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Screening for Cognitive Dysfunction in Systemic Lupus Erythematosus: a Systematic Review

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Abstract

Background: Screening instruments are brief and simple tools designed to identify alterations in cognitive functioning, as well as to rule out or confirm the presence of cognitive dysfunction. Systemic lupus erythematosus (SLE) is an inflammatory disease that affects multiple organs of the human body, including the nervous system, which can cause neuropsychiatric symptoms such as cognitive dysfunction. Objective: To analyze the scientific evidence on cognitive screening tests used in SLE and the cutoff points suggested in academic literature.

Methodology: A systematic review was conducted from 2014 to the second half of 2024, in databases such as PubMed, Scopus, Web of Science, ScienceDirect, Redalyc and SciELO, based on combinations of keywords and Boolean operators: "cognitive dysfunction", "cognitive impairment", "cognitive decline", "lupus", "systemic lupus erythematosus", "SLE", "Montreal Cognitive Assessment", "MoCA", "MMSE", "Mini-Mental State Examination", "INECO Frontal Screening", "INECO", "Addenbrooke's Cognitive Examination", and "ACE-R III".

Results: The search yielded a total of 564 works, of which 31 documents met the inclusion criteria and were analyzed. The results show that the MoCA is the preferred tool by physicians and specialists worldwide for cognitive screening in patients with SLE, both in patients with and without clear neuropsychiatric symptoms.

Conclusion: The literature consistently supports a cutoff score of <26 on the MoCA as the most widely used threshold for identifying cognitive dysfunction in individuals with systemic lupus erythematosus, with this criterion receiving the strongest empirical validation across published studies. However, some studies have explored lower cutoff scores to improve the instrument's specificity and sensitivity, especially in the SLE population.

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1. Introduction

Neuropsychological assessment (NPA) is a structured process that uses psychometric tools, whose administration time may vary depending on the goals established by the neuropsychologist. In primary care or outpatient settings, several instruments have been developed to reduce administration time while maintaining robust psychometric properties, such as specificity, the probability that the test correctly identifies individuals with normal cognitive functioning, and sensitivity, the probability that the test accurately detects individuals with cognitive impairment (Hebben & Milberg, 2011). Screening or detection instruments are short and simple tools intended to detect deterioration in cognitive functioning and to rule out or confirm the presence of mild cognitive impairment (Petersen, 1997). Similarly, a screening test is a brief assessment tool (generally 5 to 10 minutes) that evaluates one or more cognitive domains and can be useful in determining whether a comprehensive neuropsychological battery is warranted (Yuen et al., 2021a; Delgado Rayes & Sanchez Lopez, 2021).

Screening instruments are commonly used in clinical practice by physicians and psychologists. A survey conducted in Chile found that only 10.6% of clinicians reported using this type of tool in clinical practice (Vinet et al., 2023). Among the instruments used are the Mini-Mental State Examination (MMSE; Folstein et al., 1975), the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005), the INECO Frontal Screening (IFS; Torralva et al., 2009), the Addenbrooke's Cognitive Examination (ACE; Bruno et al., 2020; Mathuranath et al., 2000), the Clock Drawing Test (García-García et al., 1999), and more recent tools incorporating technological support, such as the Computerized Neuropsychological Screening Battery (BNCT; Ostrosky et al., 2024). These instruments are designed to facilitate the early detection of cognitive impairment in patients, have demonstrated adequate psychometric properties and sensitivity in various clinical populations such as schizophrenia (Rosca et al., 2020), bipolar disorder (Galimberti et al., 2020), Alzheimer's disease (Hsieh et al., 2013; Wang et al., 2022), frontotemporal dementia (Freitas et al., 2012), stroke (Wei et al., 2023), multiple sclerosis (Rosca et al., 2020), and some autoimmune diseases such as rheumatoid arthritis (Pankowski et al., 2025) and systemic lupus erythematosus (SLE) (Leslie & Crowe, 2018; Paez-Venegas et al., 2019).

Systemic lupus erythematosus (SLE) is a chronic autoimmune disease characterized by multisystem organ involvement, primarily mediated by inflammatory mechanisms and, in some cases, exacerbated by the prolonged use of immunosuppressive medications required for disease management (Morand et al., 2023). SLE can affect the nervous system (NS) through three pathological pathways: inflammatory factors mediated by cytokines that cross the blood-brain barrier, vascular events, and finally, loss of neuroplasticity (Kivity et al., 2015). Therefore, a group of patients may present alterations in the NS and neuropsychiatric symptoms, known as neuropsychiatric lupus (NPSLE), which includes 19 syndromes involving alterations in the central and peripheral nervous systems (American College of Rheumatology -ACR-, 1999), including cognitive dysfunction, commonly referred to as "lupus brain fog." It is estimated that 80% of patients with SLE develop this condition, although some studies report a prevalence ranging from 14% to 95%. These inconsistencies may be attributable to variations in patient sample characteristics, the selection of cognitive measures, and the criteria used to define impairment (Elsisi et al., 2024; Ho et al., 2018; Kozora et al., 2008). In the Colombian population, studies report the presence of cognitive dysfunction (CD) between 12.2% and 20% (Medina et al., 2024; Rubio, 2021).

The review by Kozora, Burleson, and Filler (2018) shows that patients without neuropsychiatric involvement also exhibit lower cognitive performance compared to control subjects. Therefore, screening instruments are needed for the early detection of CD and to activate appropriate care pathways and cognitive training programs (Kozora et al., 2022).

Neuropsychological assessment in SLE is suggested by the American College of Rheumatology when the professional suspects neuropsychiatric symptoms (ACR, 1999; Kammeyer et al., 2023). However, a review based on medical records in two European centers found that only 27.8% of patients with SLE and severe cognitive impairment underwent formal neuropsychological evaluation by a clinical neuropsychologist (Pamfil et al., 2015), a striking fact considering that a considerable number of patients without nervous system involvement report cognitive complaints (Kozora et al., 2018).

Comprehensive NPA consists of a series of tests that may form a flexible battery, or some prefer "standard" batteries (e.g., NEUROPSI, BANFE, WAIS…) (Delgado Reyes & Sanchez Lopez, 2021), which are administered by a trained psychologist or clinical neuropsychologist. Most of these batteries take between 2 and 4 hours to administer. In contrast, the abbreviated battery proposed by the ACR (1999) requires approximately one hour for administration (Rayes et al., 2018); it is used in patients who have clear neuropsychiatric symptoms. However, the use of short detection tools (e.g., MoCA) and computerized screening batteries (e.g., ANAM) has increased over time, as evidenced by the number of published studies (Yuen et al., 2021a).

