurologist, or they were conducted as a head-to-head comparison of two or more cognitive tests.

Study screening and selection

Two investigators (Kanjanapong S and Phannarus H) independently reviewed the titles and abstracts. The full-text versions of the publications of interest were retrieved and reviewed. Discrepancies were resolved through discussion and, if necessary, the third investigator was involved (Muangpaisan W). When needed, the authors sought additional information through direct contact with the researchers.

Data extraction

Two reviewers (Kanjanapong S and Phannarus H) independently extracted all data using a structured data extraction form. The extracted details related to the demographic data of the participants, clinical

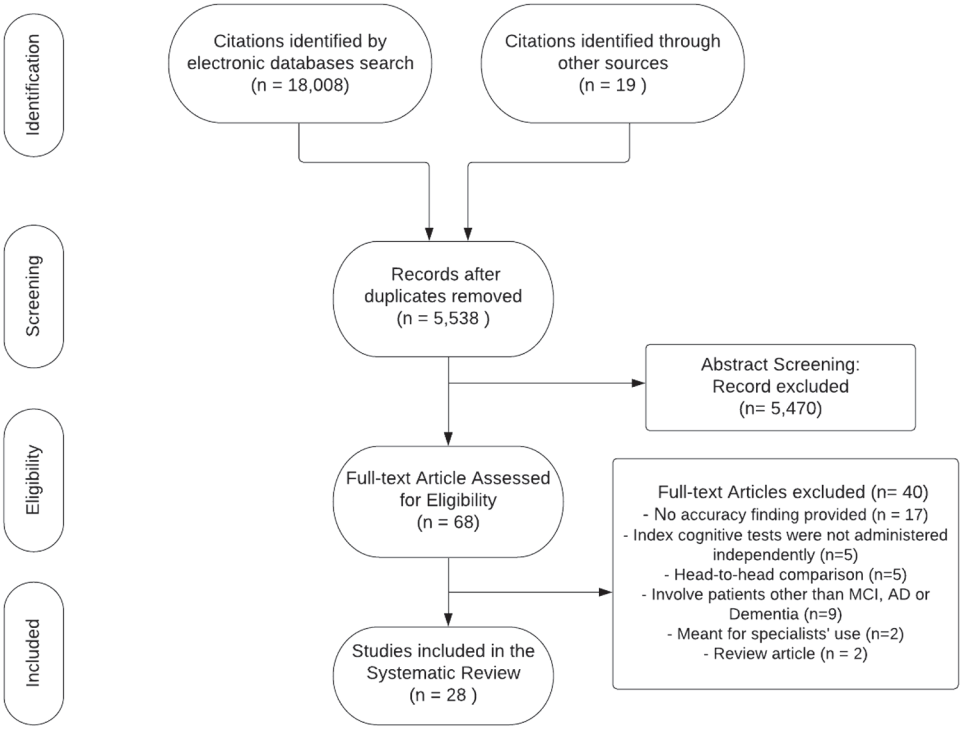

Figure 1. Flow diagram of the literature selection process according to PRISMA Guideline.

settings, screening tests, gender balance, education levels, diagnostic criteria, and diagnostic accuracy findings such as sensitivity, specificity, positive predictive value, negative predictive value, and likelihood ratio. Only the sensitivity and specificity with the optimal value at one cutoff point was reported. The information was tabulated and categorized by the type of screening test and test-type as multiple-task, single-task, and questionnaire-based as shown in Table 1-3. A pooled analysis was not feasible due to the heterogeneity of the study designs and populations. Any disagreements were resolved by consensus, and, if necessary, the third investigator (Muangpaisan W) was consulted.

Quality assessment

The Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) Tool, recommended by the Cochrane Collaboration, was used for the quality assessments[19]. QUADAS-2 evaluates four domains as patient selection, index tests, reference standards, and flow and timing. Two reviewers (Kanjanapong S and Phannarus H) independently scored each item as low risk, high risk, or unclear. Any disagreement in the evaluation was resolved through discussion. A summary of the quality assessments across the four domains is presented in Table 1.

Twenty studies (71.4%) were ranked as high risk in the domain of patient selection. Most of those studies were assessed as having a high risk due to differences in the age and gender profiles of their patient groups. In terms of the index test bias, only 10 studies (35.7%) declared that a blinding process was utilized while the screening tests were performed. In addition, most of the published studies did not clearly state the intervals between the screening assessments and the clinical diagnoses. This resulted in 71.4% of the studies being ranked as unclear in the flow-and-timing domain. Nevertheless, most (85.7%) of the publications used standard criteria to establish a diagnosis of MCI or dementia.

Results

A diagram of the present study selection process is shown in Figure 1. Sixty-eight full-text articles from five online databases and other literature sources were assessed. Twenty-eight articles were selected for the present systematic review.

Twenty-one full publications (75%) were in English, while the remainder had abstracts in English. Most of the studies included participants who were over 60 years of age. All studies used the

Table 1. Quality assessments of included publications, based on QUADAS-2

	Domain 1: Patient selection	Domain 2: Index test	Domain 3: Reference standards	Domain 4: Flow and timing
Jitapunkul, 1996 (1)[33]	⊖	⊕	⊕	?
Jitapunkul, 2000 (2)[34]	⊖	⊕	⊕	⊕
Senanarong, 2001 (3)[56]	⊖	⊕	⊕	?
Kanchanatawan, 2006 (4)[51]	⊖	⊕	⊕	?
Siri, 2006 (5)[57]	⊖	⊕	⊕	?
Jitapunkul, 2009 (6)[35]	⊖	?	⊕	?
Tangwongchai, 2009 (7)[23]	⊖	?	⊕	?
Muangpaisan, 2010 (8)[26]	⊕	?	⊕	?
Sungkarat, 2011 (9)[49]	⊖	⊕	⊕	?
Limpawattana, 2012 (10)[50]	⊖	⊕	⊕	⊕
Kusalaruk, 2012 (11)[37]	⊖	?	?	?
Limpawattana, 2012 (12)[38]	⊖	⊕	⊕	⊕
Kanjananopinit, 2014 (13)[47,48]	?	?	⊖	?
Julayanont, 2015 (14)[46]	⊕	⊕	⊕	?
Kittisares, 2015 (15)[58]	⊖	?	⊕	⊕
Kittipongpisal, 2015 (16)[53]	⊕	?	⊕	?
Charoenboon, 2016 (17)[40]	⊖	?	⊕	?
Griffiths, 2016 (18)[43]	?	?	?	?
Thaneerat, 2017 (19)[45]	?	?	⊕	?
Silpakit, 2017 (20)[39]	⊕	?	⊕	⊕
Silpakit, 2017 (21)[44]	⊖	?	⊕	⊕
Charoenboon, 2018 (22)[27]	⊖	?	⊕	?
Aniwattanapong, 2018 (23)[52]	⊖	?	⊕	⊕
Charoenboon, 2018 (24)[27]	⊖	?	⊕	?
Phannarus, 2019 (25)[36]	⊕	⊕	⊕	?
Charoenboon, 2019 (26)[41]	⊖	?	⊕	?
Institute of Geriatric Medicine, 2020 (27)[42]	⊖	⊖	⊖	⊖
Charoenboon, 2020 (28)[55]	⊖	?	⊕	?

⊖ High risk; ⊕ Low risk; ? Uncertain

cross-sectional method, and the majority (75.8%) were conducted in the special clinics at tertiary-care medical centers. The accuracy of detecting dementia was investigated for 16 multiple-task and 13 single-task screening tests. In addition, the accuracy of detecting MCI was examined for nine multiple-task and 15 single-task cognitive screening tests. Five studies (17.2%) were conducted in community-based populations. One study was carried out in a nursing home, while another was conducted at a community hospital. The sample sizes varied from 48 to 4,048 participants, and their level of formal education varied greatly across the studies.

The authors categorized the screening tests into four groups, multiple-task tests for dementia detection, multiple-task tests for MCI detection, single-task tests for cognitive impairment detection, and questionnaires for cognitive impairment detection. Table 2 and 3 details the accuracy findings of the included multiple-task screening tests. The most used multiple-task screening tests for dementia detection were the MMSE-Thai, the Thai Mental State Exam (TMSE), and the Chula Mental Test. Four studies showed additional cutoff points for elderly adults having less than six years of formal education.

