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Running head:

Cognitive screening in dialysis – a scoping review

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Abstract

Background: Cognitive impairment in end-stage kidney disease patients on dialysis is increasingly common. The study aims to review the practice of screening and evaluate the evidence on cognitive impairment prevalence in this population.

Methods: This scoping review of studies summarises the evidence on cognitive impairment in dialysis populations. The search included Medline, Cinhal, Embase, Psychinfo, PubMed and Cochrane databases for English language articles published between 2000 and 2015.

Results: Forty-five articles were reviewed. The studies were prospective observational design, with the majority conducted in the haemodialysis population. The reported prevalence of cognitive impairment ranged from 6.6% to 51%. Three screening tools were consistently used.

Conclusion: Whilst cognitive impairment is recognised in the dialysis population, there is paucity of screening data. The design of prospective comparisons ideally includes established screening instruments, particularly the Montreal Cognitive Assessment, to determine the optimal results for this population. Translation of established screening tools to increase the inclusion of people from other cultural and language groups is required. Regular screening can enhance the timing to introduce home-based care support and advance care planning discussions.

Key words

dialysis, cognitive impairment, cognitive screening, scoping review

Introduction

Globally, developments in medicine and greater understanding of human behaviour, have led to significant progress in reducing mortality and increasing the average life expectancy in developed countries. Despite improvements in healthcare and longevity, there is very little reduction in the overall effect of non-fatal diseases on population health. [1] This trend has resulted in end-stage kidney disease (ESKD) being increasingly a disease of the elderly. According to the Australia and New Zealand Dialysis and Transplant (ANZDATA) registry, in 2015, approximately two thirds of prevalent dialysis patients were 65 years and over and a third were 75 years and over. [2]

Based upon published international studies, internationally the prevalence of dementia is between 5 and 9% of the population. [3] The prevalence of dementia in patients with EKSD, who are on dialysis is largely unknown as studies of cognition in this population have excluded patients with dementia. The reported prevalence of cognitive impairment among patients with ESKD as assessed using neuropsychological tests varies from 16 to 38%. [4] In a recent systematic review, people treated with haemodialysis were found to have more cognitive impairment than the general population in most cognitive domains. [5]

There is international agreement that population based screening of people aged 65 years and older for mild cognitive impairment, primarily on the grounds that progress from mild cognitive impairment to dementia is uncertain. [6, 7, 8] Routine screening however may have value in EKSD populations, with reported rates of cognitive impairment approximately three-fold higher than the general population. Cognitive

impairment in this population may interfere with capacity for self-care and informed-decision making that puts individuals at risk for poor outcomes. If cognitive impairment is recognised early, potentially reversible causes such as delirium and depression can be identified and treated. Early recognition may provide an opportunity for advance care planning before the dementia becomes advanced. [4]

A scoping review was conducted to provide insight into the practice of screening for cognitive impairment in people with ESKD on dialysis. The review focused on optimal timing and valid instruments for screening for cognitive impairment in patients on dialysis. The prevalence of cognitive impairment using a screening tool in the studies was also determined. The purpose of the review was to identify the gaps in what is known to guide future research.

Materials and methods

The methodology framework for scoping reviews, as described by Arksey and O'Malley was used. [9] A scoping review was selected to rapidly review the literature on screening for cognitive impairment in dialysis patients to identify gaps in the evidence base, and to identify whether a full systematic review is feasible or relevant.

Identification of research questions

Through an initial review of the literature on cognitive impairment in dialysis patients, the following research questions were identified:

1. What are the validated tools for screening for cognitive impairment in dialysis patients?

2. What is the prevalence of cognitive impairment in the dialysis population when a screening tool is administered?
3. What are the optimal conditions and timings in relation to haemodialysis sessions to screen for cognitive impairment?

Identification of relevant studies

Medline, Cinhal, Embase, Psychinfo, PubMed and Cochrane databases were searched for English language articles published between 2000 and 2015. All peer-reviewed prospective observational trials that used a screening tool for cognitive impairment in haemodialysis and peritoneal dialysis populations were included. The search strategy is reported in Table 1. The studies on patients with non-dialysis chronic kidney disease, paediatrics studies, animal studies, case reports and review articles were excluded. Other exclusion criteria include dialysis dementia or aluminium toxicity, uremic encephalopathy, dialysis disequilibrium, acute kidney injury, intensive care unit dialysis and other secondary causes for cognitive impairment such as subdural haematoma.

[Please insert Table 1 here]

Study selection

Studies were selected for review in a two-step process. The study authors worked in pairs to review the titles and abstracts in step one and then the articles in step 2. When a review pair disagreed about inclusion or exclusion, the team met to discuss and agree. The process of selection through step-wide exclusion is identified in Figure 1.

[Please insert Figure 1 here]

Charting the data

Initially data were catalogued and sorted using Endnote XV and Microsoft Excel. Two investigators reviewed each article, with rotation of each pair of reviewers to enhance reliability. Data were summarised and entered into the Excel spreadsheet and organised by author, year of publication, study location, intervention type and comparator (if any), duration of the intervention, study populations, aims of the study, methodology, outcome measures, and important results.

Summarizing and reporting the results

In contrast to a systematic review, the scoping study identifies a broad range of studies irrespective of study design and quality to present an overview of all the material selected for review. [9] Description of the geographic source of studies, purpose and types of cognitive assessment tools, and prevalence of cognitive impairment in the renal dialysis population was undertaken. In reporting the prevalence of cognitive impairment, the cut-off used by the study authors was noted. The type of research methods adopted was also described.

Results

334 articles were found through the database searches. There were 45 studies meeting the inclusion criteria for final analysis (see table 2). [10-55] An overview of the reviewed articles is found in Table 2.

[Please insert Table 2 here]

The included studies were conducted across 17 countries and 13 out of 45 were conducted in the USA. Of note, none of the included studies were from the United Kingdom, Canada or Australia.

All of the studies were prospective observational studies, with 21 studies including a control group for comparison. The focus for the majority of the studies was to assess the prevalence of risk factors for, and correlates of, cognitive impairment in the dialysis population. Thirty-five out of 45 studies were conducted in the haemodialysis population, nine studies in both peritoneal dialysis and haemodialysis population, and one in the peritoneal dialysis population. Most studies included patients 65 years and older, and only two studies were conducted focusing on the younger population with a mean age of less than 40 years. [35, 55]

The Mini-Mental State Examination (MMSE) [56] as the screening tool, alone or in combination with other tools such as the Montreal-Cognitive Assessment (MoCA) [57] or the Batterie d'Evaluation Cognitive (BEC 96), [58] was used in 35 out of 45 studies. The Modified Mini-Mental State (3MS) test [59] as the screening tool was used in nine studies. Only one out of four studies using MoCA utilised it as a sole screening tool. Trained researchers or research assistants administered the cognitive screening tools, where reported.