In SLE, the use of brief screening batteries through technological tools such as computers has increased to reduce time and economic cost. According to Kozora et al. (2018), the most commonly used computerized assessment in SLE and other autoimmune diseases has been the Automated Neuropsychological Assessment Metrics (ANAM) (Reeves et al., 1996), which consist of 15 subtests, each representing an individual domain among the total 7 cognitive domains: attention and concentration, working memory, mental flexibility, spatial processing, cognitive processing efficiency, memory retrieval, mood, fatigue level, and psychomotor performance (Yuen et al., 2021a). These require approximately 30 to 45 minutes to be complete, a similar time to the protocol proposed by the ACR. The use of this battery in SLE has increased in frequency and has shown usefulness in detecting cognitive impairment in multiethnic samples. This tool has a sensitivity of 76.2%, specificity of 82.8%, and accuracy of 80% for diagnosing CD in SLE (Antonchak et al., 2011; Hanly et al., 2010; Holliday et al., 2003; Roebuck-Spencer et al., 2006). However, in Latin American context, this tool presents several challenges, especially the lack of Spanish translations and adapted normative data, as well as economic costs for primary care institutions.

Likewise, Kozora et al. (2018) state that brief mental state examinations appear to be relatively insensitive to cognitive problems in SLE. Some studies that use popular tools such as the Mini-Mental State Examination (Folstein et al., 1975) did not show good discrimination and had inconsistent results. However, the MoCA may be more useful, showing a detection rate in SLE (29.5%) higher than ANAM (25%) (Adhikari et al., 2011). Patients with SLE obtain significantly lower scores on the MoCA (mean score 14.7) compared to controls (mean score 27.9) (El-Shafey et al., 2012). Lastly, self-report measures of CD do not correlate with an objective measure of cognitive processing; however, self-reported complaints were higher in the presence of anxiety and depression (Hanly et al., 2012).

Evidence shows that CD in adults with SLE occurs in both patients with and without neuropsychiatric manifestations (SLE-NP), when compared to healthy controls (Langensee et al., 2022). Patients with SLE-NP exhibit greater cognitive impairment, particularly in attention, executive functions, memory, and phonological fluency (Zabala et al. 2018), a pattern consistent with meta-analyses reporting deficits in logical reasoning, verbal memory, attention, and working memory (Kozora et al., 2008; Leslie & Crowe, 2018). Population-based studies estimate that between 38% and 51% of individuals with SLE present some degree of cognitive impairment, with memory and visuospatial/executive functions being the most affected domains (Fernández et al., 2019). A systematic review further demonstrates a negative association between cognitive symptoms, quality of life, and social participation, underscoring the need for routine cognitive screening (Mendelsohn et al., 2021). Additionally, consistent structural abnormalities in the hippocampus, corpus callosum, and frontal cortex have been reported (Valdés Cabrera et al., 2024).

Taken together, these findings highlight the robustness of recent literature-largely supported by systematic reviews and meta-analyses-that confirms the presence of CD in SLE and identifies the principal domains affected. However, despite this growing evidence, important gaps remain regarding the instruments used for cognitive assessment. For instance, Meszaros and colleagues (2012) reported that patients were evaluated using "neuropsychological tests" or "automated neuropsychological metrics," yet did not specify the exact instruments employed. Similarly, Yuen et al. (2021a), in a broad systematic review, focused their analysis on the frequency of instruments used according to the ACR protocol; notably, this protocol does not include cognitive screening tools. Furthermore, whereas Meszaros et al. (2012) did not report cutoff scores, Yuen et al. (2021b) identified variability in the definition of CD depending on the number of tests used and the deviation-score criteria adopted-a limitation previously described by Kozora et al. (2018).

In contrast to these earlier reviews, the key contribution of the present review lies in its focus on cognitive screening tools. These instruments allow for an initial assessment of the cognitive domains recommended by the ACR and can be used in response to patient complaints or clinical suspicion at both primary care and specialist levels. Moreover, the use of such tools offers the opportunity to harmonize cutoff scores based on current scientific evidence, thereby contributing to a more consistent and comparable detection of CD in SLE.

The background presented indicates that although the ACR protocol is used when cognitive symptoms raise suspicion of NPSLE, computerized tests are often lengthy and costly for implementation in outpatient settings, particularly in Latin American contexts, while the evidence supporting paper-based screening tools remains inconsistent. Consequently, many specialists, even when they have access to brief and sensitive instruments to detect CD in SLE, are uncertain about which tool to select or how to distinguish mild cognitive impairment. Therefore, this review aims to examine the scientific evidence on the cognitive screening tests used in SLE and the cut-off scores suggested in the academic literature. Unlike previous reviews, the main contribution of this work lies in its focus on cognitive screening tools, which enable an initial assessment of the cognitive domains recommended by the ACR and can be applied in primary or specialized care when patients report cognitive complaints or when clinical suspicion arises. Moreover, the use of these tools provides an opportunity to harmonize evidence-based cut-off scores, thereby promoting a more consistent and comparable detection of CD in SLE.

2. Methods

This systematic review was conducted in accordance with the PRISMA 2020 statement (Button et al., 2016; Page et al., 2021), The PRISMA checklist is provided in Supplementary File S1. The review was carried out between 2014 and the second half of 2024. This review was not pre-registered and did not employ artificial intelligence tools for data extraction or analysis. Initially, the authors planned a 5-year review (2019-2024); however, the results did not yield a significant number of studies for the review's objectives. The databases included were PubMed, Scopus, Web of Science, ScienceDirect, Redalyc and SciELO, using combinations of keywords and Boolean operators: "cognitive dysfunction", "cognitive impairment", "lupus", "systemic lupus erythematosus", "SLE", "Montreal Cognitive Assessment", "MoCA", "MMSE", "Mini-Mental State Examination", "INECO Frontal Screening", "INECO", "Addenbrooke's Cognitive Examination" and "ACE-R III". The final integrated search string was: ("lupus" OR "systemic lupus erythematosus" OR "SLE") AND "cognitive dysfunction" OR "cognitive impairment" OR "neuropsychological assessment") AND ("Montreal Cognitive Assessment" OR "MoCA" OR "MMSE" OR "Mini-Mental State Examination" OR "INECO Frontal Screening" OR "INECO" OR "Addenbrooke's Cognitive Examination" OR "ACE-R" OR "ACE-R III"). This strategy was subsequently adapted to the specific search fields of each database.