Table 4 reports the single-task screening tests assessing cognitive impairment. Seven tests were used to examine the accuracy of dementia detection,

Table 2. Multiple-task screening tests for dementia detection

Index tests (time, minutes)	Author, year (study number)	Setting	Diagnostic criteria	Numbers of participants (% female)	Age (years); mean (SD)	Level of education; mean schooling year (SD)	Accuracy study finding
Chula Mental Test (3 minutes)	Jitapunkul, 1996 (1)[33]	Resident in the old people's home	DSM-III-R	NC 195 (86.2%) D 17 (94.3%)	NC 77.3 (7.9) D 82.1 (7.5)	NC: less than 4 years 74.4% D: less than 6 years 82.3%	Cutoff point 14/15S N 100%, SP 90%, PPV 46%, NPV 100%, LR+ 9.8, LR– 0
	Jitapunkul, 2000 (2)[34]	Geriatric clinic	DSM-III-R	ND 36 (50%) D 12 (25%)	ND 69.9 (4.5) D 77.7 (8.9)	ND: primary school or less 36.1% D: primary school or less 58.3%	Cutoff point 15/14 SN 83.3%, SP 91.7%, PPV76%, NPV 94.3%, LR+ 10, LR– –0.2
	Jitapunkul, 2009 (6)[35]	Community	DSM-IV	ND 397 (60.5%) D 23 (65.2%)	ND 68.8 (6.3) D 73 (8.7)	ND: primary school or less 88.9% D: primary school or less 95.7%	Cutoff point 16/15 SN 91%, SP 76%, PPV 18%, NPV 99%, LR+ 3.9, LR– 0.1
TMSE (10 minutes)	Senanarong, 2001 (3)[36]	Community	DSM-IV	NC 87 (57.5%) D 73 (71.2%)	NC 65.7 (4.9) D 70.7 (8.6)	NC: less than 6 years 70.11% D: less than 6 years 60.27%	Cutoff point 23/24 SN 68.5%, SP 88%, PPV 83.3%, NPV 77%, LR+ 6.0, LR– 0.4 Cutoff point 25/26 SN 80.8%, SP 57.5%, PPV 61%, NPV 78%, LR+ 1.9, LR– 0.3
	Phannarus, 2019 (25)[36]	Geriatric clinic	NIA-AA	NC 35 (62.9%) AD 30 (60.0%)	NC 75.0 (4.0) AD 76.7 (5.2)	NC: primary school or less 40% AD: primary school or less 50%	Cutoff point 24/25 SN 86.7%, SP 80%, PPV 83.3%, NPV 83%, LR+ 4.3, LR– 0.2
ACE-Thai (20 to 31 minutes)	Charoenboon, 2016 (17)[40]	University hospital	DSM-V	NC 48 (NA) MCI 29 (NA) D 30 (NA)	NC 65.6 (6.3) MCI 70.7 (7.4) D 76.9 (7.4)	NC 10.5 (5.2) MCI 8.6 (5.5) D 7.7 (4.2)	Discriminating ND and D: Cutoff point 61/62 SN 100%, SP 97%, PPV 93.8%, NPV 100%, LR+ 38.5, LR– 0
AMT (NA)	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2%) D 42 (59.5%)	NC 60 to 89 (NA) D 60 to 89 (NA)	NC: 6 years or less 68.2% D: 6 years or less 83.3%	Cutoff point 7/8 SN 69%, SP 97%, PPV 93.5%, NPV 83.1%, LR+ 22.8, LR– 0.3
MMSE-Thai 2002 (10 to 21 minutes)	Limpawattana, 2012 (12)[38]	Geriatric clinic	DSM-IV	NC 89 (59.6%) D 89 (41.6%)	NC 70.2 (5.6) D 71.9 (7.2)	NC: 6 years or less 43.8% D: 6 years or less 70.79%	Cutoff point 23/24 SN 78.7%, SP 66.3%, PPV 70%, NPV 75.6%, LR+ 2.3, LR– 0.3
	Kusalaruk, 2012 (11)[37]	Memory clinic	NA	NC 123 (54.5%) MCI 34 (NA) D 81 (NA)	NC 62 (NA) Non-NC 72.5 (NA)	NC: primary school or less 4.9%, university or more 65% Non-NC: primary school or less 26.2%, university or more 33.0%	Primary school: Cutoff point 17/18 SN 50%, SP 100%, PPV 100%, NPV 35.3% Higher than primary school: Cutoff point 22/23 SN 57.9%, SP 100%, PPV 100%, NPV 83%, LR+ 3.9, LR– 0.11
	Silpakit, 2017 (21)[39]	Psychiatric outpatient clinic	DSM-IV-TR	ND 54 (55.6%) D 93 (64.5%)	ND 71.1 (10.9) D 74.3 (8.1)	ND: primary school 33.3%, university or more 42.6% D: primary school 40.8%, university or more 23.7%	Cutoff point 22/23 SN 64.5%, SP 72.2%, PPV 18%, NPV 99%, LR+ 2.3, LR– 0.5
Mini-Cog1 (2 to 4 minutes)	Kusalaruk, 2012 (11)[37]	Memory clinic	NA	NC 123 (54.5%) MCI 34 (NA) D 81 (NA)	NC 62 (NA) Non-NC 72.5 (NA)	NC: primary school or less 4.9%, university or more 65% Non-NC: primary school or less 26.2%, university or more 33.0%	Cutoff point per protocol† SN 66.7%, SP 98.4%, PPV 96.4%, NPV 81.8%, LR+ 41, LR– 0.3
	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2) D 42 (59.5)	NC 60 to 89 (NA) D 60-89 (NA)	NC: 6 years or less 68.2% D: 6 years or less 83.3%	Cutoff point 3/4 SN 90.0%, SP 93.5%, PPV 100%, NPV 93.3%, LR+ NA, LR– NA
Mini-Cog2 (2 to 4 minutes)	Kusalaruk, 2012 (11)[37]	Memory clinic	NA	NC 123 (54.5%) MCI 34 (NA) D 81 (NA)	NC 62 (NA) Non-NC 72.5 (NA)	NC: primary school or less 4.9%, university or more 65% Non-NC: primary school or less 26.2%, university or more 33.0%	Cutoff point per protocol† SN 72.8%, SP 97.6%, PPV 95.2%, NPV 84.5%, LR+ 29.9, LR– 0.3
	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2) D 42 (59.5)	NC 60 to 89 (NA) D 60 to 89 (NA)	NC: 6 years or less 68.2% D: 6 years or less 83.3%	Cutoff point 3/4 SN 96.8%, SP 71.4%, PPV 92.6%, NPV 84.6%, LR+ NA, LR– NA
GP-Cog (NA)	Griffiths, 2016 (18)[43]	Neurological hospital	DSM-IV	ND 56 (NA) D 63 (NA	ND 69.48 (7.54) D 73.86 (5.82)	ND: primary school or less 71.4%, high school or more 23.2% D: primary school or less 66.7%, high school or more 27%	Cutoff point 4 SN 95.2%, SP 94.6%, PPV 96.7%, NPV 94.7%, LR+ 26.7, LR– 0.1
CSI-Cognitive Score (NA)	Silpakit, 2017 (20)[43]	Psychiatric hospital	DSM-IV-TR	ND 54 (55.6%) D 93 (64.5%)	ND 71.1 (10.9) D 74.3 (8.1)	NC: primary school 33.3%, secondary school 24.1%, university and higher 42.6% D: primary school 40.8%, secondary school 35.5%, university and higher 23.7%	Cutoff point 7/8 SN 59.6%, SP 68.5%, PPV 76.4%, NPV 49.3%, LR+ 1.9, LR– 0.6
Dementia Screen Test (2 to 8 minutes)	Thaneerat, 2017 (19)[45]	Multi-center, Psychiatric outpatient	DSM-V	NC 80 (NA) D 124 (NA)	All participants 69.50 (7.91)	All participants 6 years or less 74.5%, 12 years or more 15.8%	Cutoff point 4/5 SN 83.1%, SP 77.9%, PPV 62.8%, NPV 91.1%, LR+ 3.8, LR– NA
7MS (7 to 12 minutes)	Sungkarat, 2011 (9)[49]	NA	NINCDS-ADRDA	ND 129 (63.6%) D 20 (80%)	ND 74.2 (6.9) D 79.1 (5.5)	ND 6.7 (4.6) D 6.0 (4.2)	Cutoff point 0.83S N 100%, SP 89.9%, PPV NA, NPV NA, LR+ NA, LR– NA
MACE (5 minutes)	Charoenboon, 2019 (26)[41]	Memory and psychiatric clinic	DSM-V	NC 60 (76.7%) MCI 40 (60%) D 48 (68.8%)	NC 64.9 (6.5) MCI 69.4 (7.8) D 75.8 (7.5)	NC 10.2 (4.9) MCI 8.7 (5.3) D 8.1 (3.9)	Discriminating ND and D: Cutoff point 16/17 SN 95.8%, SP 85%, PPV 75.4%, NPV 97.7%, LR+ 6.4, LR– 0.5 Discriminating NC and D: Cutoff point 16/17 SN 95.8%, SP 100%, PPV 100%, NPV 96.8%, LR+ NA, LR– 0.04

