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Observational Study

Prevalence of Cognitive Impairment in Dialysis Patients in Gauteng Province, South Africa

Tebogo Ndhlovu[1,3*], Lisa Repsold[1], Kwazi Ndlovu[2] and Albert Muranda[3]

[1]Department of Biomedical Sciences, Tshwane University of Technology, Pretoria, South Africa

[2]Department of Nephrology, Groote Schuur Hospital & University of Cape Town, Cape Town, South Africa

[3]Department of Nephrology, Steve Biko Academic Hospital & University of Pretoria, Pretoria, South Africa

More Information

***Address for correspondence:** T Ndhlovu, Department of Biomedical Sciences, Tshwane University of Technology, Pretoria, South Africa, Email: NdhlovuT@tut.ac.za

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Keywords: Chronic Kidney Disease, cognitive impairment, haemodialysis, peritoneal dialysis

Abbreviations: CI: Cognitive Impairment; CKD: Chronic Kidney Disease; ESRD; End Stage Renal Disease; eGFR: Estimated Glomerular Filtration Rate; HD: Haemodialysis; MMSE: Mini Mental State Examination; PD: Peritoneal Dialysis

Abstract

Introduction: Cognitive impairment is defined as a new deficit in at least two areas of cognitive functioning. These may include disturbances in memory, executive functioning, attention or speed of information processing, perceptual motor abilities, or language. It has been shown that cognitive impairment is associated with the severity of kidney disease.

Methods: The study was a descriptive research design, with participants purposively sampled from the general chronic kidney disease population which included haemodialysis and peritoneal dialysis patients at Steve Biko Academic Hospital in Pretoria, Gauteng Province, South Africa. Hundred and fifty-one participants (76 hemodialysis & 75 peritoneal dialysis patients), 58% were males, and 42% were females aged 19-61 years. To establish the prevalence of cognitive impairment by testing the level of cognition the Mini-Mental State Examination was utilized to provide a brief screening test to quantitatively assess the cognitive abilities and cognitive changes of patients while on dialysis.

Results: Ninety-nine percent (99%) of the recruited population reported no cognitive impairment, irrespective of dialysis modality, demographic characteristics, and socio-economic status.

Conclusion: Despite the findings highlighting that the majority of the chronic kidney disease population at Steve Biko Academic Hospital reported no cognitive impairment, it is crucial to increase awareness of the potential effects of cognitive impairment on daily activities, quality of life, and treatment adherence. Early detection and management of cognitive impairment can significantly impact the quality of life and adherence to treatment among these patients. Further research is needed to understand the prevalence and impact of cognitive impairment in different populations and to develop effective interventions for its prevention and management.

Introduction and background

Cognitive impairment is a major cause of morbidity in patients with chronic kidney disease (CKD) and is associated with poor survival. Patients with CKD make day-to-day decisions about how to self-manage their condition. Having CKD in the early stages includes a risk for progression towards end-stage renal disease (ESRD) and the development of comorbidities, such as cardiovascular disease, which represents the leading cause of death in this population [1,2].

Due to recent socioeconomic developments and lifestyle changes, ESRD has shown a rapid growth trend worldwide and has become a public health issue of global concern [3]. The estimated incidence of ESRD is currently 373.4 per million per year and is associated with a heavy economic burden on patients and the healthcare systems [3]

The main causes of ESRD include renal damage caused by glomerulonephritis, diabetes nephropathy, hypertensive arteriole sclerosis, and polycystic kidney disease [4,5]. ESRD patients are presenting with almost complete and irreversible renal function loss [5]. Hemodialysis (HD) and peritoneal dialysis (PD) are the most commonly used methods in treating patients with ESRD [6]. These methods are associated with various complications that may affect both the treatment and the prognosis.

CKD is an independent risk factor for cognitive impairment and dementia [7]. Cognitive impairment may impact decision-making in the CKD population as well as the ability to adhere to dialysis recommendations, such as fluid restriction, medication, and dietary modifications. Muranda et al. (2021) previously showed a low 30% adherence rate in our chronic dialysis program at Steve Biko Academic Hospital, Pretoria, Gauteng, South Africa [8].

Although a considerable number of articles on chronic kidney disease have been published, there are a limited number of studies comparing cognitive function in HD and PD patients. Some data suggest that the prevalence of cognitive impairment may be different in patients treated with HD compared with patients treated with PD [9].

