



Topic Exploration Report ¹

Topic explorations are designed to provide a high-level briefing on new topics submitted for consideration by Health Technology Wales. The main objectives of this report are to:

- Determine the quantity of evidence available for a technology of interest.
- Identify any gaps in the evidence.
- Inform decisions on topics that warrant fuller assessment by Health Technology Wales (HTW).

Topic exploration report number	TER551
Topic	Linus Health Core Cognitive Evaluation digital assessment to detect cognitive impairment
Summary of findings	<p>Neurodegenerative disorders including Alzheimer's disease and other types of dementia typically result in cognitive impairment. Current standard of care to identify cognitive impairment usually includes paper-based cognitive assessments. Digital cognitive assessment tools are also available, including Linus Health's Core Cognitive Evaluation (CCE). The CCE involves a Digital Clock and Recall (DCR) test and a lifestyle and health questionnaire to classify whether someone has cognitive impairment and to identify possible modifiable risk factors.</p> <p>Two pieces of NICE guidance with recommendations on assessing and diagnosing dementia, one cross-sectional study on Linus CCE, and three primary studies on digital clock tests were identified.</p> <p>The study on Linus CCE did not assess the technology's effectiveness in diagnosing cognitive impairment but did show that those with self-reported memory concerns performed worse on the assessment. Studies on the digital clock drawing test (DCTclock) and DCR found that these are better at classifying early cognitive impairment than the Mini-Mental Status Examination and are also faster to administer.</p> <p>There is very little available evidence on the effectiveness of Linus CCE or the DCR component of the intervention. More evidence comparing to current standard of care is required.</p>

¹ [Cyfieithu dogfennau HTW wedi'u cyhoeddi o'r Saesneg i'r Gymraeg](#)
Translation of published technical HTW documents from English into Welsh

Introduction and aims

Mild cognitive impairment is the state between the cognitive changes of normal ageing and very early dementia. Early dementia differs from mild cognitive impairment by the level of cognitive decline and changes in mood and behaviour. Individuals diagnosed with early dementia present with multiple cognitive deficits and their memory loss is sufficient to impact on everyday social and occupational functioning. Early diagnosis of cognitive impairment and starting treatment as early as possible are important to achieve the most benefit.

Linus Health's Core Cognitive Evaluation (CCE) is an iPad-based tool. It can be administered in approximately eight minutes and can be used in primary care settings. CCE has two components: Digital Clock and Recall (DCR) and a Life and Health Questionnaire (LHQ). Together these assess multiple functional domains and potential risk factors for developing dementia. The CCE assessment produces a personalised patient report, and a clinician report with recommendations and a clinical pathway outlined.

Health Technology Wales researchers searched for evidence on clinical and cost-effectiveness of Linus CCE to detect early-stage cognitive impairment.

Evidence overview

Similar topics were the subject of previous HTW topic exploration reports (TERs): TER302 *At-home use of tablet computers to assist diagnosis and management of dementia* (HTW 2021) and TER471 *Digital cognitive assessment tools to detect early-stage impairment caused by neurodegenerative disorders* (HTW 2023). The main focus of TER471 was the technology CognICA, though evidence was identified for a range of digital cognitive assessment tools. This topic has been accepted on to HTW's work programme and the full appraisal may be expanded to technologies other than CognICA. Therefore, this TER only looked for evidence on Linus CCE to inform whether this technology should be included in the full appraisal of digital cognitive assessment tools.

Linus CCE is a digital health technology and was determined to be a Tier C technology according to the [Evidence Standards Framework for Digital Health Technologies](#). Technologies within this classification will provide information that will be used to aid treatment or diagnosis, to triage or identify early signs of a disease or condition, or will be used to guide next diagnostics or next treatment interventions.

For technologies of this classification, it is recommended that satisfactory evidence is produced to demonstrate effectiveness of the technology. This includes studies conducted in a setting similar to the UK health and care system, peer-reviewed studies and prospective studies. Evidence to support the claimed benefits of the digital health technology should include real-world evaluations of its clinical utility, and include one or more high-quality studies that support the claimed benefits of the digital health technology in a relevant setting, showing improvements in relevant outcomes. Similarly, appropriate assessment of the economics of the digital health technology should be undertaken.