NC=normal cognition; MCI=mild cognitive impairment; D=dementia; AD=Alzheimer's disease; ND=non-dementia; SN=sensitivity; SP=specificity; NPV=negative predictive value; PPV=positive predictive value; LR=likelihood ratio; NA=not available; TMSE=Thai Mental State Exam; ACE-Thai=Addenbrooke's Cognitive Examination-Thai version; AMT=Abbreviated Mental Test; MMSE-Thai=Mini Mental State Exam-Thai version; CSI=cognitive screening instrument; 7MS=Seven-Minute Screen; MACE-T=mini-Addenbrooke's Cognitive Examination-Thai version; MoCA-T=Montreal Cognitive Assessment-Thai; RUDAS=Rowland Universal Dementia Assessment Scale; SD=standard deviation

† Determining dementia cases referencing protocol in Kusalaruk et al., 2012, ‡ Determining dementia cases referencing protocol in Kanjananopinit et al., 2014

Table 2. (continued)

Index tests (time, minutes)	Author, year (study number)	Setting	Diagnostic criteria	Numbers of participants (% female)	Age (years); mean (SD)	Level of education; mean schooling year (SD)	Accuracy study finding
Serial 3 subtraction and 3-word recall (NA)	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2) D 42 (59.5)	NC 60 to 89 (NA) D 60 to 89 (NA)	NC: 6 years or less 68.2% D: 6 years or less 83.3%	Cutoff point 1/2 SN 16.7%, SP 98.5%, PPV 87.5%, NPV 65.0%, LR+ 11, LR– 0.9
MoCA-T (NA)	Tangwongchai, 2009 (7)[23]	Memory clinic	NINCDS-ADRDA, DSM-IV	NC 40 (72.5%) AD 40 (75.0%)	NC 69.6 (6.6) AD 77.6 (9.0)	NC 12.0 (5.3) AD 8.5 (4.5)	Cutoff point 21/22 SN 100%, SP 98%, PPV 97.6%, NPV 100%, LR+ 40, LR– 0
Cognistat (10 minutes)	Kanjananopinit, 2014 (13)[47,48]	Tertiary care hospital	DSM-IV	NC 50 (39%) D 50 (30%)	NC: 60 to 69 44%, 70 to 79 50%, 80+ 18% D: 60 to 69 36%, 70 to 79 38%, 80+ 26%	NC: primary school or less 60%, high school or more 28% D: primary school or less 58%, high school or more 32%	Cutoff point per protocol‡ SN 92%, SP 34%, PPV 58%, NPV 80%, LR+ NA, LR– NA
RUDAS (10 minutes)	Limpawattana, 2012 (10)[50]	Geriatric and memory clinics	DSM-IV-TR	ND 89 (59.6%) D (41.6%)	ND 70.2 (5.6) D 71.9 (7.2)	ND: 6 years or lower 43.8%, more than 6 years 56.2% D: 6 years or lower 69.8%, more than 6 years 29.2%	6 years or lower: Cutoff 22/23 SN 71.4%, SP 76.9%, PPV 83.3%, NPV 62.5%, LR+ 3.1, LR– 0.3 More than 6 years: Cutoff 23/24 SN 77%, SP 70%, PPV 57.1%, NPV 85.4%, LR+ 2.6, LR– 0.4

NC=normal cognition; MCI=mild cognitive impairment; D=dementia; AD=Alzheimer's disease; ND=non-dementia; SN=sensitivity; SP=specificity; NPV=negative predictive value; PPV=positive predictive value; LR=likelihood ratio; NA=not available; TMSE=Thai Mental State Exam; ACE-Thai=Addenbrooke's Cognitive Examination-Thai version; AMT=Abbreviated Mental Test; MMSE-Thai=Mini Mental State Exam-Thai version; CSI=cognitive screening instrument; 7MS=Seven-Minute Screen; MACE-T=mini-Addenbrooke's Cognitive Examination-Thai version; MoCA-T=Montreal Cognitive Assessment-Thai; RUDAS=Rowland Universal Dementia Assessment Scale; SD=standard deviation

† Determining dementia cases referencing protocol in Kusalaruk et al., 2012, ‡ Determining dementia cases referencing protocol in Kanjananopinit et al., 2014

Table 3. Multiple-task screening tests for mild cognitive impairment detection

Index tests (time, minutes)	Author, year (study number)	Setting	Diagnostic criteria	Numbers of participants (% female)	Age (years); mean (SD)	Level of education: mean schooling year (SD)	Accuracy study finding
MoCA-T (NA)	Tangwongchai, 2009 (7)[23]	Memory clinic	NINCDS-ADRDA, DSM-IV	NC 40 (72.5%) MCI 40 (65.0%)	NC 69.6 (6.6) MCI 73.4 (7.3)	NC 12.0 (5.3) MCI 11.3 (5.3)	Adding 1 point for subjects with 6 or less education years: Cutoff point 24/25 SN 80%, SP 80%, PPV 80%, NPV 80%, LR+ 4, LR– 0.3
MoCA-B (15 to 21 mins)	Julayanont, 2015 (14)[46]	Community hospital	NIA-AAA	NC 43 (84%) MCI 42 (83%)	NC 66.6 (6.7) MCI 70.2 (6.6)	NC 3.6 (1.1) MCI 2.9 (1.7)	Cutoff point 24/25 SN 81%, SP 86%, PPV 85%, NPV 82%, LR+ 5.7, LR– 0.2
MMSE (10 to 21 minutes)	Kusalaruk, 2012 (11)[37]	Memory clinic	NA	NC 123 (54.5%) MCI 34 (NA) D 81 (NA)	NC 62 (NA) Non-NC 72.5 (NA)	NC: primary school or less 4.9%, university or more 65% Non-NC: primary school or less 26.2%, University or more 33.0%	Primary school: Cutoff point 17/18 SN 0%, SP 100%, PPV NA, NPV NA, LR+ NA, LR– NA Primary school or more: Cutoff point 22/23 SN 13.8%, SP 100%, PPV NA, NPV NA, LR+ NA, LR– NA
Mini-Cog 1 (2 to 4 minutes)	Kusalaruk, 2012 (11)[37]	Memory clinic	NA	NC 123 (54.5%) MCI 34 (NA) D 81 (NA)	NC 62 (NA) Non-NC 72.5 (NA)	NC: primary school or less 4.9%, university or more 65% Non-NC: primary school or less 26.2%, university or more 33.0%	Cutoff point per protocol† SN 12%, SP 98.4%, PPV 66.7%, NPV 80.1%, LR+ 7.2, LR– 0.9
	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2%) MCI 657 (63%)	NC: 60 to 69 65.2%, 70 to 79 30.3% MCI: 60 to 69 49.5%, 70 to 79 39.4%	NC: 6 years or less 68.2% MCI: 6 years or less 86.2%	Cutoff point 3/4 SN 64.1%, SP 93.5%, PPV 100%, NPV 17.0%, LR+ 10.5, LR– 0.4
Mini-Cog 2 (2 to 4 minutes)	Kusalaruk, 2012 (11)[37]	Memory clinic	NA	NC 123 (54.5%) MCI 34 (NA) D 81 (NA)	NC 62 (NA) Non-NC 72.5 (NA)	NC: primary school or less 4.9%, university or more 65% Non-NC: primary school or less 26.2%, university or more 33.0%	Cutoff point per protocol† SN 11.8%, SP 97.6%, PPV 57.1%, NPV 0.8%, LR+ 4.8, LR– 0.9
	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2%) MCI 657 (63%)	NC: 60 to 69 65.2%, 70 to 79 30.3% MCI: 60 to 69 49.5%, 70 to 79 39.4%	NC: 6 years or less 68.2% MCI: 6 years or less 86.2%	Cutoff point 3/4 SN 71.3%, SP 71.4%, PPV 99%, NPV 13.6%, LR+ 2.5, LR– 0.4
ACE-T (20 to 31 minutes)	Charoenboon, 2016 (17)[40]	University hospital	DSM-V	NC 48 (NA) MCI 29 (NA)	NC 65.6 (6.3) MCI 70.7 (7.4)	NC 10.5 (5.2) MCI 8.6 (5.5)	Cutoff point 75/76 SN 90%, SP 96%, PPV 92.8%, NPV 93.9%, LR+ 21.5, LR– 0.1
MACE (5 minutes)	Charoenboon, 2019 (26)[41]	Memory and psychiatric clinic	DSM-V	NC 60 (76.7%) MCI 40 (60%)	NC 64.9 (6.5) MCI 69.4 (7.8)	NC 10.2 (4.9) MCI 8.7 (5.3)	Cutoff point 21/22 SN 95%, SP 85%, PPV 81%, NPV 96%, LR+ 6.3, LR– 0.1
Serial 3 subtraction and 3-word recall (NA)	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2%) MCI 657 (63%)	NC: 60 to 69 65.2%, 70 to 79 30.3% MCI: 60 to 69 49.5%, 70 to 79 39.4%	NC: 6 years or less 68.2% MCI: 6 years or less 86.2%	Cutoff point 1/2 SN 4%, SP 98.5%, PPV 96.3%, NPV 9.4%, LR+ NA, LR– NA
AMT (NA)	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2%) MCI 657 (63%)	NC: 60 to 69 65.2%, 70 to 79 30.3% MCI: 60 to 69 49.5%, 70 to 79 39.4%	NC: 6 years or less 68.2% MCI: 6 years or less 86.2%	Cutoff point 7/8 SN 21.9%, SP 97%, PPV 98.6%, NPV 11.1%, LR+ NA, LR– NA