A battery of detailed neuropsychological testing, in addition to the use of a screening tool, was done in 17 out of 45 studies. Only one study out of 17 compared the performance of the two screening tools, MMSE and MoCA, with the

neuropsychological battery of tests. [49] In this study, the authors reported that there was a greater incidence of detection of cognitive impairment with NP (70%) compared with MOCA (59%) and MMSE (46.3%). [49] The MoCA for a cut-off value of ≤24 out of 30 was found to be more sensitive and specific in screening for the cognitive impairment, with sensitivity of 76.7% and specificity of 78.6%, compared to MMSE for a cut-off value of ≤24 out of 30, with sensitivity of 55.2% and specificity of 75.0%. [49] In one study, 66% of haemodialysis patients had moderate to severe cognitive impairment based on the neuropsychological testing and 59% of patients scored two standard deviations below mean on MoCA. [53] A cross-sectional study of cognitive function in 374 haemodialysis patients aged 55 years and older found a prevalence of cognitive impairment in 87.3% based on neuropsychological testing and in 40.5% based on the 3MS test. [36]

The prevalence of cognitive impairment could not be estimated in 14 out of 28 studies using a screening tool alone to assess the global cognitive function. The purpose of these studies was to assess the risk factors for, and correlates of, cognitive impairment and not estimating the prevalence. The test scores were reported as a continuous variable in their statistical tests. One of the studies, reporting the cognitive scores in the context of detecting early cerebral regional homogeneity changes in neurologically asymptomatic patients, found none of the 20 patients aged less than 50 years had abnormal MMSE. [33] In the remaining 13 studies the prevalence of cognitive impairment varied from 6.6% [43] to 51% [11] with MMSE as the screening tool and from 16% [46] to 39.7% [20] with 3MS as the screening tool. In two of the studies that compared the prevalence of cognitive impairment in haemodialysis and peritoneal dialysis patients, the difference was not statistically significant. [24, 43]

There was only one study assessing the variation in cognitive performance using a screening tool alone. The study administered MoCA before and after the dialysis session in two different settings, in a group room and in a separate room. It was found that the cognitive performance based on MoCA scores were best when assessed before the dialysis session in a separate room. [48] Three studies on samples of less than 100 participants investigated the timing of cognitive assessment using neuropsychological tests, rather than simply screening. However the results were conflicting. The cognition was best immediately before haemodialysis in one, [14] immediately after haemodialysis in the second, [15] and 24 hours post-haemodialysis in the third. [37] One cross-over randomised controlled trial of timing for assessment of cognitive performance using MMSE and detailed neuropsychological tests found no difference in scores between the one hour before haemodialysis and the first hour, concluding that assessment before dialysis was appropriate. [17]

Discussion

The most common screening tool administered in the reviewed studies was MMSE followed by 3MS and MoCA. The BEC 96 was only used in one study. Because the BEC 96 is hardly known outside the French scientific community, its usefulness as a screening instrument is difficult to assess when only English language articles were reviewed. The MoCA and MMSE are brief tests, taking less than 10 minutes to administer, whereas 3MS is a more detailed test. [60]

The MoCA was specifically designed to detect mild cognitive impairment. [57] The MoCA is more sensitive to detecting visuospatial and executive functional deficits than

MMSE and is a better screening test for patients with subcortical vascular cognitive impairment. [61] While Alzheimer's disease accounts for up to 80% of cases of dementia in general population, [62] the high burden of cardiovascular disease in dialysis patients, means that the pattern of cognitive impairment is subcortical in nature. [63] In the study by Tiffin-Richards and colleagues, MoCA with a cut-off value of ≤24 was more sensitive and specific in screening for cognitive impairment in dialysis patients than MMSE with a cut-off value of ≤24. [49] There were 16 more studies that administered a screening tool as part of a battery of neurophysiological tests for assessment of cognitive dysfunction in dialysis patients. None of these 16 studies assessed the performance of the screening tool used against the battery of neuropsychological tests and it is a lost opportunity. Based on the single study, [49] MoCA appears to be a preferred screening tool for cognitive impairment in dialysis population.

The prevalence of cognitive impairment varied widely in the reviewed studies. The variation may be attributed to differing sensitivities of the screening tools, use of different cut-off score to define cognitive impairment, variable sample sizes, age, gender, education levels, and cultural differences depending on where the study was conducted. The differences in inclusion and exclusion criteria depending on the purpose of the study may also explain the variable prevalence. While the prevalence of cognitive impairment in people in dialysis is not clear, two systematic reviews found that people with ESKD with or without dialysis consistently had lower scores indicating a high likelihood of cognitive impairment. [5, 63]

In the recently published Choice of Renal Replacement Therapy (CORETH) project, almost one half of 767 eligible dialysis patients had missing cognitive testing data. [64] The patients with missing data were those with disease-related limitations for cognitive testing like visual, motivational, or motor difficulties. The authors of this study conclude that the estimates of cognitive impairment in the dialysis population may be biased and that the cognitive testing resources that overcome the above limitations may be useful in the future. [64] Excluding patients with previous stroke and patients with dementia also leads to significant underestimation of the prevalence of cognitive impairment in the population studied. [65] Inability to speak a language, for example inability to speak English in studies from USA [20,32] or French in studies from France, [51] was one of the exclusion criteria in many studies. Their exclusion may have biased the reported prevalence of cognitive impairment in those studies. Rather than excluding these patients, future studies should consider using validated translations of the selected cognitive screening tool in these patients.

There has been limited investigation into timing of screening for cognition. Based on one study with a small sample (n=26), the best time and place to communicate information to patients on haemodialysis appears to be before dialysis [17, 48] and in a separate room. [48] In practice, the timing of neuropsychological assessment is more likely to be determined by the logistics like willingness and ability of the patient to participate in a detailed neuropsychological assessment after a haemodialysis session, willingness of patient come in early for an assessment before haemodialysis session, or to visit the hospital or clinic on a non-haemodialysis day, and resources available for a home assessment on a non-haemodialysis day. The timing of cognitive screening in people on dialysis is an area for further investigation.

There is an opposition to screening for cognitive impairment in the general elderly population [66] and routine screening of at risk populations is not recommended in national guidelines. [6,7,8] One of the reasons for the recommendation against routine screening is that the majority of older people with mild cognitive impairment do not progress to dementia or their cognitive function may even improve. However, there is compelling evidence that cognitive impairment occurs early in ESKD [63] and that people on dialysis have worse cognition than the general population. [5, 63] Further, in a recent study of dialysis patients with cognitive impairment, there is evidence that the cognition declines faster, with effects on the decision-making capacity. [67]

One of the benefits of early diagnosis of cognitive impairment in the dialysis population is identifying substitute decision makers and facilitating advance care planning. The main advantage of completing an advance care plan under these circumstances is to clearly document a person's wishes with respect to the timing of treatment withdrawal before the person loses decisional capacity and the ability to give informed consent. In the ANZDATA registry, in 2014, the cause of death for one in three dialysis patients was recorded as withdrawal from dialysis. [2] The advance care planning process requires a shared process of decision-making between the patient, the patient's family and clinicians. When this process begins early, there are opportunities for the patient, family and clinicians to share their perspectives and negotiate goals of care over several conversations [68]. An early discussion about if and when to withdraw from dialysis therapy can relieve family carers of the burden of responsibility for making the decision on behalf of the person who is cognitively impaired. Currently the important process of advance care planning remains suboptimal in this population. [69]

The Australian Commission on Safety and Quality in Health Care (ACSQHC) *'Delirium Clinical Care Standard'* recommends cognitive screening at presentation to hospital in patients with key risk factors for delirium like age 65 years and over, known cognitive impairment/dementia, severe medical illness and current hip fracture. [70] Dialysis patients are older, have a large burden of disease and have high rate of hospitalisation compared to general population. [71] The prevalence of cognitive impairment is higher in the dialysis population in the reviewed studies that recruited a control population for cognitive screening. This underscores the need for cognitive screening in the dialysis population to identify patients with delirium and at risk of delirium early to institute appropriate management and preventative measures.