Guidance

National Institute for Health and Care Excellence (NICE) guidance 97 (NG97) recommends using a validated, brief, structured cognitive instrument for cognitive testing in cases of suspected dementia (NICE 2018). The guidance provides examples of some of these cognitive instruments, which are mainly paper-based and administered by a healthcare professional, but some of them are paper-based and self-administered and some are computerised but administered by a healthcare professional (NICE 2018). NG97 also recommends that dementia should not be

Evidence overview

ruled out solely because the person has a normal score on a cognitive instrument (NICE 2018). NG54 recommends that a specialist assessment should be considered for people with suspected dementia and learning disabilities (NICE 2016).

Primary evidence

One non-comparative cross-sectional study of Linus CCE was identified. Libon et al. (2023) screened 199 patients, who did not have diagnosed dementia or mild cognitive impairment, with Linus CCE and found that participants with self-reported memory concerns scored lower on a combined delay three-word/clock drawing index ($p < 0.016$), the total summary clock drawing command/copy score ($p < 0.050$), and clock drawing to command Drawing Efficiency ($p < 0.036$) and Simple and Complex Motor ($p < 0.029$) indices. However, the performance of the CCE in diagnosing dementia or mild cognitive impairment was not investigated in this study.

No other studies involving Linus CCE were identified; however, the topic proposer provided three studies investigating digital clock drawing tests, an aspect of the CCE.

DCTclock is a digitised version of the clock drawing test that uses AI to analyse drawing behaviour and provides data on cognitive function beyond successful task completion (Souillard-Mandar et al. 2021). In a validation study of 1,833 participants, the authors found that all DCTclock metrics were statistically significantly different between those with and those without cognitive impairment. DCTclock was also compared to existing clock scoring systems and the Mini-Mental Status Examination (MMSE), and the authors concluded that DCTclock offered a significant improvement in the detection of early cognitive impairment.

A cross-sectional study of 264 “clinically normal” patients and 36 patients with a diagnosis of mild cognitive impairment or early Alzheimer dementia found that DCTclock provided very good discrimination between these two groups, with an area under the receiver operator curve (AUC) of 0.86 (Rentz et al. 2021). This study also showed that DCTclock summary score and spatial reasoning subscore were associated with higher levels of amyloid and tau burden, biomarkers of Alzheimer’s disease, in clinically normal participants suggesting possible use of the assessment in early detection of pathological changes.

The DCR assessment involves the DCTclock test and a three-word immediate and delayed verbal recall test. It is specifically DCR that is included in the CCE. In a prospective, multisite, cross-sectional study, Jannati et al. (2024) compared the performance of DCR to MMSE for identifying cognitive impairment. In a sample of participants who were cognitively unimpaired ($n = 360$), had mild cognitive impairment ($n = 234$), or had probable mild Alzheimer’s dementia ($n = 111$), DCR was found to be better at classifying mild cognitive impairment or early dementia than MMSE (AUC 0.70 versus 0.63, respectively). It was also found that of 104 participants that MMSE classified as cognitively unimpaired, who had confirmed verbal memory impairment from a different assessment, DCR correctly classified 80.7% of these as cognitively impaired. DCR was also found to be significantly faster to administer and was less susceptible to bias due to ethnicity than MMSE.

Ongoing study

One ongoing clinical trial of Linus CCE was identified. [NCT05900310](#) was registered in June 2023 as a validation study of the CCE’s clinical decision support. However, the estimated study completion date was stated as August 2023 but there have been no further updates to the trial registry and potential published results of this study have not been identified.

Areas of uncertainty

- There is very little evidence on the effectiveness of Linus CCE and no comparative evidence on the full use of the technology.
- The only study identified on Linus CCE does not investigate the technology's ability to diagnose dementia or cognitive impairment.
- Due to the limited amount of evidence on Linus CCE, it is unlikely that a full appraisal could be conducted at this time. However, there is potential to include this technology in a future broader appraisal of digital cognitive assessment tools.