NC=normal cognition; MCI=mild cognitive impairment; D=dementia; ND=non-dementia; SN=sensitivity; SP=specificity; NPV=negative predictive value; PPV=positive predictive value; LR=likelihood ratio; NA=not available; MoCA-T=Montreal Cognitive Assessment-Thai; MoCA-B=Montreal Cognitive Assessment-Basic; MMSE-Thai=Mini Mental State Exam-Thai version; ACE-Thai=Addenbrooke's Cognitive Examination-Thai version; MACE-T=mini-Addenbrooke's Cognitive Examination-Thai version; AMT=Abbreviated Mental Test; SD=standard deviation

† Determining dementia cases referencing protocol in Kusalaruk et al., 2012

Table 4. Single-task screening tests for cognitive impairment detection

Index tests	Author, year (study number)	Setting	Diagnostic criteria	Numbers of participants (% female)	Age (years); mean (SD)	Level of education: mean schooling year (SD)	Accuracy study finding
Clock-Drawing Test by CCSS	Jitapunkul, 2000 (2)[34]	Geriatric clinic	DSM-III-R	ND 36 (50%) D 12 (25%)	ND 69.9 (4.5) D 77.7 (8.9)	ND: primary school or less 36.1%, secondary 33.3%, higher 30.5% D: no 25%, primary 33.3%, secondary 33.3%, higher 8.3%	Cutoff point 6/7 SN 100%, SP 94.1%, PPV 85.7%, NPV 100%, LR+ 18, LR– 0
	Kanchanatawan, 2006 (4)[51]	Community	NINCDS-ADRDA	HC 644 (NA) D 25 (NA)	NA	NA	Cutoff Point 5/6 SN 88%, SP 82%, PPV 16%, NPV 99%, LR+ 4.9, LR– 14.6
Clock-Drawing Test	Charoenboon, 2017 (25)[54]	Memory clinic	DSM-V	NC 60 (71.7%) MCI 35 (60%) D 47 (72.3%)	NC 66.2 (7.0) MCI 69.9 (8.1) D 74.7 (8.9)	NC 9.7 (5.2) MCI 9.2 (5.4) D 8.7 (9.4)	Detecting MCI: Cutoff point 4/5 SN 57.1%, SP 70%, PPV 52.6%, NPV 73.7%, LR+ 1.9, LR– 0.6 Detecting dementia (ND vs. D): Cutoff point 2/3 SN 76.6%, SP 87.4%, PPV 75%, NPV 88.3%, LR+ 6.1, LR– 0.3 Detecting dementia (NC vs. D): Cutoff point 2/3 SN 76.7%, SP 93.3%, PPV 90%, NPV 83.6%, LR+ 11.5, LR– 0.3
CLOX1	Silpakit, 2017 (21)[44]	Psychiatric hospital	DSM-IV-TR	ND 54 (55.6%) D 93 (64.5%)	ND 71.1 (10.9) D 74.3 (8.1)	ND: primary school or less 36.1% D: primary school or less 58.3%	Cutoff point 7/8 SN 43.8%, SP 92.2%, PPV 90.7%, NPV 50, LR+ 5.6, LR– 0.6
Thai Boston Naming Test	Aniwattanapong, 2018 (23)[52]	Dementia clinic	NINCDS-ADRDA	NC 62 (82.3%) MCI 60 (73.3%) AD 60 (68.3%)	NC 68.0 (5.7) MCI 74.8 (6.3) D 78.8 (7.1)	NC 12.4 (5.0) MCI 10.0 (5.5) Dementia 6.9 (5.7)	Detecting dementia (ND vs. D): Cutoff point 4/5 SN 70%, SP 91%, PPV 79.2%, NPV 86%, LR+ 7.8, LR– 0.3
Digit Forward	Muangpaisan, 2010 (8)[26]	Community	DSM-IV	HC 517 (75%) MCI 77 (65%)	NC 63.7 (7.3) MCI 66.3 (7.9)	NC 6.7 (3.2) MCI 6.1 (3.3)	Cutoff point 12/13 SN 63%, SP 69%, PPV 23.4%, NPV 92.7%, LR+ 2.1, LR– 0.5
Digit Backward	Muangpaisan, 2010 (8)[26]	Community	DSM-IV	HC 517 (75%) MCI 77 (65%)	NC 63.7 (7.3) MCI 66.3 (7.9)	NC 6.7 (3.2) MCI 6.1 (3.3)	Cutoff point 4/5 SN 77%, SP 57%, PPV 17.6%, NPV 94.4%, LR+ 1.4, LR– 0.4
Verbal Fluency-Animals	Muangpaisan, 2010 (8)[26]	Community	DSM-IV	HC 517 (75%) MCI 77 (65%)	NC 63.7 (7.3) MCI 66.3 (7.9)	NC 6.7 (3.2) MCI 6.1 (3.3)	Cutoff point 14/15 SN 83%, SP 42%, PPV 17.4%, NPV 93.9%, LR+ 1.4, LR– 0.4
	Charoenboon, 2018 (24)[27]	Memory & psychiatric clinics	DSM-V	NC 61 (77.1%) MCI 40 (60%) D 49 (69.4%)	NC 64.7 (6.7) MCI 69.4 (7.8) D 76.0 (7.0)	NC 10.4 (5.0) MCI 8.7 (5.3) D 7.7 (4.1)	Detecting MCI: Cutoff point 12/13 SN 50, SP 93.4%, PPV 83.3%, NPV 74%, LR+ 7.6, LR– 53.5 Detecting dementia: Cutoff point 12/13 SN 83.7%, SP 93.4%, PPV 91.1%, NPV 87.7%, LR+ 12.8, LR– 0.2
Verbal Fluency-Alphabet (Letter Soh)	Muangpaisan, 2010 (8)[26]	Community	DSM-IV	HC 517 (75%) MCI 77 (65%)	NC 63.7 (7.3) MCI 66.3 (7.9)	NC 6.7 (3.2) MCI 6.1 (3.3)	Cutoff point 7/8 SN 80, SP 57%, PPV 22%, NPV 95%, LR+ 1.9, LR– 0.3
Verbal Fluency-Alphabet (Letter Koh)	Muangpaisan, 2010 (8)[26]	Community	DSM-IV	HC 517 (75%) MCI 77 (65%)	NC 63.7 (7.3) MCI 66.3 (7.9)	NC 6.7 (3.2) MCI 6.1 (3.3)	Cutoff point 9/10 SN 50%, SP 73%, PPV 22%, NPV 90.9%, LR+ 1.9, LR– 0.7 Cutoff point 6/7 SN 83.7%, SP 82%, PPV 78.9%, NPV 86.2%, LR+ 4.6, LR– 0.2
Word List Learning Test	Kittipongpisal, 2015 (17)[53]	Psychiatric hospital	NA	NC 44 (56.8%) D 33 (63.6%)	NC 72 (10) D 73 (7.2)	NC 6.9 (2.1) Dementia 7.1 (2.7)	Cutoff point –45/–44 SN 79.3%, SP 73.8%, PPV 68.4%, NPV 82.1%, LR+2.9, LR– 0.3
	Silpakit, 2017 (22)[39]	Psychiatric hospital	DSM-4-TR	ND 54 (55.6%) D 93 (64.5%)	NC 71.1 (10.9) D 74.3 (8.1)	ND: primary school or less 36.1% D: primary school or less 58.3%	Cutoff point 13/14 SN 52.8%, SP 74.1%, PPV 77%, NPV 48.8%, LR+ 2.0, LR– 0.6
Overlapping infinity loops	Charoenboon, 2017 (22)[54]	Memory clinic	DSM-V	NC 60 (71.7%) MCI 35 (60%) D 47 (72.3%)	NC 66.2 (7.0) MCI 69.9 (8.1) D 74.7 (8.9)	NC 9.7 (5.2) MCI 9.2 (5.4) D 8.7 (9.4)	Detecting MCI: Cutoff point 0/1 SN 17.1%, SP 96.7%, PPV 75%, NPV 66.7%, LR+ 5.1, LR– 0.9 Detecting dementia (ND vs. D): Cutoff point 0/1 SN 63.8%, SP 91.6%, PPV 78.9%, NPV 83.6%, LR+ 7.6, LR– 0.4 Detecting dementia (NC vs. D): Cutoff point 0/1 SN 63.8%, SP 96.7%, PPV 93.8%, NPV 77.3%, LR+ 19.2, LR– 0.4
Wire Cubes	Charoenboon, 2017 (22)[54]	Memory clinic	DSM-V	NC 60 (71.7%) MCI 35 (60%) D 47 (72.3%)	NC 66.2 (7.0) MCI 69.9 (8.1) D 74.7 (8.9)	NC 9.7 (5.2) MCI 9.2 (5.4) D 8.7 (9.4)	Detecting MCI: Cutoff point 1/2 SN 65.7%, SP 53.3%, PPV 45.1%, NPV 72.7%, LR+ 1.4, LR– 0.6 Detecting dementia (ND vs. D): Cutoff point 1/2 SN 93.6%, SP 46.3%, PPV 46.3%, NPV 93.6%, LR+ 1.7, LR– 0.1 Detecting dementia (NC vs. D): Cutoff point 1/2 SN 93.6%, SP 53.3%, PPV 61.1%, NPV 91.4%, LR+ 2.0, LR– 0.1
3-word Recall	Charoenboon, 2020 (28)[55]	Memory clinic	DSM-V	NC 65 (76.9%) MCI 45 (62.2%)	NC 64.1 (7.2) MCI 69.4 (7.7)	NC 10.3 (5.0) MCI 9.1 (5.5)	Detecting MCI: Cutoff point 1/2 SN 51.1%, SP 96.7%, PPV NA, NPV NA, LR+ 6.6, LR– NA
				NC 65 (76.9%) D 52 (67.3%)	NC 64.1 (7.2) D 75.7 (8.0)	NC 10.3 (5.0) D 8.1 (4.3)	Detecting dementia: Cutoff point 1/2 SN 86.5%, SP 92.3%, PPV NA, NPV NA, LR+ 11.3, LR– NA