Navigating health services places significant cognitive demand on dialysis patients. At every stage of their healthcare journey they need to process, understand, assimilate, recall information and be involved in shared decisions about their care. Cognitive impairment is strongly correlated with poor health literacy leading to reduced capacity to engage in self-care and achieve desirable health outcomes. [72] Adherence with complex medication regimens, treatment regimens, dietary restriction and fluid restrictions is a major challenge for dialysis patients. [73] Cognitive impairment is linked to decreased adherence to the complex treatment regimen. [74] Early detection of cognitive impairment in the dialysis population will help with successful interventions to overcome the practical barriers faced by these vulnerable patients and improve adherence.

This scoping review was restricted to studies published in English potentially leading to underrepresentation of the non-English-speaking population and usefulness of non-English instruments, such as the BEC 96. Through the exclusion of conference abstracts, we may have missed contemporary research on prevalence or timing. This may limit the applicability of our conclusions. The study did not address the quality of evidence by design and consequently provides a descriptive summary of available research.

The most common screening tool used in the reviewed studies was MMSE. Based on a single study, MoCA is more sensitive and specific compared to MMSE and the best time to administer MoCA appears to be before dialysis in a separate room. The reported prevalence of cognitive impairment in dialysis patients is highly variable and is likely to be biased due to studies excluding patients with stroke, dementia, and others who could not consent or complete the assessments. There is a need for studies in dialysis population comparing and validating commonly available cognitive screening tools including those that are used in culturally and linguistically diverse population.

Declarations

The authors have no financial or non-financial affiliations with any organizations in the subject matter or material discussed in the manuscript.

References

1. Salomon JA, Wang H, Freeman MK, Vos T, Flaxman AD, Lopez AD, Murray CJ. Healthy life expectancy for 187 countries, 1990–2010: a systematic analysis for the Global Burden Disease Study 2010. *Lancet* 2013; 380(9859): 2144-2162. doi: 10.1016/S0140-6736(12)61690-0
2. Australian & New Zealand Dialysis & Transplant Registry. The 39th Annual ANZDATA report (2016). http://www.anzdata.org.au/v1/report_2016.html. Accessed March 17, 2017.
3. Prince M, Wimo A, Guerchet M, Ali G-C, Wu Y-T, Prina M. World Alzheimer Report 2015 *The Global Impact of Dementia: an analysis of prevalence, incidence, cost and trends.* 2015. Alzheimer's Disease International, London.
4. Tamura MK, Yaffe K. Dementia and cognitive impairment in ESRD: diagnostic and therapeutic strategies. *Kidney Int* 2011; 79(1): 14-22. doi: 10.1038/ki.2010.336
5. O'Lone E, Connors M, Masson P, Wu S, Kelly PJ, Gillespie D, et al.. Cognition in people with end-stage kidney disease treated with hemodialysis: a systematic review and meta-analysis. *Am J Kidney Dis* 2016; 67(6): 925-935. doi: 10.1053/j.ajkd.2015.12.028
6. Guideline Adaptation Committee. *Clinical Practice Guidelines and Principles of Care for Dementia.* Sydney: NHMRC Partnership Centre for Dealing with Cognitive and Related Functional Decline in Older People: 2016.
7. Canadian Task Force on Preventive Health Care, Pottie K, Rahal R, Jaramillo A, Birtshistle R, Thombs BD, Singh H, Connor Gorber S, Dunfield L, Shane A, Bacchus M, Bell N, Tonelli M. Recommendations on screening for cognitive impairment in older adults. *CMAJ* 2016; 188(1): 37-46.

8. Moyer VA, U.S. Prevention Services Task Force. Screening for cognitive impairment in older adults: U.S. Preventative Services Task Force recommendation statement. *Ann Intern Med* 160(11): 791-7.

9. Arksey H, O'Malley L. Scoping Studies: Towards a Methodological Framework. *Int J Soc Res Meth* 2005; 8(1): 19-32.

10. Abdelrahman HM, Elawam AE, Alghitany AN. Cognitive impairment among Egyptian older adults on hemodialysis. *Middle East J Age Ageing* 2014; 11(18): e24.

11. Bossola M, Ciciarelli C, Di Stasio E, Panocchia N, Conte GL, Rosa F, et al. Relationship between appetite and symptoms of depression and anxiety in patients on chronic hemodialysis. *J Ren Nutr* 2012; 22(1): 27-33. doi: 10.1053/j.jrn.2011.02.005

12. Bossola M, Laudisio A, Antocicco M, Tazza L, Colloca G, Tosato M, Zuccala G. Cognitive performance is associated with left ventricular function in older chronic hemodialysis patients: result of a pilot study. *Aging Clin Exp Res* 2014; 26(4): 445-451. doi: 10.1007/s40520-013-0191-x

13. Condé SA, Fernandes N, Santos FR, Chouab A, Mota MM, Bastos MG. Cognitive decline, depression and quality of life in patients at different stages of chronic kidney disease. *J Bras Nefrol* 2010; 32(3): 242-248.

14. Costa AS, Tiffin-Richards FE, Holschbach B, Frank RD, Vassiladou A, Kruger T, et al. Clinical predictors of individual cognitive fluctuations in patients undergoing hemodialysis. *Am J Kidney Dis* 2014; 64(3): 434-442. doi: 10.1053/j.ajkd.2014.02.012

15. Cukor D, Ver Halen N, Asher DR, Goldberg MA, Slyker J, Kimmel PL. A pilot investigation of cognitive improvement across a single hemodialysis treatment. *J Nephrol* 2013; 26(2): 323-330. doi: 10.5301/jn.5000148

16. Dahbour SS, Wahbeh AM, Hamdan MZ. Mini mental status examination (MMSE) in stable chronic renal failure patients on hemodialysis: The effects of hemodialysis on the MMSE score. A prospective study. *Hemodial Int* 2009; 13(1): 80-85. doi: 10.1111/j.1542-4758.2009.00343.x

17. Drew DA, Tighiouart H, Scott TM, Lou KV, Shaffi K, Weiner DE, Sarnak MJ. Cognitive performance before and during hemodialysis: a randomized cross-over trial. *Nephron Clin Pract* 124(3-4): 151-8. doi: 10.1159/000356393

18. Fadili W, Al Adlouni A, Louhab N, Habib Allah M, Kissani N, Laouad I. Prevalence and risk factors of cognitive dysfunction in chronic hemodialysis patients. *Aging Ment Health* 2014; 18(2): 207-211. doi: 10.1080/13607863.2013.823375

19. Gad AH, Ramzy GM, Abdelhamid YM, ElMassry HA, Masoud MM. Cognitive Impairment in Hemodialysis Patients. *Egyptian J Neurol, Psych Neurosurg* 2012; 49(3): 245-249.

20. Hain DJ. Cognitive function and adherence of older adults undergoing hemodialysis. *Nephrol Nurs J* 2008; 35(1): 23-29.