Literature search results

Health technology assessments and guidance

HTW. (2021). At-home use of tablet computers to assist diagnosis and management of dementia. Topic exploration report TER302. Health Technology Wales. Available at: <https://healthtechnology.wales/reports-guidance/at-home-use-of-tablet-computers-to-assist-diagnosis-and-management-of-dementia/> [Accessed 11 June 2024].

HTW. (2023). Digital cognitive assessment tools to detect early-stage impairment caused by neurodegenerative disorders. Topic exploration report TER471. Health Technology Wales. Available at: <https://healthtechnology.wales/reports-guidance/digital-cognitive-assessment-tools/> [Accessed 11 June 2024].

NICE. (2016). Mental health problems in people with learning disabilities: prevention, assessment and management. NICE guideline NG54. National Institute for Health and Care Excellence. Available at: <https://www.nice.org.uk/guidance/ng54> [Accessed 11 June 2024].

NICE. (2018). Dementia: assessment, management and support for people living with dementia and their carers. NICE guideline NG97. National Institute for Health and Care Excellence. Available at: <https://www.nice.org.uk/guidance/ng97> [Accessed 11 June 2024].

Individual studies

Libon DJ, Matusz EF, Cosentino S, et al. (2023). Using digital assessment technology to detect neuropsychological problems in primary care settings. *Frontiers in Psychology*. 14. doi: <https://doi.org/10.3389/fpsyg.2023.1280593>

Ongoing research

NCT05900310. (2023). Linus Health CDS Retrospective Validation Study. Available at: <https://clinicaltrials.gov/study/NCT05900310?tab=table>

Provided by Topic Proposer

Jannati A, Toro-Serey C, Gomes-Osman J, et al. (2024). Digital Clock and Recall is superior to the Mini-Mental State Examination for the detection of mild cognitive impairment and mild dementia. *Alzheimer's Research & Therapy*. 16(1): 2. doi: <https://doi.org/10.1186/s13195-023-01367-7>

Rentz DM, Papp KV, Mayblyum DV, et al. (2021). Association of Digital Clock Drawing With PET Amyloid and Tau Pathology in Normal Older Adults. *Neurology*. 96(14): e1844-e54. doi: <https://doi.org/10.1212/WNL.00000000000011697>

Souillard-Mandar W, Penney D, Schaible B, et al. (2021). DCTclock: Clinically-Interpretable and Automated Artificial Intelligence Analysis of Drawing Behavior for Capturing Cognition. *Frontiers in Digital Health*. 3. doi: <https://doi.org/10.3389/fdgth.2021.750661>

Date of search

11 June 2024

Concepts used

Linus, core cognitive evaluation, CCE, cognitive impairment, MCI, dementia, neurodegenerative disorder, Alzheimer*

Proposed research question and evidence selection criteria (if selected)

Proposed Research question	What is the clinical and cost effectiveness of digital cognitive assessment tools to detect early-stage impairment caused by neurodegenerative disorders?
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	Inclusion criteria	Exclusion criteria
Population	Adults with suspected early-stage impairment caused by neurodegenerative disorders (such as dementia and Alzheimer's disease)	
Intervention	Digital cognitive assessments (self-administered or delivered by a healthcare professional). Delivered in primary care or memory clinic settings	
Comparison/ Comparators	<p>Paper-based cognitive assessments usually administered by healthcare professional but can be self-administered. NICE guideline (NG97) recommends using a validated, brief structured cognitive instrument such as the:</p> <ul style="list-style-type: none"> • 10-point cognitive screener (10-CS) • 6-item cognitive impairment test (6CIT) • 6-item screener • Memory Impairment Screen (MIS) • Mini-Cog • Test Your Memory (TYM) (self-administered) 	
Outcome measures	Diagnostic accuracy Speed of diagnosis Convergent validity Usability Health related QoL Resource use Economic outcomes	

Proposed speciality	Caring for older people
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