NC=normal cognition; MCI=mild cognitive impairment; D=dementia; ND=non-dementia; HC=healthy control; SN=sensitivity; SP=specificity; NPV=negative predictive value; PPV=positive predictive value; LR=likelihood ratio; NA=not available; CCSS=Chula Clock-drawing Scoring System; SD=standard deviation

Table 4. (continued)

Index tests	Author, year (study number)	Setting	Diagnostic criteria	Numbers of participants (% female)	Age (years); mean (SD)	Level of education: mean schooling year (SD)	Accuracy study finding
Name and Address Recall	Charoenboon, 2020 (28)[55]	Memory clinic	DSM-V	NC 65 (76.9%) MCI 45 (62.2%)	NC 64.1 (7.2) MCI 69.4 (7.7)	NC 10.3 (5.0) MCI 9.1 (5.5)	Detecting MCI: Cutoff point 2/3 SN 68.9%, SP 93.8%, PPV NA, NPV NA, LR+ 11.2, LR– NA
				NC 65 (76.9%) D 52 (67.3%)	NC 64.1 (7.2) D 75.7 (8.0)	NC 10.3 (5.0) D 8.1 (4.3)	Detecting dementia: Cutoff point 2/3 SN 94.2%, SP 93.8%, PPV NA, NPV NA, LR+ 15.3, LR– NA
Famous Person	Charoenboon, 2020 (28)[55]	Memory clinic	DSM-V	NC 65 (76.9%) D 52 (67.3%)	NC 64.1 (7.2) D 75.7 (8.0)	NC 10.3 (5.0) D 8.1 (4.3)	Detecting dementia: Cutoff point 2/3 SN 94.2%, SP 93.8%, PPV NA, NPV NA, LR+ 15.3, LR– NA
				NC 65 (76.9%) D 52 (67.3%)	NC 64.1 (7.2) D 75.7 (8.0)	NC 10.3 (5.0) D 8.1 (4.3)	Detecting dementia: Cutoff point 2/3 SN 78.8%, SP 80%, PPV NA, NPV NA, LR+ 3.9, LR– NA

NC=normal cognition; MCI=mild cognitive impairment; D=dementia; ND=non-dementia; HC=healthy control; SN=sensitivity; SP=specificity; NPV=negative predictive value; PPV=positive predictive value; LR=likelihood ratio; NA=not available; CCSS=Chula Clock-drawing Scoring System; SD=standard deviation

Table 5. Questionnaire-based screening tests for cognitive impairment detection

	Author, year (study number)	Setting	Diagnostic criteria	Numbers of participants (% female)	Age (years); mean (SD)	Level of education: mean schooling year (SD)	Accuracy study finding
Alzheimer's Questionnaire	Kittisares, 2015 (15)[58]	Neurology clinic	NINCDS-ADRDA	NC 40 (82.5%) MCI 51 (70.6%) D 19 (73.7%)	NC 62.5 (9.9) MCI 66.1 (9.9) D 78 (8.8)	NC: primary school or less 45% MCI: primary school or less 82.4% D: primary school or less 52.7%	Detecting MCI: Cutoff point 4/5 SN 79.4%, SP 93.8%, PPV NA%, NPV NA%, LR+ 12.7, LR– 0.2 Detecting dementia: Cutoff point 13/14 SN 97.4%, SP 96.2%, PPV NA, NPV NA, LR+ 25.3, LR– 0.3
14-Question Questionnaire	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2%) MCI 657 (63.0%) D 42 (59.5%)	NC: 60 to 69 65.2%, 70 to 79 30.3%, 80 to 89 4.5% MCI: 60 to 69 49.5%, 70 to 79 39.4%, 80 to 89 10.7% D: 60 to 69 49.5%, 70 to 79 39.4%, 80 to 89 10.7%	NC: 6 years or less 68.2% MCI: 6 years or less 86.2% D: 6 years or less 83.3%	Detecting MCI: Cutoff point 30/31 SN 6.8%, SP 93.9%, PPV 90.5%, NPV 9.1%, LR+ NA, LR– NA Detecting dementia: Cutoff point 30/31 SN 26.2%, SP 93.9%, PPV 69.1%, NPV 65.3%, LR+ NA, LR– NA
IQCODE-8	Silpakit, 2017 (20)[39]	Psychiatric hospital	DSM-4-TR	ND 54 (55.6%) D 93 (64.5%)	NC 71.1 (10.9) D 74.3 (8.1)	ND: Primary school or less 36.1% D: Primary school or less 58.3%	Cutoff point 24/25 SN 62.2%, SP 64.7%, PPV 74.3%, NPV 50.7%, LR+ 1.8, LR– 0.6
	Institute of Geriatric Medicine, 2020 (27)[42]	Community	DMS-V	NC 66 (65.2%) MCI 657 63.0%) D 42 (59.5%)	NC: 60 to 69 65.2%, 70 to 79 30.3%, 80 to 89 4.5% MCI: 60 to 69 49.5%, 70 to 79 39.4%, 80 to 89 10.7% D: 60 to 69 49.5%, 70 to 79 39.4%, 80 to 89 10.7%	NC: 6 years or less 68.2% MCI: 6 years or less 86.2% D: 6 years or less 83.3%	Detecting MCI: Cutoff point 3.41/3.42 SN 14.9%, SP 100%, PPV 100%, NPV 10%, LR+ NA, LR– NA
IQCODE-16	Senanarong, 2001 (3)[56]	Community-based population	DSM-IV	NC 87 (57.5%) D 73 (71.2%)	NC 65.81 (4.33) D 70.71 (7.64)	NC: Less than 6 years 68.9% D: Less than 6 years 60.2%	Four years of education or less: Cutoff point 3.56/3.57 SN 81.8%, SP 90%, PPV 86.8%, NPV 84.8%, LR+ 7.8, LR– 0.2 More than 4 years of education: Cutoff point 3.46/3.47 SN 83.6%, SP 86.2%, PPV 83.6%, NPV 86.2%, LR+ 6.1, LR– 0.2
	Silpakit, 2017 (21)[39]	Psychiatric hospital	DSM-IV-TR	ND 54 (55.6%) D 93 (64.5%)	ND 71.1 (10.9) D 74.3 (8.1)	ND: primary school or less 36.1% D: primary school or less 58.3%	Cutoff point 50/51 SN 69.2%, SP 72.6%, PPV NA, NPV NA, LR+ 2.5, LR– 0.4
IQCODE-32	Siri, 2003 (5)[57]	Geriatric clinic	DSM-V	NC 100 (72.5%) D 100 (66%)	NC 71.23 (6.38) D 74.52 (7.22)	NC: primary School or less 40%, high school or more 48% D: primary school or less 55%, high school or higher 34%	Cutoff point 3.41/3.42 SN 90%, SP 95%, PPV 94.7%, NPV 90.4%, LR+ 18, LR– 0.1