2.1 Eligibility criteria

Inclusion and Exclusion Criteria and General Search Strategy: To carry out the systematic literature review, the following inclusion and exclusion criteria were established: (1) to refer to the use of a cognitive screening instrument; (2) studies published during the time period from 2014 to the second semester of 2024 were included; (3) all included works must include a clinically diagnosed SLE population; (4) studies published in English, Spanish, and Portuguese were included; (5) reflections, systematic reviews, meta-analysis, or other reflective documents were excluded.

2.2 Data Search Procedure

Bibliographic citations were identified using EndNote X9/2018, and duplicate studies were removed. For study selection, two researchers initially reviewed titles and abstracts according to the inclusion criteria. Using Cohen's k coefficient, inter-rater reliability was determined to be 0.86 (95% CI: 0.66–1.00), considered good. Two reviewers, one with a doctorate and one a clinical neuropsychologist, evaluated titles and abstracts according to the inclusion and exclusion criteria. The reviewers independently reviewed each retrieved title and abstract to determine its eligibility according to the inclusion criteria. Subsequently, the full text was reviewed to determine its eligibility. Different combinations were examined to minimize the number of unwanted works, while ensuring that articles previously known to be important to the topic were not excluded from the search. Therefore, the strategy was intentionally more inclusive than exclusive (Restrepo et al., 2019). Ethical approval was not required for this study because it is a systematic review based on previously published data. The detailed search strategies for each database are provided in Supplementary File S2.

2.3 Article Selection:

From the combination of Boolean operators and keywords, a total of 564 documents were initially identified. After removing 113 duplicate records and 125 records for other reasons, including clearly irrelevant records identified prior to screening (n = 30), outside the time period (n=60), reflection papers (n=24) and no inclusion if patients with SLE (n=11). A total of 326 records remained for title and abstract screening. Of these, 226 reports were sought for retrieval. Forty-six reports could not be retrieved, leaving 180 full-text reports assessed for eligibility. Finally, 31 studies met the inclusion criteria and were included in the systematic review. The complete study selection process is presented in Figure 1.

2.4 Data Extraction

Data extraction was performed independently by two reviewers using a standardized data extraction form. Extracted variables included study characteristics, sample size, cognitive screening instruments, cut-off values, cognitive domains assessed, and main findings. Discrepancies were resolved through discussion and consensus, with the involvement of a third reviewer when necessary.

2.5 Methodological quality assessment

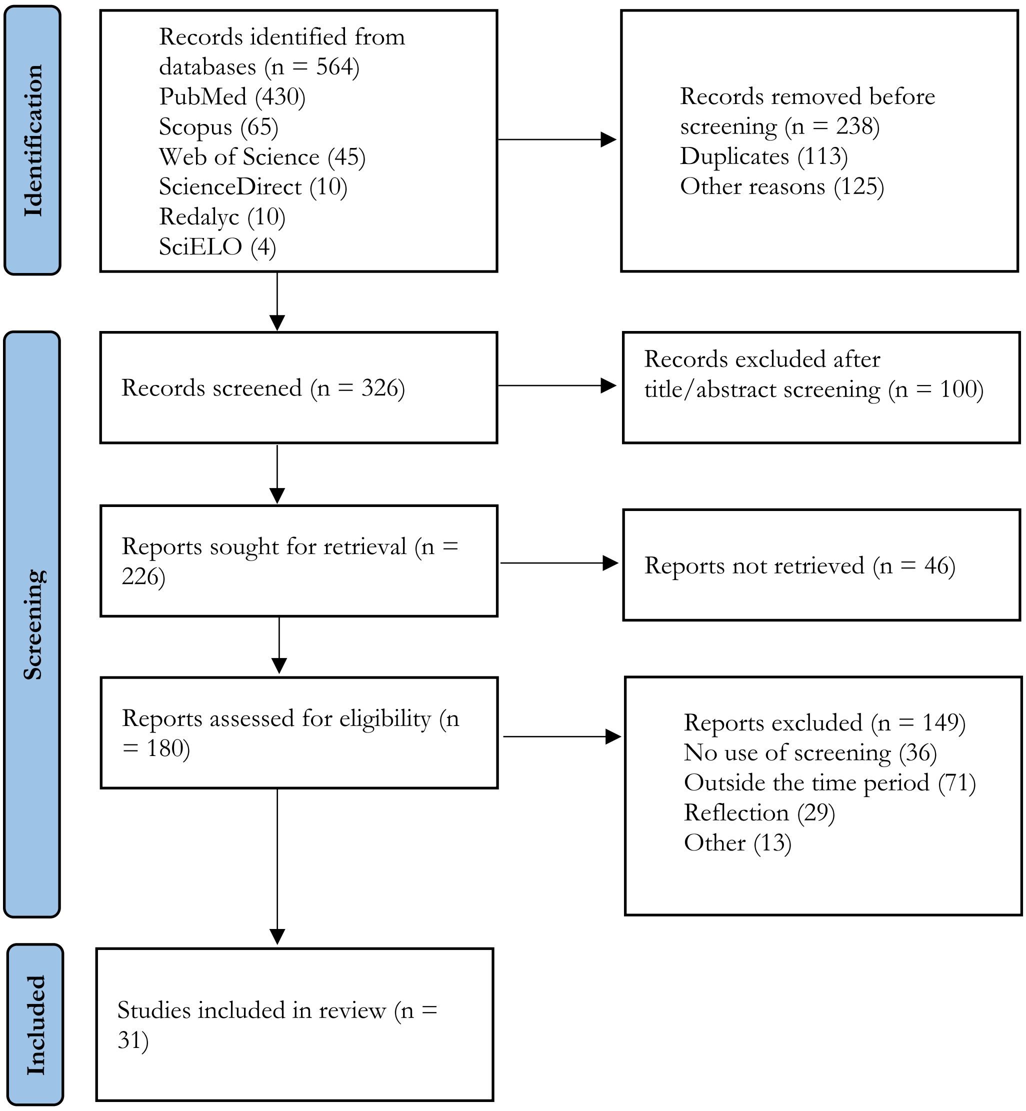
Methodological quality was assessed using the Joanna Briggs Institute (JBI) critical appraisal checklist for analytical cross-sectional studies. Each study was evaluated across eight domains, and responses were coded as "Yes", "No", or "Unclear". The total score for each study was converted into a percentage. Studies were classified as high quality (≥87.5%), moderate quality (75%), and low quality (<75%). Item-level ratings for each study are provided in Supplementary Table S1.

3. Results

The study selection process is presented in Figure 1. This diagram was created using the free web tool developed by Haddaway et al. (2022), "PRISMA2020", which similarly provides a clearer and more detailed template. The characteristics of the included studies, the cognitive domains assessed, and the methodological quality are presented in Supplementary Table S2.

Figure 1.