21. Harciarek M, Williamson JB, Biedunkiewicz B, Lichodziejewska-Niemierko M, Debska-Slizien A, Rutkowski B. Risk factors for selective cognitive decline in dialyzed patients with end-stage renal disease: evidence from verbal fluency analysis. *J Int Neuropsychol Soc* 2012; 18.1 (2012): 162-167. doi: 10.1017/S1355617711001445

22. Huang YC, Kuo YW, Lee TH, Lee M, Hsiao MC, Wang CL, Lee JD. Hypoalbuminemia and not hyperhomocysteinemia as a risk factor for dementia in hemodialysis patients. *J Ren Nutr* 2008; 18(4): 347-354. doi: 10.1053/j.jrn.2007.12.003

23. Isshiki R, Kobayashi S, Iwagami M, Tsutumi D, Mochida Y, Isioka K, et al. Cerebral Blood Flow in Patients With Peritoneal Dialysis by an Easy Z-Score Imaging System for Brain Perfusion Single-Photon Emission Tomography. *Ther Apher and Dial* 2014*;* 18(3): 291-296. doi: 10.1111/1744-9987.12107

24. Jung S, Lee YK, Choi SR, Hwang SH, Noh JW. Relationship between cognitive impairment and depression in dialysis patients. *Yonsei Med J* 2013; 54(6): 1447-1453. doi: 10.3349/ymj.2013.54.6.1447

25. Kalaitzidis RG, Karasavvidou D, Tatsioni A, Balafa O, Pappas K, Spanos G,et al. Risk factors for cognitive dysfunction in CKD and hypertensive subjects. *Int Urol Nephrol* 2013; 45(6): 1637-1646. doi: 10.1007/s11255-013-0450-y

26. Kalirao P, Pederson S, Foley RN, Kolste A, Tupper D, Zaun D, et al. Cognitive impairment in peritoneal dialysis patients. *Am J Kidney Dis* 2011; 57(4): 612-620. doi: 10.1053/j.ajkd.2010.11.026

27. Kang EW, Abdel-Kader K, Yabes J, Glover K, Unruh M. Association of sleep-disordered breathing with cognitive dysfunction in CKD stages 4-5. *Am J Kidney Dis* 2012; 60(6): 949-958. doi: 10.1053/j.ajkd.2012.08.033

28. Kato M, Kawaguchi K, Nakai S, Murakami K, Hori H, Ohashi A, et al. Potential therapeutic system for Alzheimer's disease: removal of blood Aβs by hemodialzyers and its effect on the cognitive functions of renal-failure patients. *J Neural Transm* 2012; 119(12): 1533-1544. doi: 10.1007/s00702-012-0844-5.

29. Kitaguchi N, Kawaguchi K, Nakai S, Murakami K, Ito S, Hoshino H, et al. Reduction of Alzheimer's disease amyloid-beta in plasma by hemodialysis and its relation to cognitive functions. *Blood Purif* 2011; 32(1): 57-62. doi: 10.1159/000322624

30. Kobayashi S, Mochida Y, Ishioka K, Oka M, Maesato K, Moriya H, et al. The effects of blood pressure and the renin–angiotensin–aldosterone system on regional cerebral blood flow and cognitive impairment in dialysis patients. *Hypertens Res* 2014; 37(7): 636-641. doi: 10.1038/hr.2014.57

31. Kutlay S, Nergizoglu G, Duman N. Recognition of neurocognitive dysfunction in chronic hemodialysis patients. *Ren Fail* 2001; 23(6): 781-787.

32. Leinau L, Murphy TE, Bradley E, Fried T. Relationship between conditions addressed by hemodialysis guidelines and non-ESRD-specific conditions affecting quality of life. *Clin J Am Soc Nephrol* 2009; 4(3): 572-578. doi: 10.2215/CJN.03370708

33. Li C, Su H, Qiu Y, Lu XF, Shen S, Zhan WF, et al. Regional homogeneity changes in hemodialysis patients with end stage renal disease: in vivo resting-state functional MRI study. *PloS One* 2014; 9(2): e87114. doi: 10.1371/journal.pone.0087114

34. Lux S, Mirzazade S, Kuzmanovic B, Plewan T, Eickhoff SB, Shah NJ, et al. Differential activation of memory-relevant brain regions during a dialysis cycle. *Kidney Int* 2010; 78(8): 794-802. doi: 10.1038/ki.2010.253

35. Martins CT, Ramos GS, Guaraldo SA, Uezima CB, Martins JP, Ribeiro Junior E. Comparison of cognitive function between patients on chronic hemodialysis who carry out assisted physical activity and inactive ones. *J Bras Nefrol* 2011; 33(1): 27-30.

36. Murray AM, Tupper DE, Knopman DS, Gilbertson DT, Pederson SL, Li S, et al. Cognitive impairment in hemodialysis patients is common. *Neurology* 2006; 67(2): 216-223.

37. Murray AM, Pederson SL, Tupper DE, Hochhalter AK, Miller WA, Li Q, et al. Acute variation in cognitive function in hemodialysis patients: a cohort study with repeated measures. *Am J Kidney Dis* 2007; 50(2): 270-278.

38. Nasser ME, Shawki S, El Shahawy Y, Sany D. Assessment of cognitive dysfunction in kidney disease. *Saudi J Kidney Dis Transpl* 2012; 23(6): 1208-1214. doi: 10.4103/1319-2442.103561.

39. Odagiri G, Sugawara N, Kikuchi A, Takahashi I, Umeda T, Saitoh H, et al. Cognitive function among hemodialysis patients in Japan. *Ann Gen psychiatry* 2011; 10(1): 20. doi: 10.1186/1744-859X-10-20

40. Pipkin M, Eggers PW, Larive B, Rocco V, Stokes JB, Suri RS, et al. Recruitment and training for home hemodialysis: experience and lessons from the Nocturnal Dialysis Trial. *Clin J Am Soc Nephrol* 2010; 5(9): 1614-1620. doi: 10.2215/CJN.02440310

41. Post JB, Morin KG, Sano M, Jegede AB, Langhoff E, Spungen AM. Increased presence of cognitive impairment in hemodialysis patients in the absence of neurological events. *Am J Nephrol* 2012; 35(2): 120-126. doi: 10.1159/000334871

42. Sarnak MJ, Tighiouart H, Scott TM, Lou KV, Sorensen EP, Giang LM, et al. Frequency of and risk factors for poor cognitive performance in hemodialysis patients. *Neurology* 2013; 80(5): 471-480. doi: 10.1212/WNL.0b013e31827f0f7f.