NC=normal cognition; MCI=mild cognitive impairment; D=dementia; ND=non-dementia; SN=sensitivity; SP=specificity; NPV=negative predictive value; PPV=positive predictive value; LR=likelihood ratio; NA=not available; IQCODE=Informant Questionnaire on Cognitive Decline in the Elderly; SD=standard deviation

while eight studied the validation of MCI detection. Category fluency in both animals and fruits, and Clock-Drawing Tests were studied most frequently. Only one test, the verbal fluency with the Letter Soh test, performed well in detecting MCI. All the others were only able to differentiate dementia cases.

The accuracies of the questionnaire-based screening tools are presented in Table 5. Various versions of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE), along with the Alzheimer's Questionnaire (AZQ) and 14-Question Questionnaire, were included. IQCODE-32 was found to be most accurate in identifying dementia patients.

Discussion

The present study systematic review captured a

comprehensive list of screening tests for cognitive impairment validated in Thailand. Most studies were based in specialized clinics in Bangkok and other metropolitan areas in Thailand. Only one study was conducted in the southern region. Overall, the authors observed a lack of community-based studies. The most recent study by the Institute of Geriatric Medicine was the first large-scale study to be conducted in a multiple-site, community-based population. The present study findings support the need for the validation of the screening tests in community settings in all regions of Thailand. This includes determining whether the same tests perform differently in local dialects. Clarifying this issue will expand the generalizability of the tests and allow providers to assess their patients more accurately.

The Thai Clinical Practice Guidelines: Dementia, published in 2014, strongly recommend the use of the MMSE-Thai and the TMSE as cognitive screening tests[20,21]. These tests are among the most studied, multiple-task, cognitive testing tools, and among the most used in clinical practice. The explanation is that the two tests assess patients' global cognition. Additionally, they are well-known and relatively easily administered by practitioners. In the authors review, both MMSE-Thai and TMSE had a high accuracy in detecting dementia, but not MCI. Since MMSE and its variants became licensed by the Psychological Assessment Resources, researchers have sought alternatives[22]. Other multiple-task cognitive tests such as MoCA-T, Seven-Minute Screen, and Rowland Universal Dementia Assessment Scale, have been shown to be highly sensitive in the detection of cognitive impairment.

Not only has investigators' interest in detecting dementia increased substantially, but also the efforts of researchers to identify the preceding stage, MCI, have soared. Tangwongchai and Hemrungrojn et al[23] were the first to study an MCI group using the MoCA-T. Other researchers have subsequently studied more cognitive screening tests in MCI participants. Besides the MoCA-T, multiple-task screening tests that performed with high validity in MCI detection were the Addenbrooke's Cognitive Examination III-Thai version (ACE-T) and the Mini-Addenbrooke's Cognitive Examination III-Thai version (MACE-T). The more recent researchers have characterized MCI participants meticulously, using standardized criteria and investigative methods. With the use of an appropriate screening tool, a patient with cognitive changes can receive a timely diagnosis and access the available resources and support. Most MCI studies have been conducted in tertiary-care centers, with subjects being recruited from the institutions' memory clinics. However, this may not reflect the true prevalence of MCI cases in the population. Conducting more research on MCI in community cohorts will provide physicians with better diagnostic tools and reliable practice guidelines.

A single-task cognitive test is usually selected when a certain impairment is suspected. Overall, very few of the included single-task cognitive tests exhibited high validity in detecting cognitive impairment. This is because most single-task cognitive tests target a specific cognitive ability and cannot capture a heterogenous origin deficit and presentation across all patients. Among the high-performing tasks, the Clock-Drawing Test (CDT) identified dementia cases in the Thai population accurately. The present study results agreed with the previous literature on the CDT worldwide[24]. What made the CDT stand out from other single-task cognitive test is its ability to assess multiple cognitive domains and functions, both qualitatively and quantitatively. This, along with the convenience of being able to administer the test at the bedside, explains why the CDT remains popular and widely accepted. Nevertheless, its validity in detecting MCI is still inconsistent[25]. The present review found that the single-task cognitive test with the highest validity for MCI detection is a letter fluency test using Letter Soh, with a cutoff point of 7, assessed by Muangpaisan et al in 2010[26]. However, a category fluency test using the animal category with a 13/14 cutoff point, assessed by Charoenboon et al in 2018, showed the highest performance in detecting dementia. The verbal fluency test using category and letter fluency, is another widely used, single-task cognitive test that assesses multiple cognitive functions in only one minute[27,28]. The mutual characteristic of these high-performing, single-task screening tests is their ability to assess various cognitive domains. Nonetheless, the other single-task cognitive tests that aim for specific domains are still essential. With a range of tests available, clinicians have the flexibility of administering a single test to patients with a particular impairment or using a set of tests to comprehensively assess their cognition.

Information from collaterals is priceless in determining a diagnosis of cognitive impairment. A questionnaire completed by the informants, such as the IQCODE, is widely used to detect cognitive changes in patients[29]. The included versions of IQCODE used 8 to 32 questions. This could be investigated further

as a preferred option for the illiterate. The main limitations of the IQCODE are firstly, the need to have an informant available who knows the patient well, for at least 10 years, and secondly, their reliability. The strength noted for the questionnaires is their applicability in large epidemiology surveys, especially when direct histories are absent. The questionnaires could be administered by non-healthcare providers or self-administered. Moreover, as the patients' clinical condition worsens, the informant input becomes especially helpful in tracking their progression.

In many studies, the cognitively normal volunteers were more likely to be on a younger age spectrum and have a higher educational level than the dementia cases. Therefore, the discrimination noted between the controls and the cases in some studies may be due to age and education differences. The quality assessment revealed that over 80% of the studies ranked as high risk on the patient-selection domain. Furthermore, without a comprehensive neuropsychology measure, cases of mild MCI could be mistakenly labeled as cognitively normal. Fortunately, Thai researchers are increasingly reporting how they categorized their participants into the various cognitive statuses using standard criteria. This supports the reliability and quality of their research. On the other hand, some studies only compared cognitively normal older people and dementia cases. In addition, some publications did not describe the severity of the participants with dementia, which meant the reported validity of the tests may appear too high. The cognitive tests applicability in clinical practice has become less appealing as the dementia clinical statuses are already obvious. What is more, some authors have suggested reporting validity by making comparisons between normal and cognitively impaired groups as this approach would reflect how patients are presented in real-world clinical settings.

It is challenging to distinguish MCI from age-related cognitive decline, especially in groups with a low formal education level. Elderly adults with a limited education can be misclassified as MCI if their cognitive test scores were not interpreted with caution[30]. This is a very important issue as the average formal education level of elderly Thai adults is only 5.4 years[31]. Many authors suggested the use of additional cutoff points for people with less than six years of formal education, while others have recommended adding one point to adjust the total score before an interpretation is made. Among the included studies, the Chula Mental Test, Verbal Fluency with the Letter Soh, IQCODE-3, IQCODE-8, and IQCODE-32 sensitively detected cognitive impairment in groups with low education. Furthermore, a modified version of MoCA, called MoCA-Basic (MoCA-B), was developed and validated as an MCI screening tool specifically for elderly adults with low education. Among the included reviews, several studies recruited a large proportion of elderly adults with low education or illiteracy. It is recommended that providers take the baseline characteristics of each cohort into an account when looking at applying the test results.