PRISMA 2020 flow diagram of study selection



Note. The flow diagram was developed following the PRISMA 2020 guidelines (Page et al., 2021) and adapted using the PRISMA 2020 flow diagram generator (Haddaway et al., 2022).

Table 1 summarizes the 31 studies included in the present systematic review. Initially, it can be seen that traditional pencil-and-paper tests are more commonly implemented in traditional studies. 67.7% use the MoCA, 29% use the MMSE, 6.5% the CDT, and 3.2% the RBANS. Regarding computerized platforms, only 6.5% use CANTAB and 6.5% the ANAM. As for the geographical location of the studies, 41.9% were published in countries from the American continent, 38.7% in Asia, 16.1% in Europe, and 3.2% in Oceania (Table 2). Following the inclusion criteria, all selected studies included patients diagnosed with SLE. Only one of them incorporated a comparison group with patients with multiple sclerosis (Stavrogianni et al., 2024), while the study by Yue et al. (2020) compared two groups with SLE: one with CD and another without it.

Regarding the age of the population, only one study did not report this data (Barraclough et al., 2021). The minimum age of inclusion was 13 years (Yue et al., 2020), 15 years (Mahdavi Adeli et al., 2016), and 16 years (Ahmadzade et al., 2024; Calderón et al., 2017), which is relevant, as cognitive screening tests do not present strong statistical consistency at these ages, which may affect their sensitivity and specificity. However, it is important to note that in other pediatric pathologies, such as congenital heart disease, a good statistical fit of these screening tools has been observed (Pike et al., 2017). In addition, childhood SLE can present clinical overlap with the symptoms of juvenile idiopathic arthritis, creating a challenge in determining cognitive symptoms (Frazzei et al., 2022; Smitherman et al., 2023).

As for the upper age limit, the studies included participants up to 64 years (Medina et al., 2024; Raghunath et al., 2021) and 65 years (Kanapathy et al., 2019; Mahdavi Adeli et al., 2016). The rest of the studies considered in this review included participants over 18 years old in their samples.

Table 1.

Studies included in the systematic review

Author	Sample size (n)	Country	Screening	Cut Point
Medina et al. (2024)	31	Colombia	MoCA	<26/30 points CD
Ahmadzade et al. (2024)	90	Iran	MoCA	<26/30 points CD
Plantinga et al. (2024)	434	USA	CDT	≤10 Potential cognitive decline
Stavrogianni et al. (2024)	30	Greece	MoCA	<21/30 points CD
Wang et al. (2023)	50	China	MoCA	<26/30 points CD
Borba et al. (2023)	103	Brazil	MoCA MMSE	<25/30 points CD <23/30 points CD
Tayer-Shifman et al. (2023)	285	Canada	MoCA	<26/30 points CD
Grover et al. (2023)	79	India	MoCA	<26/30 points CD
Suntoko et al. (2023)	56	Indonesia	MoCA	<26/30 points CD
Koolvisoot & Chumjang (2023)	200	Thailand	MoCA	17-24/30 mild CD ≤16/30 severe CD
Yang et al. (2022)	38	China	MMSE	≤ 26/30 points CD

Monahan et al. (2023)	357	Netherlands	MMSE	≤25/30 Moderate CD ≤20/30 Severe CD
Munguía-Realpozo et al. (2022)	67	Mexico	MoCA	<26/30 points CD
Lim et al. (2022)	50	Singapore	MoCA	<26/30 points CD
Lu et al. (2021)	121	China	RBANS	51–90: Low cognition
Barraclough et al. (2021)	62	UK	CANTAB	Not reported
Kim et al. (2021)	58	USA	MoCA	<26/30 points CD
Raghunath et al. (2021)	95	Australia	MoCA	<28/30 points CD
Papastefanakis et al. (2021)	71	Greece	MoCA	<26/30 points CD
Yue et al. (2020)	78	China	MoCA	<26/30 points CD
Tayer-Shifman et al. (2019)	211	Canada	ANAM	z ≤ -1.5 CD in two or more domains
Chalhoub & Luggen (2019)	78	USA	MoCA ANAM	<26/30 points CD z ≤ -1.5 CD in two or more domains
Paez-Venegas et al. (2019)	44	Mexico	MoCA MMSE	≤25/30 points CD ≤25/30 points CD
Kanapathy et al. (2019)	200	Malaysia	MoCA	<26/30 points CD
Ceccarelli et al. (2018)	58	Italy	MMSE	≤25/30 points CD
Butt et al. (2017)	43	Pakistan	MoCA	<26/30 points CD
Bizzo et al. (2017)	51	Brazil	MMSE	≤25/30 points CD
Nantes et al. (2017)	98	Canada	MoCA MMSE	<26/30 points CD <26/30 points CD
Mahdavi Adeli et al. (2016)	54	Iran	MMSE CDT	<22/30 points CD <6/10 points CD
Maciel et al. (2016)	54	Brazil	MoCA MMSE	≤25/30 points CD ≤25/30 points CD
Calderón et al. (2017)	101	Chile	CANTAB	Not reported

Note. Source: Author's own work. MoCA: Montreal cognitive assessment; MMSE: Mini-mental state examination; CDT: Clock Drawing Test; CANTAB: Cambridge Neuropsychological Test Automated Battery; ANAM: Automated Neuropsychological Assessment Metrics; RBANS: The Repeatable Battery for the Assessment of Neuropsychological Status.

Table 2.

Geographic distribution of the included studies

Continent	Countries	Number of studies	Percentage
America	Brazil	4	41.9%
	Canada	2	
	Colombia	1	
	Chile	1	
	United States	3	
	Mexico	2	
Europe	Greece	2	16.1%
	United Kingdom	1	
	Netherlands	1	
	Italy	1	
Asia	China	4	38.7%
	Iran	2	
	Singapore	1	
	India	1	
	Indonesia	1	
	Thailand	1	
	Malaysia	1	
	Pakistan	1	
Oceania	Australia	1	3.2%

Most of the included studies that use pencil-and-paper tests apply and verify the cut-off point initially proposed by the seminal work of each test. However, in the case of the MoCA used in lupus, the standard cut-off score (26/30) ensures excellent sensitivity (Papastefanakis et al., 2021). Nevertheless, different cut-off points have been considered. For example, Raghunath et al. (2021) confirmed that the MoCA has adequate sensitivity and specificity for use in SLE with a threshold of <28, showing 80% sensitivity and 45% specificity (Tayer-Shifman et al., 2023). Papastefanakis et al. (2021) also notes that lower cut-off scores may provide greater specificity. Based on this, Lim et al. (2022) propose using a lower threshold of <25 in SLE patients without clear neuropsychiatric manifestations, improving the sensitivity for detecting executive function impairment from 60% to 80%. Lower cut-off points (22–23/30) have also been considered in lupus (Papastefanakis et al., 2021). Regarding the studies that implemented computerized tools, these did not report cut-off points, as they compare performance against the normative data of the tests or convert results to Z-scores (Barraclough et al., 2021; Calderón et al., 2017; Chalhoub & Luggen, 2019; Tayer-Shifman et al., 2019;), a factor that may limit their use in contexts lacking validation studies.