43. Sithinamsuwan P, Niyasom S, Nidhinandana S, Supasyndh O. Dementia and depression in end stage renal disease: comparison between hemodialysis and

continuous ambulatory peritoneal dialysis. *J Med Assoc Thai* 2005; 88 (Suppl 3): s141-s147

44. Soykan A, Boztas H, Kutlay S, Ince E, Nergizoglu G, Dilekoz AY, Berksun O. Do sexual dysfunctions get better during dialysis? Results of a six-month prospective follow-up study from Turkey. *Int J Impot Res* 2005; 17(4): 359-363.
45. Soysal P, Isik AT, Buyukaydin B, Kazancioglu R. A comparison of end-stage renal disease and Alzheimer's disease in the elderly through a comprehensive geriatric assessment. *Int Urol Nephrol* 2014; 46(8): 1627-1632. doi: 10.1007/s11255-014-0739-5
46. Tamura MK, Larive B, Unruh ML, Stokes JB, Nissenson A, Mehta RL, et al.. *Clin J Am Soc Nephrol* 2010; 5(8): 1429-1438. doi: 10.2215/CJN.01090210
47. Tamura MK, Meyer JB, Saxena AB, Huh JT, Wadley VG, Schiller B. Prevalence and significance of stroke symptoms among patients receiving maintenance dialysis. *Neurology* 2012; 79(10): 981-987. doi: 10.1212/WNL.0b013e31826845e9
48. Tholen S, Schmaderer C, Kusmenkov E, Chmielewski S, Forsti H, Kehl V, et al. Variability of cognitive performance during hemodialysis: standardization of cognitive assessment. *Dement Geriatr Cogn Disord* 2014; 38(1-2): 31-38. doi: 10.1159/000357803
49. Tiffin-Richards FE, Costa AS, Holschbach B, Frank RD, Vassiliadou A, Kruger, T, et al. The Montreal Cognitive Assessment (MoCA)-a sensitive screening instrument for detecting cognitive impairment in chronic hemodialysis patients. *PLoS One* 2014; 9(10): e106700. doi: 10.1371/journal.pone.0106700
50. Tilki HE, Akpolat T, Tunalı G, Kara A, Onar MK. Effects of haemodialysis and continuous ambulatory peritoneal dialysis on P300 cognitive potentials in uraemic patients. *Ups J Med Sci* 2004; 109(1): 43-48.

51. Tyrrell J, Paturel L, Cadec B, Capezzali E, Poussin G. Older patients undergoing dialysis treatment: cognitive functioning, depressive mood and health-related quality of life. *Aging Ment Health* 2005; 9(4): 374-379.

52. van Doorn KJ, Heylen M, Mets T, Verbeelen D. Evaluation of functional and mental state and quality of life in chronic haemodialysis patients. *Int Urol Nephrol* 2004; 36(2): 263-267.

53. Wolfgram DF, Sunio L, Vogt E, Smith HM, Visotcky A, Laud P, Whittle J. Haemodynamics during dialysis and cognitive performance. *Nephrology* 2014; 19(12): 771-776. doi: 10.1111/nep.12324

54. Yavuz N, KarataşL M, Kinç Ş. Correlates for End-Stage Renal Disease Patients. *Scand J Caring Sci*. 2000; 14(3): 179-183.

55. Zhang R, Liu K, Yang L, Zhou T, Qian S, Li B, et al. Reduced white matter integrity and cognitive deficits in maintenance hemodialysis ESRD patients: a diffusion-tensor study. *Eur Radiol* 2015; 25(3): 661-668. doi: 10.1007/s00330-014-3466-5

56. Molloy D, Standish TI. A guide to the standardized Mini-Mental State Examination. *Int Psychogeriatr* 1997; 9 Suppl 1:87-94.

57. Nasreddine ZS, Phillips NA, Bedirian V, Charbonneau S, Whitehead V, Collin I, Cummings JL, Chertkow H. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc* 2005; 53(4): 695-699.

58. Signoret, J. L. Evaluation des troubles de la me´moireet des de´sordres cognitifs associe´s: B.E.C. 96. 1989; Paris: Editions IPSEN.

59. Teng EL, Chui HC. The modified Mini-Mental State (3MS) examination. J Clin Psychiatry 1987; 48(8): 314-8..

60. Tsoi KK, Chan JY, Hirai HW, Wong SY, Kwok TC. Cognitive tests to detect dementia: a systematic review and meta-analysis. *JAMA Int Med* 2015; 175(9): 1450-1458. doi: 10.1001/jamainternmed.2015.2152

61. Ihara M, Okamoto Y, Takahashi R. Suitability of the Montreal cognitive assessment versus the mini-mental state examination in detecting vascular cognitive impairment. *J Stroke Cerebrovasc Dis* 2013; 22(6): 737-741. doi: 10.1016/j.jstrokecerebrovasdis.2012.01.001

62. Australian Institute of Health and Welfare. Australia's Health 2016. Australia's health series no.15. Cat. No. AUS199. Canberra, AIHW: 2016.

63. Pereira AA, Weiner DE, Scott T, Chandra P, Bluestein R, Girffith J, Sarnak MJ. Subcortical cognitive impairment in dialysis patients. *Hemodial Int* 2007; 11(3): 309-314.

63. Berger I, Wu S, Masson P, Kelly PJ, Duthie FA, Whiteley W, Parker D, Gillespie D, Webster AC. Cognition in chronic kidney disease: a systematic review and meta-analysis. *BMC Medicine* 14: 206. DOI 10.1186/s12916-016-0745-9

64. Neumann D, Robinski M, Mau W, Girndt M. Cognitive Testing in Patients with CKD: The Problem of Missing Cases. *Clin J Am Soc Nephrol* 2017; 12(3): 391-398. doi: 10.2215/CJN.03670316

65. Corraini P, Henderson VW, Ording AG, Pedersen L, Horváth-Puhó E, Sørensen HT. Long-term risk of dementia among survivors of ischemic or hemorrhagic stroke. *Stroke* 2017;48(1):180-186. doi: 10.1161/STROKEAHA.116.015242

66. Le Couteur D, Doust JA, Creasey H, Brayne C. Political drive to screen for pre-dementia: not evidence based and ignores the harms of diagnosis. *BMJ* 2013; 347: f5125. doi: 10.1136/bmj.f5125

67. Iyasere O, Okai D, Brown E. Cognitive function and advanced kidney disease: longitudinal trends and impact on decision-making. *Clin Kidney J* 2017; 10 (1): 89-94

68. Manalo, M.F.C. End-of-life decisions about withholding or withdrawing therapy: medical, ethical and religio-cultural considerations. Palliative Care 2013; 7: 1-5.

69. Goff SL, Eneanya ND, Feinberg R, Germain MJ, Marr L, Berzoff J, et al. Advance care planning: a qualitative study of dialysis patients and families. *Clin J Am Soc Nephrol* 2015; 10(3): 390-400. doi: 10.2215/CJN.07490714

70. Australian Commission on Safety and Quality in Health Care. Delirium Clinical Care Standard. Sydney, ACSQHC: 2016

71. Mathew AT, Strippoli GF, Ruospo M, Fishbane S. Reducing hospital readmissions in patients with end-stage kidney disease. *Kidney Int* 2015; 88(6): 1250-1260. doi: 10.1038/ki.2015.307

72. Wolf MS, Curtis LM, Wilson EAH, Revelle W, Waite KR, Smith SG, et al. Literacy, cognitive function, and health: results of the LitCog study. *J Gen Intern Med* 2012; 27(10): 1300-1307

73. Kammerer K. Garry G, Hartigan M, Carter B, Erlich L. Adherence in patients on dialysis: strategies for success. *Nephrol Nurs J* 2007; 34(5): 479-486.