Most of the selected studies applied the cross-sectional method and were conducted at specialized clinics. The methodology is often the initial step to validate a novel cognitive test[32]. These specialized clinics offer well-characterized participants diagnosed in a resource-rich environment. The drawback is that the prevalence of cognitive impairment and dementia in those clinics is very high in comparison with the community or general outpatient settings. The reported validity of cognitive tests may cloak how they perform in everyday clinical practice. Therefore, a community-based study with the true prevalence is much needed. During the reviewing process, only seven community-based studies were identified. Such studies usually require a large group of participants to achieve the substantial number of index cases required. Some studies bypassed this logistic obstacle by applying a cognitive screen instrument to identify those with an abnormal score beforehand. However, the prescreening interfered with how a diagnosis of cognitive impairment was made and created significant bias. Additionally, longitudinal studies are strongly needed. As neurodegenerative diseases are progressive nature, the longer the physicians follow the changes in the participants, the more they will learn. Both Thai and worldwide researchers need more support to carry out longitudinal studies in low-prevalence settings. By doing so, they will improve the generalizability of the findings and allow the needs of all elderly adults to be better addressed.

The present systematic review is the first to comprehensively report cognitive assessments in Thailand. Unfortunately, the two earlier articles did not apply the systematic review method and were published when MCI was relatively little studied. Moreover, the present study is also the first systematic review of cognitive tools from a country in South-East Asia. This Asian region currently has the highest standardized prevalence of dementia among the elderly as well as the highest proportional increase of dementia cases, in comparison to other regions in

Asia[32]. Despite that, the standardization of cognitive screening tools in South-East Asia has received little attention. The two previously mentioned articles on cognitive assessment tools in Asia predominantly focused on the use of cognitive tests in East Asia. The authors hope that the current review will prove to be an example of the benefits of sharing perspectives on cognitive screening with others. Cognitive screening tests are crucial, and discussions are needed on how the researcher can collaborate to increasingly refine them. Publishing the current findings also supports the cognitive assessment process in an era of globalization, in which people regularly travel and migrate. The present review's other strength includes a qualitative assessment section discussing the test-domain quality of the systematic method. This addresses the opportunities and important steps for future cognitive test validation in Thailand.

The present systematic review has several limitations. Firstly, the included studies were conducted in heterogenous populations with diverse backgrounds. As a result, the authors were not able to perform a pooled analysis and did not include screening tests that needed certified administrators. Therefore, several cognitive tests presently available in Thailand were not included in the analyses. Many cognitive screening tests that have been validated in Thailand are adopted tools where the original assessments were largely taken from the western countries. The authors urge researchers to adapt the contents carefully and appropriately to the Thai language and culture. Moreover, if researchers aimed to develop a new tool, the authors believe that it is vital that they be particularly careful with their methodology and processes as, based on our review, original studies are fraught with pitfalls. Additionally, the authors observed a heterogeneity in the diagnoses and blinding of the results of the screening tests. Achieving commonality in diagnostic methods and approaches to the blinding of the results is a significant step toward ensuring that research quality is acceptable, and bias is minimized. Addressing these concerns will lead to screening tests for cognitive impairment with high accuracy suited to elderly Thai adults.

Conclusion

The research on, and the development of, screening tests for cognitive impairment for the elderly Thai population have flourished greatly over the last decade. The present systematic review demonstrated the characteristics and validity of various cognitive assessments available in Thailand. The purpose is to provide a guide for practitioners needing to select a screening test suitable for their patients. Choosing a suitable test and using an appropriate interpretation will greatly benefit the diagnostic process, patient management, and case follow-up. The strengths and limitations revealed by the current review present a blueprint for future cognitive-test validations. A well-designed research methodology should be implemented to reduce bias and ensure high quality validation. There are opportunities to validate existing screening tests in a well-characterized cohort, to develop screening tests specifically for elderly adults with a low formal education level, and to conduct research on community-based populations.

What is already known on this topic?

There was a previous review on cognitive assessments studied in Thai elderly adults in 2000. Study of cognitive assessment in Thailand has grown significantly since. Thai researchers and publishers have produced many new tools and adaptation of existed tools that are widely used in international level.

What this study adds?

This is the first report to comprehensively collect cognitive publication on screening tests for Thai elderly adults. The analyses include describing each test quality assessment, characteristic of participants, accuracy study and limitation, which help demonstrate the gaps for future Thai researchers. The finding provides the clinicians information to appropriately select the screening test for their patient's maximum benefit.

Acknowledgement

The authors did not receive any specific grant for the present research from any funding agency in the public, commercial, or not-for-profit sectors.

Authors' contributions

Kanjanapong S carried out the literature search, screening, data extraction, quality assessment, table compilation, and manuscript writing. Phannarus H participated in literature searches, data extraction, and quality assessment. Muangpaisan W was involved in screening, data extracting, and critical manuscript editing. All three authors were involved in methodology planning and approved the final manuscript.

Availability of data and material

The datasets generated or analyzed during the

current study are available from the corresponding author on reasonable request.

Conflicts of interest

The authors have each completed the International Committee of Medical Journal Editors Form for uniform Disclosure of Potential Conflicts of Interest. None of the authors disclose any potential conflict of interest.

References

1. Prince M, Jackson J. World Alzheimer report 2009: The global prevalence of dementia. London: Alzheimer's Disease International; 2009.
2. World Health Organization and Alzheimer's Disease International. Dementia: a public health priority. Geneva: WHO; 2012.
3. Alzhiemer's Disease International. Dementia in the Asia Pacific region: the epidemic is here. Acta Neurol Taiwan 2007;16:183-7.
4. Albert MS, DeKosky ST, Dickson D, Dubois B, Feldman HH, Fox NC, et al. The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the National Institute on Aging—Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimer's Dement 2011;7:270-9.
5. Overton M, Pihlsgård M, Elmståhl S. Prevalence and incidence of mild cognitive impairment across subtypes, age, and sex. Dement Geriatr Cogn Disord 2019;47:219-32.
6. Hilal S, Ikram MK, Saini M, Tan CS, Catindig JA, Dong YH, et al. Prevalence of cognitive impairment in Chinese: Epidemiology of Dementia in Singapore study. J Neurol Neurosurg Psychiatry 2013;84:686-92.
7. Ravaglia G, Forti P, Montesi F, Lucicesare A, Pisacane N, Rietti E, et al. Mild cognitive impairment: Epidemiology and dementia risk in an elderly Italian population. J Am Geriatr Soc 2008;56:51-8.
8. Petersen RC, Knopman DS, Boeve BF, Yonas E, Ivnik RJ, Smith GE, et al. Mild cognitive impairment: Ten years later. Arch Neurol 2009;66:1447-55.
9. Rodakowski J, Saghafi E, Butters MA. Non-pharmacological interventions for adults with mild cognitive impairment and early stage dementia: An updated scoping review. Mol Aspects Med 2015;43-44:38-53.
10. Barnett JH, Lewis L, Blackwell AD, Taylor M. Early intervention in Alzheimer's disease: A health economic study of the effects of diagnostic timing. BMC Neurol 2014;14:101.
11. Muangpaisan W, Petcharat C, Srinonprasert V. Prevalence of potentially reversible conditions in dementia and mild cognitive impairment in a geriatric clinic. Geriatr Gerontol Int 2012;12:59-64.
12. Getsios D, Blume S, Ishak KJ, MacLaine G, Hernández L. An economic evaluation of early assessment for Alzheimer's disease in the United Kingdom. Alzheimer's Dement 2012;8:22-30.
13. Arvanitakis Z, Shah RC, Bennett DA. Diagnosis and management of dementia: review. JAMA 2019;322:1589-99
14. Folstein. Mini-mental state. A grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189-98.
15. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. J Am Geriatr Soc 2005;53:695-9.
16. Mathuranath PS, Nestor PJ, Berrios GE, Rakowicz W, Hodges JR. A brief cognitive test battery to differentiate Alzheimer's disease and frontotemporal dementia. Neurology 2000;55:1613-20.
17. Siri S. Screening test for dementia in community. J Public Health Nursing 2000;27:115-30.
18. Silpakit O. Review article : Dementia screening. J Men Health Thai 2013;21:34-47.
19. Whiting PF, Rutjes AW, Westwood ME, Mallett S, Deeks JJ, Reitsma JB, et al. QUADAS-2: A revised tool for the quality assessment of diagnostic accuracy studies. Ann Intern Med 2011;155:529-36.
20. Prasat Neurological Institute Department of Medical Services Ministry of Public Health, Thailand. Clinical practice guidelines: dementia. Nonthaburi: Ministry of Public Health; 2014.
21. Train The Brain Forum Committee. Thai Mental State Examination (TMSE). Siriraj Hosp Gaz 1993;45:359-74.
22. Rosati E, Rosati CM, Folstein M, Folstein S, Mchugh P. Copyright in Phanasathit diagnostic tests: not yet the end for fair use 1. J Intellect Prop Law Pract 2012;7:510-4.
23. Tangwongchai S, Phanasathit M, Charernboon T, Akkayagorn L, Hemrungrojn S, Phanthumchinda K, et al. The validity of Thai version of the Montreal Cognitive Assessment (MoCA-T) [Internet]. 2009 [cited 2019 Dec 19]. Available from: http://thammanard.blogspot.com/2011/10/validity-of-thai-version-of-montreal.html.
24. Park JK, Jeong EH, Seomun GA. The clock drawing test: A systematic review and meta-analysis of diagnostic accuracy. J Adv Nurs 2018;74:2742-54.
25. Ehreke L, Luppa M, König HH, Riedel-Heller SG. Is the Clock Drawing Test a screening tool for the diagnosis of mild cognitive impairment? A systematic review. Int Psychogeriatr 2010;22:56-63.
26. Muangpaisan W, Intalapaporn S, Assantachai P. Digit span and verbal fluency tests in patients with mild cognitive impairment and normal subjects in Thai-community. J Med Assoc Thai 2010;93:224-30.
27. Charoenboon T. Verbal fluency in the Thai elderly, elderly with mild cognitive impairment and elderly with dementia. J Ment Health Thai 2018;26:91-102.