4. Discussion

CD is a symptom commonly reported by patients with SLE. The implementation of cognitive screening in clinical practice may improve its detection, which would allow future research to focus on addressing unmet cognitive needs in patients with SLE, both in those presenting neuropsychiatric symptoms and those who do not (Raghunath et al., 2021). Thus, the objective of the present review was to analyze the scientific evidence on the cognitive screening tests used in SLE and the cut-off points suggested in academic literature.

The results of the present review show that, in various countries, pencil-and-paper cognitive screening instruments are selected as the first option for evaluation when CD is suspected in patients with SLE. Among these, the MoCA and MMSE are the most frequently used; both have been validated in different countries and across neurodegenerative, metabolic, and autoimmune pathologies. In the case of SLE, several studies have used them either as definitive diagnostic tools or as part of broader assessment protocols. This is due to their accessibility, practicality, and short administration time (10–15 minutes), which fits the timing of outpatient consultations.

Previous systematic reviews have examined cognitive dysfunction in patients with systemic lupus erythematosus (SLE) from a broader perspective, primarily focusing on prevalence, associated clinical factors, and neuropsychological profiles. For instance, Leslie and Crowe (2018) and Mendelsohn et al. (2021) provided comprehensive overviews of cognitive impairment in SLE, highlighting its heterogeneity and its association with disease activity and neuropsychiatric manifestations. Similarly, Yuen et al. (2021a) explored cognitive deficits in SLE, emphasizing the variability in affected domains such as memory, attention, and executive functions. More recently, Valdés Cabrera et al. (2024) contributed to the understanding of cognitive dysfunction by synthesizing evidence on its clinical and functional impact. However, these reviews have largely focused on cognitive impairment as a clinical phenomenon rather than on the specific tools used for its detection.

In contrast, the present review specifically addresses the use of cognitive screening instruments and the variability of cut-off points employed across studies. This focus allows for a more detailed understanding of how cognitive dysfunction is operationalized and identified in both clinical and research settings. By examining tools such as the Montreal Cognitive Assessment (MoCA), Mini-Mental State Examination (MMSE), and other neuropsychological batteries, this review highlights important inconsistencies in cut-off values and their implications for the detection of cognitive impairment. Consequently, this work provides added value by bridging the gap between the conceptual understanding of cognitive dysfunction in SLE and its practical assessment, offering insights that may contribute to improved screening practices and greater standardization in future research.

Their psychometric properties, when adapted to different contexts, make them viable first-line tools. However, validation studies for both MoCA and MMSE in SLE have shown mixed results and further research is needed to confirm their validity (Rayes et al., 2018). Virtual or computerized instruments are less commonly chosen due to cost barriers, accessibility issues, and language adaptation challenges, especially in countries where English is not the official language, such as Spanish-speaking South American territories. Lastly, advances in technology also limit the long-term use of these tools (Yuen et al., 2021b).

In general, the utility and support for the MMSE as a screening tool for CD in SLE has not been well established (Yuen et al., 2021b). According to Monahan et al. (2023), this may be since the MMSE was developed for the evaluation of severe CD and major neurocognitive disorders and is therefore less useful in detecting neuropsychological impairments in patients with SLE. However, the studies by Borba et al. (2023) and Mahdavi Adeli et al. (2016) show that patients with SLE present lower scores in language, spatial orientation, and psychomotor speed when compared to the MoCA, which more notably captures deficits in abstraction, visuospatial/executive capacity, and delayed recall (Koolvisoot & Chumjang, 2023).

Initially, Nasreddine and colleagues (2005) reported higher specificity (100%) for the MMSE compared to the MoCA (87%), although the MoCA showed greater sensitivity than the MMSE, with 100% and 78%, respectively. A more recent study by Nantes et al. (2017) confirmed these psychometric properties, finding that sensitivity was higher for the MoCA (73%) compared to the MMSE (27%), although the MMSE was more specific (90%) than the MoCA (63%). For this reason, both tests are considered to be complementary (Borba et al., 2023). Lastly, the MMSE may be capable of detecting cognitive changes over time, as evidenced by the study of Ceccarelli et al. (2018), where, after a 10-year follow-up, CD had improved in most patients with SLE.

The study by Yang et al. (2022) performed a correlation analysis on abnormalities in the Amplitude of Low-Frequency Fluctuations (ALFF), used to explore spontaneous brain activity, and MMSE scores, finding that SLE patients with CD showed different characteristics in the strength and stability of intrinsic brain functional connectivity. Likewise, SLE patients may frequently exhibit dysfunction of the basal ganglia, linked to MMSE performance. Additionally, episodic memory deficits reported in patients on the MMSE were associated with reduced cortical thickness in the left supramarginal gyrus, superior temporal gyrus, and superior frontal gyrus (Bizzo et al., 2017; Maciel et al., 2016).

The MoCA is a brief, freely available screening tool that allows for follow-up over time (Koolvisoot & Chumjang, 2023). Chalhoub and Luggen (2019) comment that this screening tool is promising and practical for identifying the risk of CD in patients with SLE. However, reports are contradictory. Medina et al. (2024) report an approximate 3:1 ratio between an abnormal MoCA result and a diagnosis of CD using specific neuropsychological tests, which shows that using MoCA as a screening method is not sufficient to identify cognitive impairments in SLE. MoCA had a detection probability for CD of 16%, compared to 36% with a reference neuropsychological battery (Lim et al., 2022).

According to Tayer-Shifman et al. (2023), MoCA is limited in sensitivity and specificity compared to a full evaluation battery, although a sensitivity of 73% and a specificity of 63% has also been reported (Nantes et al., 2017). In patients with NP-SLE, differences are detected in mild impairments compared to patients without clear NP-SLE symptoms. Similarly, this applies to patients with multiple sclerosis presenting overlapping SLE symptoms and patients with disease duration longer than two years (Ahmadzade et al., 2024; Butt et al., 2017; Stavrogianni et al., 2024).