74. Campbell N, Boustani MA, Skopelja EN, Gao S, Unverzagt FW, Murray MD. Medication adherence in older adults with cognitive impairment: a systematic evidence-based review. *Am J Geriatr Pharmacother.* 2012; 10(3): 165-177. doi: 10.1016/j.amjopharm.2012.04.004

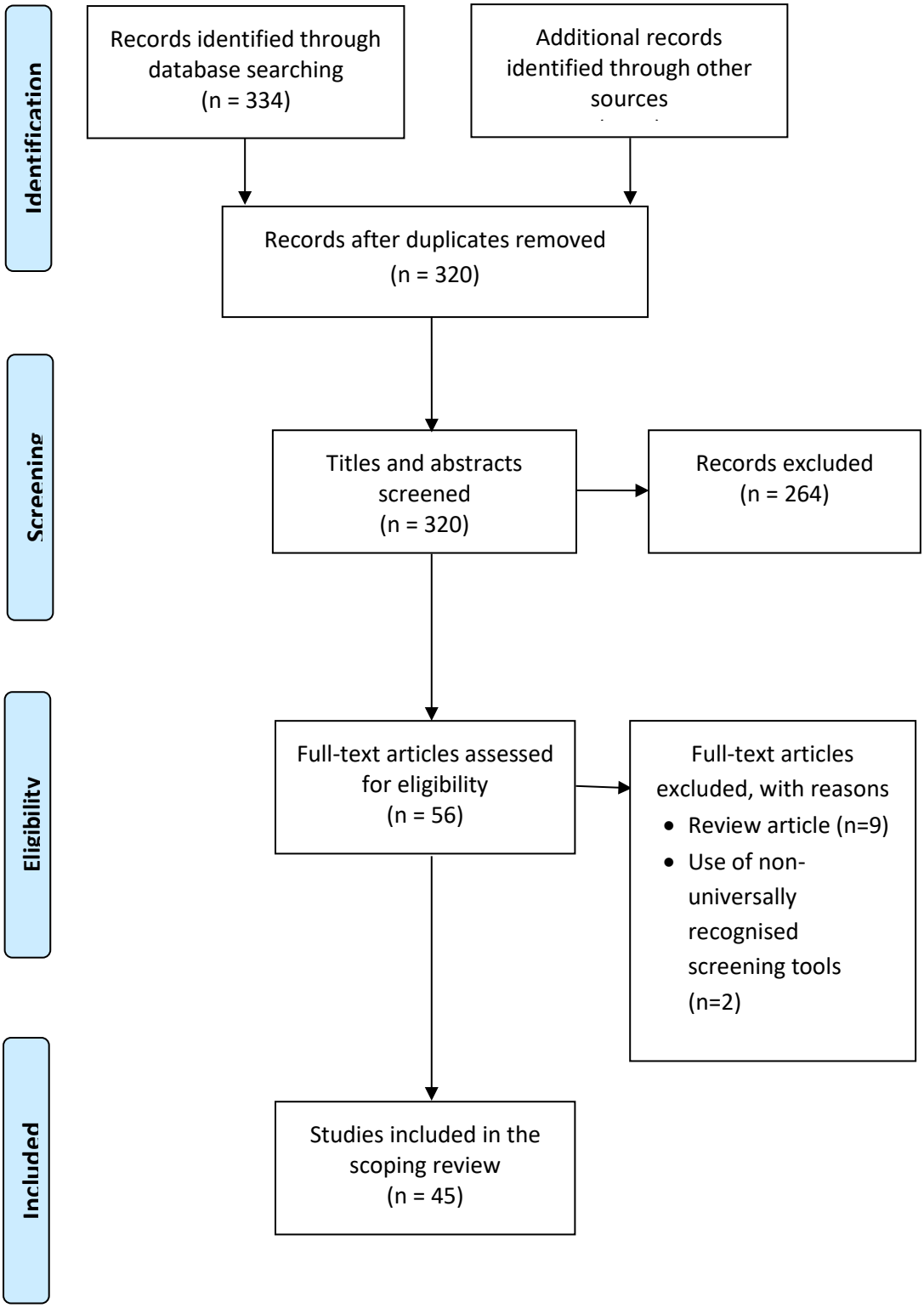

Figure 1. PRISMA flow diagram showing the studies included and excluded in the review

Table 1: Search concepts and keywords

Concept	Controlled and natural keywords
Cognition	“dementia” OR “dementia” [tw] "delirium"[mh] OR “delirium”[tw] "cognition"[mh] OR cognition[tw] OR “cognition disorders”[mh]
Dialysis	"renal dialysis"[mh] OR “dialysis”[mh] OR dialysis[tw] OR hemodialy*[tiab] OR haemodialy*[tiab] OR dialy*[ti] OR peritoneal dialysis[tw] OR dialysis patient*[tiab] OR end-stage renal[ti] OR dialysis therapy[tiab] OR "Hemofiltration"[majr] OR "Renal Replacement Therapy"[majr:noexp] OR esrd[ti] OR renal replacement[ti]
Databases	
▪ Medline (Ovid) ▪ Embase ▪ CINAHL (Cumulative Index to Nursing and Allied Health)	▪ Cochrane Library ▪ Psycinfo ▪ PubMed
Limits	
2000-2015; English	

Table 2 Extracted data displaying timing of assessment, screening tools used and the prevalence reported in the studies

Author, Publication Year, Country of Study	Study Groups	Sample			Exclusion Criteria of Interest				Screening Tools	Prevalence based on Screening Test	Assessment Timing
		Size	Age (years)	Gender (M/F)	Advanced Dementia	Cerebrovascular Disease	Psychiatric Disease	Lack of Language Fluency			
Abdelrahman, H.M.M., 2014 Egypt [10]	HD	94	67.26 ±4.95	39/55	Not reported.	Excluded.	Excluded.	Not reported.	MMSE	Normal (MMSE 30) – 26 (28%) Mild CI (MMSE 26-29) – 32 (34%) Early Dementia (MMSE 21-25) – 21 (23%) Moderate Dementia (MMSE 11-20) – 8 (8%) Severe Dementia (MMSE 0-10)- 7 (7%)	Not reported
Bossola, M., 2012 Italy [11]	HD	90	Group I: 58.8±15.7 Group II: 67.9±12.9 Group III: 72.1±10.1	Group I- 30/13 Group II– 10/12 Group III– 14/11	Excluded.	Excluded.	Excluded.	Not reported.	MMSE	Group I - MMSE 24.7±0.4 Group II - 23.2±0.7 Group III-22.5±0.9	Not reported
Bossola, M., 2014 Italy [12]	HD	72	62±15	45/27	Not reported.	Excluded.	Excluded.	Not reported.	MMSE	*MMSE below 24*- 37 (51%)	During mid-week HD session
Conde, S.A., 2010, Brazil [13]	HD	30	57.4±10.7	18/12	Not reported.				MMSE	Presented only in graphical form. Proportion of patients with altered MMSE was worst in HD patients but not statistically significant.	Not reported
	PD	37	59.1±13.6	12/15							
	Pre-dialysis	32	60.7±13.7	17/15							
	HBP	30	56.8±11.5	10/20							
Costa, A.S., 2014 Germany [14]	HD	47	57.3±14.4	24/23	Not reported.	Excluded.	Excluded.	Excluded.	MoCA & MMSE	Not reported. Excluded from individual based statistical analysis due to low reliability.	Day before HD and directly after HD session; controls - twice within 24 hours
	Controls	40	57.6±11.9	18/22							
Cukor, D., 2013 USA [15]	HD	25	50±12.1	9/16	Not reported.				MMSE	*Mean MMSE* HD - 27.4±1.7 PD - 28.2±1.2	HD - immediately pre and post PD - two measures at 4 hour gap
	PD (Controls)	6	47.9±11.6	1/5							
Dahbour, S.S., 2009 Jordan [16]	HD	54	46±15.2	36/18	Excluded.	Excluded.	Not reported.	Not reported.	MMSE	*MMSE:* Before HD - 26.5±2.7 After HD - 26.4±3.3 Controls - 28.4±1.6	Before scheduled dialysis and repeated 2-4weeks later after they finished dialysis
	Controls	54	47.3±12.5	38/16							
Drew D.A., 2013	Group I	21	58.1±18.0	15/6	Excluded.	Not reported.		Excluded.	MMSE		

USA* [17]	Group II	19	59.8 ±16.4	9/10	Not reported.					Mean MMSE 26.7±2.6 with the first test. Mean MMSE 27.0±2.6 with the second test.	Randomized cross-over design; 21 patients tested at 1hour before dialysis then crossed over one month later to be tested during the 1st hour of dialysis. The second group of 19 patients followed the reverse sequence.