28. Shao Z, Janse E, Visser K, Meyer AS. What do verbal fluency tasks measure? Predictors of verbal fluency performance in older adults. Front Psychol 2014;5:772.
29. Jorm AF, Jacomb PA. The Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): socio-demographic correlates, reliability, validity and some norms. Psychol Med 1989;19:1015-22.
30. Manly JJ, Byrd D, Touradji P, Sanchez D, Stern Y. Literacy and cognitive change among ethnically diverse elders. Int J Psychol 2004;39:47-60.
31. Office of the Education Council, Ministry of Education, Thailand. Education level among Thai population. Bangkok: Office of the Education Council; 2018.
32. Paddick SM, Gray WK, McGuire J, Richardson J, Dotchin C, Walker RW. Cognitive screening tools for identification of dementia in illiterate and low-educated older adults, a systematic review and meta-analysis. Int Psychogeriatr 2017;29:897-29.
33. Jitapunkul S, Lailett C, Worakul P, Srikiatkhachorn A, Ebrahim S. Chula Mental Test: A screening test for elderly people in less developed countries. Int J Geriatr Psychiatry 1996;11:715-20.
34. Jitapunkul S. Validity of clinical use of the clock-drawing test in Thai elderly patients with memory problems. J Med Assoc Thail 2000;83:342-7.
35. Jitapunkul S, Chansirikanjana S, Thamarpirat J. Undiagnosed dementia and value of serial cognitive impairment screening in developing countries: A population-based study. Geriatr Gerontol Int 2009;9:47-53.
36. Phannarus H, Muangpaisan W, Siritipakorn P, Chotinaiwattarakul W. Cognitive profiles and optimal cut-offs for routine cognitive tests in elderly individuals with Parkinson's disease, Parkinson's disease dementia, Alzheimer's disease, and normal cognition. Psychogeriatrics 2020;20:20-7.
37. Kusalaruk P. A validity study of the mini-cog test in Thai dementia patients. Rama Med J 2012;35:264-71.
38. Limpawattana P, Tiamkao S, Sawanyawisuth K, Thinkhamrop B. Can Rowland Universal Dementia Assessment Scale (RUDAS) replace Mini-Mental State Examination (MMSE) for dementia screening in a Thai geriatric outpatient setting? Am J Alzheimers Dis Other Demen 2012;27:254-9.
39. Silpakit O, Kittipongpisal S, Chomchuen S. The diagnostic accuracy of the Thai dementia assessment tools for primary care. J Ment Health Thai 2017;25:137-47.
40. Charernboon T, Jaisin K, Lerthattasilp T. The Thai bersion of the Addenbrooke's cognitive Examination III. Psychiatry Investig 2016;13:571-3.
41. Charernboon T. Diagnostic accuracy of the Thai version of the Mini-Addenbrooke's Cognitive Examination as a mild cognitive impairment and dementia screening test. Psychogeriatrics 2019;19:340-4.
42. Institute of Geriatric Medicine Department of Medical Services, Thailand. The developement of suitable cognitive screening tools for Thailand. Nonthaburi: Institute of Geriatric Medicine; 2020.
43. The 9th Pan-Pacific Conference on Rehabilitation. PPCR conference abstract book. The general practitioner assessment of cognition. GPCOG (Thai Version): Validity and reliability. 29-30 November 2014, Hong Kong; 2014.
44. Silpakit O. The diagnostic accuracy of the Thai version of Brief Community Screening Instrument for Dementia (CSI-D). J Ment Health Thai 2017;25:20-31.
45. Thaneerat T, Tooreerach U, Petrugs B, Kimsao P, Hongchukiet K, Deeduang B. Development of dementia screening test for Thai elderly. J Psychiatr Assoc Thai 2017;62:177-86.
46. Julayanont P, Tangwongchai S, Hemrungrojn S, Tunvirachaisakul C, Phanthumchinda K, Hongsawat J, et al. The Montreal cognitive assessment–basic: A screening tool for mild cognitive impairment in illiterate and low-educated elderly adults. J Am Geriatr Soc 2015;63:2550-4.
47. Kanjananopinit S, Charoensak S, Keawpornsawan T. The study of psychometric properties of cognistat Thai version. J Psychiatr Assoc Thai 2014;59:409-18.
48. Kanjananopinit S. The study of psychometric properties of cognistat Thai version [thesis]. Bangkok: Mahidol University; 2012 [cited 2020 Mar 29]. Available from: http://10.24.101.11/e-thesis/2555/cd470/5236344.pdf.
49. Sungkarat S, Methapatara P, Taneyhill K, Apiwong R. Sensitivity and specificity of seven-minute screen (7MS) Thai version in screening Alzheimer's disease. J Med Assoc Thai 2011;94:842-8.
50. Impanation P, Tiamkao S, Sawanyawisuth K. The performance of the Rowland Universal Dementia Assessment Scale (RUDAS) for cognitive screening in a geriatric outpatient setting. Aging Clin Exp Res 2012;24:495-500.
51. Kanchanatawan B, Jitapunkul S, Supapitiporn S, Chansirikarnjana S. Validity of clock drawing test (CDT), scoring by Chula clock-drawing scoring system (CCSS) in screening dementia among Thai elderly in community. J Med Assoc Thai 2006;89:1150-6.
52. Aniwattanapong D, Tangwongchai S, Supasitthumrong T, Hemrunroj S, Tunvirachaisakul C, Tawankanjanachot I, et al. Validation of the Thai version of the short Boston Naming Test (T-BNT) in patients with Alzheimer's dementia and mild cognitive impairment: clinical and biomarker correlates. Aging Ment Health 2018;23:840-50.
53. Kittipongpisal S. The accuracy study of the Thai word list learning test. J Ment Health Thai 2015;23:91-101.
54. Charernboon T. Diagnostic accuracy of the overlapping infinity loops, wire cube, and clock drawing tests for cognitive impairment in mild cognitive impairment and dementia. Int J Alzheimers Dis 2017;2017:5289239.
55. Charernboon T. A moment to remember: Performance of the three-word recall, name and address recall and famous person tasks on Thai elderly with mild cognitive impairment and dementia. J Med Assoc Thail

2020;103:19-23.
56. Senanarong V, Assavisaraporn S, Sivasiriyanonds N, Printarakul T, Jamjumrus P, Udompunthuruk S, et al. The IQCODE: an alternative screening test for dementia for low educated Thai elderly. J Med Assoc Thai 2001;84:648-55.
57. Siri S, Okanurak K, Chansirikanjana S, Kitayaporn D, Jorm AF. Modified Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) as a screening test for dementia for Thai elderly. Southeast Asian J Trop Med Public Health 2006;37:587-94.
58. Kittisares A, Tanprawate S, Tangwongchai S, Chan S. The validity of Thai version of Alzheimer's questionnaire [Internet]. 2015 [cited 2019 Dec 19]. Available from: https://www.researchgate.net/publication/282333139_The_validity_of_Thai_version_of_Alzheimer's_questionnaire.