The study by Wang et al. (2023) revealed that higher MoCA scores in patients with SLE are associated with greater gray matter volume in regions such as the bilateral frontal lobes, the left temporal lobe, and the cingulate gyrus, suggesting a potential relationship between higher volume and better cognitive performance. Additionally, the positive correlations with cerebral blood flow in both white and gray matter "suggest that better cognitive function is associated with better blood flow, which supports brain metabolism and communication for optimal functioning" (p. 63). Through other non-invasive techniques such as Nailfold Capillaroscopy (NFC), which is frequently used to assess microvascular involvement in rheumatic diseases, no relationship was found between NFC results and CD as measured by the MoCA (Munguía-Realpozo et al., 2022).

The clinical and serological profile of lupus did not show statistical significance with the MoCA and MMSE (Borba et al., 2023), although interleukin-6 (IL-6) showed a weak negative correlation ($r = -0.387$) with the total MoCA score (Suntoko et al., 2023). Likewise, the anti-NMDAR serum antibody can be used as a predictor of cognitive dysfunction, and the presence of anticardiolipin IgM ($OR = 6.81$, 95% confidence interval 1.45–32.01, $p = 0.031$) was associated with impaired MoCA scores (Kanapathy et al., 2019; Yue et al., 2020).Using the RBANS (*The Repeatable Battery for the Assessment of Neuropsychological Status*), a screening test administered in 20–30 minutes that contains twelve subtests providing five general index scores (memory, visuospatial, language, and attention) and a total score, Lu et al. (2021) found that

SLE patients with low cognition showed lower levels of albumin, F-T3, and F-T4, and higher levels of D-dimer, anti-dsDNA antibodies, and IgM compared to those with high cognition.

MoCA has shown correlations with conventional neuropsychological assessment tools. Raghunath et al. (2021) reported a significant correlation between MoCA scores and 9 of the 10 cognitive assessment criteria from the ACR-recommended battery. It also showed greater agreement with other evaluation tests, with sensitivity (84%) and specificity (100%) outperforming the MMSE and the Cognitive Symptoms Inventory (CSI), although all three instruments correlated with the reference neuropsychological battery in the same order (MoCA > MMSE > CSI) (Paez-Venegas et al., 2019). On the other hand, MoCA did not correlate with self-reported measures of everyday cognition (CSI: $r = -0.13$, $p = 0.37$; CF: $r = 0.23$; $p = 0.10$) (Kim et al., 2021). Finally, MoCA and ANAM showed a significant correlation ($r = 0.51$, $p < 0.001$) (Chalhoub & Luggen, 2019).

An interesting aspect is that the study by Medina et al. (2024), conducted in the Colombian context, uses the standard cut-off score for the test. However, previous validation studies of the MoCA in Colombia have calibrated the cut-off point to distinguish between normal cognition and CD in the general population at 20–21/30, and between CD and dementia at 17–18/30 (Pedraza et al., 2016). The use of cut-off scores is a common practice in primary care settings; however, these do not necessarily offer a complete picture of cognitive functioning, particularly at the individual level and in high-functioning individuals, where performance is strongly correlated with education (Karr & Iverson, 2020). Therefore, it is necessary to study new approaches that consider sociodemographic variables in the general population, and in patients with SLE, it would also be important to consider factors such as time since diagnosis, use of medications like prednisolone, accumulated organ damage, and the presence of comorbid pathologies (Koolvisoot & Chumjang, 2023).

Another pencil-and-paper test used in two studies is the Clock Drawing Test (Mahdavi Adeli et al., 2016; Plantinga et al., 2024), which, when combined with the Trail Making Test Part B (TMT-B), could cover most individuals with impairments in fluid cognition (FC). According to Plantinga et al. (2024), combining these tests may be useful as a screening tool, since TMT-B is linked to FC, and poor performance in the free-drawing Clock Test reflects executive function or frontotemporal impairment. This combination may be helpful as an initial detector of cognitive decline in SLE, particularly in patients who are unwilling or unable to complete longer evaluations, which may be distressing and fatiguing. These two tests together identify most individuals classified as potentially impaired by the NIH Toolbox Fluid Cognition Battery. Further research on this new alternative is required.

In relation to virtual or computerized tools for cognitive screening, the CANTAB is one of the instruments used. It evaluates cognitive processes such as memory (verbal and visual), emotional processing, sustained attention, executive function, and spatial working memory. This test did not find differences between two groups of SLE patients: those with stable/low disease activity and those with active disease. However, the same study found that functional brain processes, but not cognitive-behavioral measures, were affected by disease activity. Patients experiencing a lupus flare showed reduced ability to suppress regions of the default mode network (DMN) during a working memory task (Barraclough et al., 2021). Likewise, this battery in SLE patients shows that executive dysfunction (spatial planning) is associated with lower scores in role limitations due to physical health problems, emotional problems, and general health perceptions (Calderón et al., 2017). The other virtual tool implemented in SLE patients is ANAM, which demonstrates a sensitivity of 78–80% and a specificity of 70%, providing support for ANAM's discriminative validity in cognitive impairment and its utility for cognitive screening in adults with SLE (Tayer-Shifman et al., 2019).

These findings underscore the need for greater standardization in cognitive screening approaches in SLE, particularly regarding the selection of instruments and the definition of clinically meaningful cut-off points.

5. Conclusion

Brief tools for assessing cognitive impairment in clinical settings may be more accessible and practical for both healthcare professionals and patients with systemic lupus erythematosus (SLE). These tests offer valuable information about the patient's current cognitive status, which can support shared decision-making and help establish realistic therapeutic goals (Plantinga et al., 2024). Specifically, in the case of SLE, the MoCA appears to be the preferred tool among physicians and specialists worldwide for cognitive screening in patients with and without clear neuropsychiatric symptoms. The literature indicates that the most commonly used cut-off point to determine CD is <26, and it is the most frequently reported in published studies. However, lower cut-off points are also being explored to increase the specificity and sensitivity of these instruments.

In the Colombian population, the prevalence of CD in patients with SLE is still unknown. Medina et al. (2024) found it in 16% of the population using specific neuropsychological tests and in 37% using the MoCA screening tool. However, the latter is scored based on a cut-off point of <26, while studies with the general population consider a score of 20–21/30 as the threshold for cognitive impairment. This highlights the need for differential analyses in the SLE population, taking into account both sociodemographic and clinical variables specific to the disease.

One limitation of the present systematic review is the non-inclusion of meta-analyses, which could provide more robust data to support the discussion and consolidation of the topic, as well as offer more concrete and reliable guidelines for professionals working with SLE patients. Another relevant aspect is the lack of differential analysis by biological sex. Although the presence of lupus in men is less frequent, with a reported proportion of 2/10, being more common in women (Willame et al., 2021),its intensity in men tends to be higher, which could lead to greater cognitive sequelae and a more significant impact on quality of life.