Author, Publication Year, Country of Study	**Study Groups**	**Sample**			**Exclusion Criteria of Interest**				**Screening Tools**	**Prevalence based on Screening Test**	**Assessment Timing**
		Size	**Age (years)**	**Gender (M/F)**	**Advanced Dementia**	**Cerebrovascular Disease**	**Psychiatric Disease**	**Lack of Language Fluency**			
Fadili, W., 2014 Morocco [18]	HD	108	60.94±7.5	57/51	Excluded.	Not excluded.	Excluded.	Not reported.	MMSE	MMSE <24- 27 (25%)	First hour of HD
Gad, A.H., 2012 Egypt [19]	HD Controls	50 50	48.2±4.8 Reported to be matched to HD patients.	25/25	Not reported.				MMSE	HD MMSE <24- 33(66%)	Not reported
Hain, D.J., 2008 USA [20]	HD	63	72.71±7.75	35/22	Excluded.	Not reported.	Depression not excluded.	Excluded.	3MS (Modified MMSE)	3MS <80 – 25 (40%)	30mins after start of dialysis
Harciarek, M., 2012 Poland [21]	HD Controls	49 30	47.9±12.01 47.23±10.21	27/22 22/8	Excluded.	Excluded.	Excluded.	Excluded.	MMSE	*MMSE HD* Baseline 28.57±0.98 1st follow up- 28.59±0.99 2nd follow up- 28.56±0.96	24 hours after the last dialysis
Huang, Y.C., 2008 Taiwan [22]	HD	147	Group I- 68±8.46 Group II- 57.51±12.64	61/86	Not reported.				MMSE	MMSE scores not reported.	Shortly before dialysis session
Isshiki, R., 2014 Japan [23]	PD Controls	18 60	67.5±6.9 71.5±8.3	12/6 28/32	Not reported.	Excluded.	Not reported.	Not reported.	MMSE	MMSE 27 or more- 14 (78%) 24-26- 3 (17%) 25 or less- 1 (5%)	Not applicable.
Jung, S., 2013 South Korea [24]	HD PD Controls	29 27 12	55.8±8.7 52.4±11.6 44.7±10.7	13/16 14/13 11/1	Excluded.	Not reported.	Excluded.	Not reported.	MMSE	*MMSE <24-* HD – 7 (24.1%) PD – 3 (11.1%)	Off dialysis, minimum 1 hour from last dialysis treatment
Kalaitzidis, R.G., 2013 Greece [25]	HBP CKD stage I, II	96** 160**	53±1.51 50.2±11.8	62/35** 15/4**	Not reported.	Excluded.	Excluded.	Not reported.	MMSE	Not reported	On HD ptients before dialysis session middle of the week

	CKD stage III		63.1±9.4	20/9**							
	CKD stage IV		64.1±12.2	33/14**							
	HD		60.4±13.8	17/14**							
	PD		58.6±15.7	20/13**							
Kalirao, P., 2011 USA [26]	PD	51	57.5±14.8	34/17	Not excluded.	Not excluded.	Excluded.	Excluded.	3MS (Modified MMSE)	*3MS raw scores* PD - Range 93 to 100, SD 6.7 HD - Range 83 to 100, SD 8.6 Controls - Range 94.3 to 100, SD 5.7	During off-dialysis time, with an interval of at least 2 hours from the time of last dialysis
	HD	338	71.2±9.5	183/155							
	Controls	101	68.5±9.6	44/57							
Kang, E.W., 2012 USA [27]	HD	70	52.6±14.6	110/59	Excluded.	Excluded.	Excluded.	Not reported.	3MS (Modified MMSE)	*3MS* Total 91.7±7.4 SDB 90.5±7.9 Non-SDB 92.8±6.8	HD - morning of a non-dialysis day at home
	PD	17									
	CKD	82									
Kato, M., 2012 Japan [28]	HD	57	69.4±3.8	29/28	Not reported.				MMSE	HD - 27.4±2.4 CKD - 25.8±2.4 Controls - 28±2	Not reported
	CKD	26	66.6±14.7	18/8							
	Controls	17	66.6±4.1	5/12							
Kitaguchi, N., 2011 Japan [29]	HD	37	68.9±4.1	16/21	Not reported.				MMSE	MMSE 27.1±2.4	Not reported

Author, Publication Year, Country of Study	Study Groups	Sample			Exclusion Criteria of Interest				Screening Tools	Prevalence based on Screening Test	Assessment Timing
		Size	Age (years)	Gender (M/F)	Advanced Dementia	Cerebrovascular Disease	Psychiatric Disease	Lack of Language Fluency			
Kobayashi, S., 2014 Japan [30]	HD	54	67.8±11.3	33/21	Not reported.	Excluded.	Not reported.	Not reported.	MMSE	MMSE 28 or more- 34(63%), MMSE 25-27-13 (24%) MMSE 24 or less- 7(13%)	Not reported
Kutlay, S., 2001 Turkey [31]	HD	84	Mean- 42	47/37	Not reported.	Not excluded.	Not excluded.	Not reported.	MMSE	Mild impairment (MMSE 18-23)- 18 (21%) Mod-severe (MMSE <18)- 9 (11%)	At various times - before, during, after and at intervals. Immediate beginning and termination of dialysis avoided
Leinau, L., 2009 USA [32]	HD	109	61±10	71/38	Not excluded.	Not reported.	Not reported.	Excluded.	MMSE	Cognitive impairment reported to be present in 41(38%). Break-up of the scores are not provided.	Mid-week, after the dialysis treatment was underway
Li, C., 2014 China [33]	HD Controls	20 20	37.1±8.6 38.3±6.5	15/5 15/5	Not reported.	Excluded.	Excluded.	Not reported.	MMSE	MMSE scores were normal in all the patients.	Not reported.
Lux, S., 2010 Germany [34]	HD Controls	12 12	45±11.5 44.7±10	11/1 11/1	Not reported.	Excluded.	Excluded.	Not reported.	MMSE	*MMSE* HD - 29.1± 1 Controls- 29.5 ± 0.9	End of their long dialysis interval for HD patients
Martins, C.T., 2011 Brazil [35]	HD	86	<35 years - 11 35-60 years- 47 >60 years - 28	41/45	Not reported.				3MS (Modified MMSE)	3MS less than average in 45 (52% of total) <35 years- 3 (26%) 35-60 years- 22 (47%) >60 years- 20 (71%)	First hour of HD
Murray, A.M., 2006 USA [36]	Whole HD cohort Random HD sample Controls	338 101 101	71.2±9.5 70.4±9.4 68.5±9.6	183/155 57/44 45/56	Not reported.	Not reported.	Not reported.	Excluded.	3MS (Modified MMSE)	3MS (338 Patients) 88.3±8.6; <1.5 SD 59.5%, 1.5-1.99 SD- 27.5% >1.99 SD- 13%	One of three times - 1hr before, 1hr after, the day after last run
Murray, A.M., 2007 USA [37]	HD	28	66.7±9.5	10/18	Excluded.	Not excluded.	Excluded.	Excluded.	MMSE	*MMSE- Mean (SE)* T1 26.6(0.51) T2 26.5(0.51), T3 27.1(0.50), T4 27.6(0.51)	1hr before, 45-90min into the session, 1hr after, 24-30hr after
Nasser, M. E.T., 2012 Egypt [38]	CKD HD AKI	50 50 20	Median 45 (range 22 to 60) with no	Patients with kidney	Not reported.	Excluded.	Excluded.	Not reported.	MMSE	HD - MMSE 26.5±1.5	Not reported