Given the heterogeneity of CD in lupus, future research should complement the MoCA with other screening instruments that can provide more sensitive information on cognitive processes such as frontal lobe functioning. Examples include the INECO Frontal Screening (IFS) (Torralva et al., 2009) and the Addenbrooke's Cognitive Examination (Bruno et al., 2020; Mathuranath et al., 2000). It is also important to expand the scientific evaluation of the relevance of using MoCA in SLE, especially in the Latin American context.

It is important to clarify that screening provides an entry point to understanding the neuropsychological functioning of patients, enabling early alerts and timely referral for in-depth evaluations conducted by a clinical neuropsychologist, ideally one trained in autoimmune disorders. This aspect is especially relevant in Colombia, where neuropsychology is recognized as a specialized health service (Acosta et al., 2014) and is part of the mandatory health coverage plan. Finally, it is essential to carry out and update the protocol proposed by the American College of Rheumatology (ACR) (Mikdashi et al., 2007).

It is essential for healthcare personnel to understand the scope and limitations of cognitive screening tests, especially in complex clinical contexts such as lupus. According to Olazarán et al. (2016), healthcare systems are organized into two key levels of care: the first corresponds to primary care (PC), and the second to specialized care (SC). PC represents the patient's first point of contact with the health system and has among its main functions outpatient care, prevention, and the early detection of disorders, making it the ideal setting for the initial identification of CD. SC, on the other hand, is responsible for confirming diagnoses, establishing etiologies, and initiating specific treatments, which requires more detailed assessments.

In this regard, cognitive screening is a valuable strategy for initial detection, particularly in contexts where comprehensive neuropsychological evaluation is not feasible due to economic, physical, or cognitive limitations of the patients occur, for example, in acute hospital units or in patients with brain injury. However, as Block et al. (2017) point out, neuropsychological evaluation differs from screening due to its thoroughness, methodological depth, and diagnostic capacity. It involves not only the administration of specialized tests but also the integration of results with neurological, medical, psychosocial data, and a solid understanding of neuroscience.

Therefore, in lupus as in other medical or psychological conditions, screening should not be considered sufficient or definitive for diagnosing cognitive dysfunction; rather, it should be understood as a first step that guides the need for a broader and more specialized clinical evaluation.

Conflict of interest statement

The authors declare that the research was conducted in the absence of any potential conflict of interest.

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Authors' Contribution

ACD: Data collection, analysis, and interpretation of results. DALM: Review and editing of the complete manuscript. All authors approved the final version of the manuscript.

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The authors used generative artificial intelligence (AI) tools to support language editing and improve clarity of expression. No AI tools were used in the conception, design, data analysis, or interpretation of the study. All intellectual content, scientific reasoning, and final decisions were carried out exclusively by the authors, who assume full responsibility for the manuscript.

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Supplementary materials

Supplementary File S1.

PRISMA 2020 Checklist

Section	Item	Checklist Item	Reported
TITLE	1	Identify as systematic review	Provided
ABSTRACT	2	Structured summary	Provided
INTRODUCTION	3	Rationale	Provided
	4	Objectives	Provided
METHODS	5	Eligibility criteria	Provided
	6	Information sources	Provided
	7	Search strategy	Provided (see also “Supplementary S2”)
	8	Selection process	Provided
	9	Data collection process	Provided
	10	Data items	Provided
	11	Risk of bias assessment	Provided
	12	Effect measures	Not applicable
	13	Synthesis methods	Provided
	14	Reporting bias	Not applicable
	15	Certainty assessment	Not applicable
RESULTS	16	Study selection	Provided (see also Prisma dyagram)
	17	Study characteristics	Provided (see also Table S1)
	18	Risk of bias results	Provided (Supplementary Table S1)
	19	Individual results	Provided
	20	Synthesis results	Provided
	21	Reporting bias	Not applicable
	22	Certainty of evidence	Not applicable
DISCUSSION	23	Interpretation	Provided
	24	Limitations	Provided
	25	Implications	Provided
OTHER INFORMATION	26	Registration	Not registered
	27	Protocol	Not available
	28	Funding	Provided
	29	Competing interests	Provided
	30	Data availability	Provided

Supplementary File S2.

Database-specific search strategies

Search strategies were adapted to the syntax and requirements of each database

Database	Code
PubMed	("systemic lupus erythematosus" OR SLE) AND ("cognitive dysfunction" OR "cognitive impairment" OR cognition) AND ("screening" OR "assessment" OR "neuropsychological test" OR MoCA OR MMSE OR ANAM OR RBANS OR CANTAB OR CDT) Filters: Humans, English, Spanish
Scopus	TITLE-ABS-KEY ("systemic lupus erythematosus" OR SLE) AND TITLE-ABS-KEY ("cognitive dysfunction" OR "cognitive impairment" OR cognition) AND TITLE-ABS-KEY ("screening" OR "assessment" OR "neuropsychological test" OR MoCA OR MMSE OR ANAM OR RBANS OR CANTAB OR CDT)
Web of science	TS=("systemic lupus erythematosus" OR SLE) AND TS=("cognitive dysfunction" OR "cognitive impairment" OR cognition) AND TS=("screening" OR "assessment" OR "neuropsychological test" OR MoCA OR MMSE OR ANAM OR RBANS OR CANTAB OR CDT)
ScienceDirect	("systemic lupus erythematosus" OR SLE) AND ("cognitive dysfunction" OR "cognitive impairment") AND ("screening" OR "neuropsychological assessment" OR MoCA OR MMSE OR ANAM OR RBANS OR CANTAB OR CDT)
SciELO	("lupus eritematoso sistémico" OR "systemic lupus erythematosus") AND ("deterioro cognitivo" OR "cognitive impairment") AND ("evaluación" OR "screening" OR MoCA OR MMSE)
Redalyc	("lupus eritematoso sistémico") AND ("deterioro cognitivo") AND ("evaluación neuropsicológica" OR "screening")

Supplementary Table S1.

Characteristics of included studies and item-level methodological quality assessment using the JBI checklist

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total	Quality
Medina et al. (2024)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Ahmadzade et al. (2024)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Plantinga et al. (2024)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Stavrogianni et al. (2024)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Wang et al. (2023)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Borba et al. (2023)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Tayer-Shifman et al. (2023)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Grover et al. (2023)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Suntoko et al. (2023)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Koolvisoot & Chumjang (2023).	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Yang et al. (2022)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Monahan et al. (2023)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Munguía-Realpozo et al. (2022)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Lim et al. (2022)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Lu et al. (2021)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Barraclough et al. (2021)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Kim et al. (2021)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Raghunath et al. (2021)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Papastefanakis et al. (2021)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Yue et al. (2020)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Tayer-Shifman et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Chalhoub & Luggen (2019).	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total	Quality
Paez-Venegas et al. (2019)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Kanapathy et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Ceccarelli et al. (2018)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Butt et al. (2017)	Y	Y	Y	Y	N	N	N	Y	5/8	Low
Bizzo et al. (2017)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Nantes et al. (2017)	Y	Y	Y	Y	Y	Y	Y	Y	8/8	High
Mahdavi Adeli et al. (2016)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Maciel et al. (2016)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate
Calderón et al. (2017)	Y	Y	Y	Y	N	N	Y	Y	6/8	Moderate

Note Q1. inclusion criteria clearly defined; Q2: study subjects and setting described; Q3: exposure measured validly; Q4: standard criteria used; Q5: confounders identified; Q6: strategies for confounders; Q7: outcomes measured validly; Q8: appropriate statistical analysis. Yes = 1, No/Unclear = 0.

Supplementary Table S2.

Characteristics, cognitive domains, and methodological quality of included studies (n = 31)

Author (Year)	Country	Sample (n)	Instrument	Cut-off	Study Design	Cognitive Domains	Main Findings	Methodological Quality (JBI)
Medina et al. (2024)	Colombia	31	MoCA	<26	Cross-sectional	Global cognition	Detected CD in SLE patients	Moderate
Ahmadzade et al. (2024)	Iran	90	MoCA	<26	Cross-sectional	Executive, memory	Association with biomarkers	High
Plantinga et al. (2024)	USA	434	CDT	≤10	Cross-sectional	Executive	Useful for screening	Moderate
Stavrogianni et al. (2024)	Greece	30	MoCA	<21	Case-control	Attention, memory	Lower scores in SLE	Moderate
Wang et al. (2023)	China	50	MoCA	<26	Cross-sectional	Global cognition	Linked to brain volume	High
Borba et al. (2023)	Brazil	103	MoCA/MMSE	<25 / <23	Cross-sectional	Multiple domains	MoCA more sensitive	High
Tayer-Shifman et al. (2023)	Canada	285	MoCA	<26	Cross-sectional	Global cognition	High prevalence of cognitive impairment	High
Grover et al. (2023)	India	79	MoCA	<26	Cross-sectional	Executive, attention	Impairment linked to disease activity	Moderate
Suntoko et al. (2023)	Indonesia	56	MoCA	<26	Cross-sectional	Global cognition	Effective screening in clinical settings	Moderate
Koolvisoot y Chumjang (2023).	Thailand	200	MoCA	17–24 mild / ≤16 severe	Cross-sectional	Global cognition	Differentiates severity of impairment	High
Yang et al. (2022)	China	38	MMSE	≤26	Cross-sectional	Global cognition	Limited sensitivity for mild impairment	Moderate
Monahan et al. (2023)	Netherlands	357	MMSE	≤25 / ≤20	Cross-sectional	Global cognition	Identifies moderate–severe impairment	High

Author (Year)	Country	Sample (n)	Instrument	Cut-off	Study Design	Cognitive Domains	Main Findings	Methodological Quality (JBI)
Munguía-Realpozo et al. (2022)	Mexico	67	MoCA	<26	Cross-sectional	Executive, memory	Detects early cognitive dysfunction	Moderate
Lim et al. (2022)	Singapore	50	MoCA	<26	Cross-sectional	Global cognition	Useful screening in outpatient settings	Moderate
Lu et al. (2021)	China	121	RBANS	51–90	Cross-sectional	Memory, attention	Detects domain-specific deficits	High
Barraclough et al. (2021)	UK	62	CANTAB	Not reported	Cross-sectional	Multiple domains	Useful for detailed cognitive profiling	Moderate
Kim et al. (2021)	USA	58	MoCA	<26	Cross-sectional	Global cognition	Valid screening tool in SLE	Moderate
Raghunath et al. (2021)	Australia	95	MoCA	<28	Cross-sectional	Executive, attention	Higher cut-off improves sensitivity	High
Papastefanakis et al. (2021)	Greece	71	MoCA	<26	Cross-sectional	Global cognition	Confirms cognitive impairment prevalence	Moderate
Yue et al. (2020)	China	78	MoCA	<26	Cross-sectional	Global cognition	Associated with disease duration	Moderate
Tayer-Shifman et al. (2019)	Canada	211	ANAM	z ≤ -1.5	Longitudinal	Processing speed, attention	Sensitive to subtle deficits	High
Chalhoub & Luggen (2019)	USA	78	MoCA / ANAM	<26 / z ≤ -1.5	Cross-sectional	Multiple domains	Combined tools improve detection	Moderate
Paez-Venegas et al. (2019)	Mexico	44	MoCA / MMSE	≤25	Cross-sectional	Global cognition	Consistent detection across tools	Moderate
Kanapathy et al. (2019)	Malaysia	200	MoCA	<26	Cross-sectional	Global cognition	High prevalence of impairment	High
Ceccarelli et al. (2018)	Italy	58	MMSE	≤25	Cross-sectional	Global cognition	Limited sensitivity vs MoCA	Moderate

Author (Year)	Country	Sample (n)	Instrument	Cut-off	Study Design	Cognitive Domains	Main Findings	Methodological Quality (JBI)
Butt et al. (2017)	Pakistan	43	MoCA	26	Cross-sectional	Global cognition	Borderline sensitivity	Low
Bizzo et al. (2017)	Brazil	51	MMSE	≤25	Cross-sectional	Global cognition	Detects moderate impairment	Moderate
Nantes et al. (2017)	Canada	98	MoCA / MMSE	<26	Cross-sectional	Global cognition	MoCA superior to MMSE	High
Mahdavi Adeli et al. (2016)	Iran	54	MMSE / CDT	<22 / <6	Cross-sectional	Executive, global cognition	CDT complements MMSE	Moderate
Maciel et al. (2016)	Brazil	54	MoCA / MMSE	≤25	Cross-sectional	Global cognition	Comparable performance between tools	Moderate
Calderón et al. (2016)	Chile	101	CANTAB	Not reported	Cross-sectional	Multiple domains	Useful for detailed assessment	Moderate

Note. CD = cognitive dysfunction; MoCA = Montreal Cognitive Assessment; MMSE = Mini-Mental State Examination; CDT = Clock Drawing Test; RBANS = Repeatable Battery for the Assessment of Neuropsychological Status; ANAM = Automated Neuropsychological Assessment Metrics; CANTAB = Cambridge Neuropsychological Test Automated Battery.