	Controls	20	significant difference between groups	disease-64/56							
Odagiri, G., 2011 Japan [39]	HD	154	65.1±13.3	88/66	Not reported.	Not excluded.	Not reported.	Not reported.	MMSE	*MMSE <24* HD 18.8% Controls 6%	Not reported
	Controls	852	57.8±12.2	314/38							
Pipkin, M., 2010 [40]	HD Group I	54	54±14	34/20	Not reported.	Not reported	Not reported.	Excluded.	3MS (Modified MMSE)	3MS scores are not reported.	Not reported
	HD Group II	33	50.9±13	23/10							

Author, Publication Year, Country of Study	Study Groups	Sample			Exclusion Criteria of Interest				Screening Tools	Prevalence based on Screening Test	Assessment Timing
		Size	Age (years)	Gender (M/F)	Advanced Dementia	Cerebrovascular Disease	Psychiatric Disease	Lack of Language Fluency			
Post, J.B., 2012, USA [410	HD Controls	50 26	63±10 64±10	All male patients in both HD and Controls	Excluded.	Excluded.		Excluded.	MMSE	All subjects scored 26 or more on MMSE.	Non dialysis day except for 4
Sarnak, M.J., 2013 USA [42]	HD	314	63±16	168/146	Excluded.	Not excluded.	Not reported.	Excluded.	MMSE	MMSE <24- 78 (22%) during the selection process.	First hour of HD
Sithinamsuwan, P., 2005 Thailand [43]	HD PD	60 30	53.67±15.84 55.67±14.18	33/27 21/9	Not reported.	Not reported.	Depression not excluded.	Not reported.	MMSE	*MMSE <24;* HD - 5(8.3%) PD - 1(3.3%)	Not reported
Soykan, A., 2005 Turkey [44]	HD	43	41.53±11.48	25/18	Not reported.	Not reported.	Excluded.	Not reported.	MMSE	Not reported	Not reported
Soysal, P., 2014 Turkey [45]	Group I Group II Group III	121 188 270	73.1±7.1 72.2±8.1 72.7±8.3	68/53 76/112 106/164	Not excluded.	Excluded.	Excluded.	Not reported.	MMSE	Only mean values provided. Significantly lower than the control group.	After mid-week HD session
Tamura, M.K., 2010 USA [46]	HD	383	51.6±13.3	238/145	Not reported.	Not excluded.	Depression not excluded.	Excluded.	3MS (Modified MMSE)	Median 3MS score- 90 (IQR 83-94) 3MS score <80- 61 (16%) [74 (19%) had isolated impairment in executive function on Trails B]	Mid-week predialysis or non-dialysis day
Tamura, M.K., 2012 USA [47]	Group I Group II	80 46	55±15 55±14	50/30 34/12	Excluded.	Not excluded.	Excluded.	Excluded.	3MS (Modified MMSE)	*3MS Score* Group I - 89.7±7.7 Group II - 2.2±1.5 (multivariable adjusted)	In a quiet room prior to mid-week dialysis session
Tholen, S., 2014 Germany [48]	HD	26	65.81±16.11	17/9	Not reported.	Excluded.	Not reported.	Not reported.	MMSE & MoCA	Only mean values provided. MoCA scores best before HD in a single/separate room.	MoCA before HD group/separate room, 2 hours in to HD, after HD group/separate room. MMSE during HD.
Tiffin-Richards, F.E., 2014 Germany [49]	HD Controls	43 42	58.3±13.9 57.9±11.8	25/18 20/22	Not reported.	Excluded.	Excluded.	Not reported.	MMSE & MoCA	MoCA (24 or less) - 59% (26), MMSE - 46.3% (19)	Non-dialysis day
Tilki, H.E., 2004 Turkey [50]	HD PD Controls	25 17 25	37.3±2.7 44.2±3.9 41.2±3.5	13/12 7/10 14/11	Not reported.				MMSE	*MMSE scores* Controls - 30±0.2 PD - 29±0.3 Pre-HD - 26±1.5 Post-HD 28±0.3	Two hours before and after a standard HD session

Tyrrell, J., 2005 France [51]	HD	25	Not reported	35/16	Not reported.	Not reported.	Depression not excluded.	Excluded.	MMSE & BEC 96	Median (Range) MMSE- 24 (16-28), CI 24 (47%) Median (Range) BEC 96- 82 (56-94) CI 15 (29.4%) Both normal- 25 (49%) Both abnormal-12 (24%), Abnormal MMSE only- 12 (24%) Abnormal BEC 96 only- 2 (4%)	During individual appointment with psychologist
	PD	26									
Author, Publication Year, Country of Study	**Study Groups**		**Sample**		**Exclusion Criteria of Interest**				**Screening Tools**	**Prevalence based on Screening Test**	**Assessment Timing**
van Doorn, J.K., 2004 Belgium [52]	HD	70	Range 19-92 Median 70.5 Mean 67.9	Predominantly female.	Not reported.				MMSE	MMSE <23 - 17(22%)	Not reported
Wolfgram, D.F., 2014 USA [53]	HD	38	65.9±9	33/5	Excluded.	Excluded.	Not reported.	Not reported.	MoCA	59% had 2SD below mean.	Following dialysis (92%), before dialysis or off days (8%)
Yavuz, N., 2000 Turkey [54]	HD	112	Mean 39.89 (range 19-75)	63/49	Not reported.				3MS (Modified MMSE)	Only 102 to had 3MS test. Article reports Max score as 26 as opposed to 100 in other articles. Score Min 2 Max 26 Mean 14.03 SD 5.97.	Not reported
Zhang, R., 2015 China [55]	HD	26	34.6±7.3	12/14	Not reported.	Excluded.	Excluded.	Not reported.	MMSE	MMSE scores significantly lower in HD patients compared to controls.	Not reported
	Controls	28	33.7±12.5	13/15							

CKD = Chronic Kidney Disease; HD = haemodialysis; PD = peritoneal dialysis; HBP = high blood pressure; MMSE = Mini-mental Status Examination; MoCA = Montreal Cognitive Assessment; BEC 96 = La Batterie d'Évaluation Cognitive; SDB = Sleep Disordered Breathing

Age and cognitive test scores in the format = mean ± SD where not otherwise specified.

Prevalence in the format = number (%)

* A substudy of the Cognition and Dialysis Study of Sarnak, M.J., 2013, USA

** Discrepancies noted between total number of participants and gender-specific breakdown.