Heterogeneity between studies was high, and age and sex were significant contributors. Six cross-sectional and six longitudinal studies were included in their meta-analysis. While there were few included studies, there was no evidence of publication bias, and their data suggest that a lower estimated glomerular filtration rate (eGFR), an indicator of kidney disease severity, may be associated with a greater incidence of cognitive impairment [10]. A study by Madero *et al.*(2008) reported the prevalence of cognitive impairment in individuals with kidney failure around 30 to 60% [11].

The economic burden of mild cognitive impairment and CKD-related cognitive changes is poorly understood, and the cost of dementia has been studied in detail. Lower neuropsychological test scores are associated with increased social and financial costs, including caregiver burden [10,12,13]. In clinical practice, screening for or monitoring cognitive impairment relies on the use of cognitive tests. For many clinicians, ease of use and quick administration of cognitive tests may be particularly important. Brief cognitive screening tests, such as the Mini-Mental State Examination (MMSE), have been popular as a result [14].

However, general screening tools may not differentiate specific aspects of cognition that are most affected. Cognition is classified into several discrete domains, encompassing such diverse processes as visio-spatial perception, auditory memory, visual memory, attention span, motor function, and mathematical reasoning. The pattern of cognitive impairment in CKD is not clear. With dialysis, CKD-related cognitive impairment is at least partially reversible (with the domains of orientation & attention, and memory showing significant improvement), and all domains show improvement with renal transplantation [15,16].

Methods

The study took place at the Dialysis Unit at Steve Biko Academic Hospital, Pretoria, Gauteng, South Africa. Participants were purposively sampled from this study area utilizing a cohort descriptive research design. All patients at the dialysis unit were eligible to participate in the study (Figure 1) The participants were recruited on the basis of willingness to participate in the study, having been on dialysis for at least three months, receiving haemodialysis three times a week and those on peritoneal dialysis doing regular exchanges as per recommendations.

Methods, techniques, and/or strategies used to gather the data and the materials were through the MMSE questionnaire, which was administered during participants' 4-hour dialysis session in the dialysis unit and therefore collected by the researcher after completion.

The study took place from January 2023 to September 2023. The researcher was available to assist all participants requiring help with completing the questionnaires.

Assessment of mini mental state examination tool

The MMSE is a quick and easy measure that assesses seven areas of cognitive functioning, and it was shown to have both good test-retest reliability (0.80–0.95) and acceptable sensitivity and specificity to detect mild to moderate stages of dementia [17-22].

The mini-mental state examination as shown in Table 1 is a widely used, well-validated screening tool for cognitive impairment [23]. It tests six areas of cognitive function. The first area of cognitive function, orientation, is assessed by asking the usual questions about time, day, date, and location.

The second area of cognitive function, registration, is actually a short-term memory test where the subject must recall three objects named by the examiner. The third and fourth areas, attention and calculation, are measured by having the subject begin with 100 and counting backwards by 7 (serial 7's).

In recall, the subject must recall the three objects named previously. Language functions are assessed by having the subject name simple objects, repeat a sentence, and

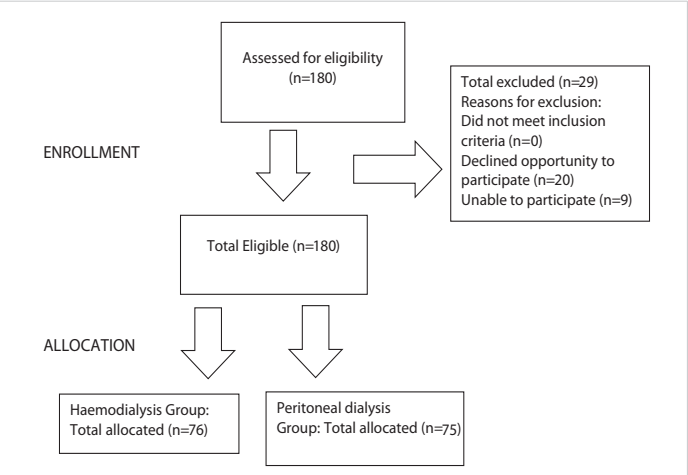

Figure 1: Methodology flow diagram.

Table 1: Items on the Mini Mental State Examination [23].

Items	Maximum Score
Orientation What is the year, season, date, day, month? Where are we (province) (country) (town) (hospital) (floor)?	 5 5
Registration Name 3 objects: (1 second to say each). Ask the patient for all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until the patient learns all three. Count the trials and record.	3
Attention and calculation Serial subtraction of 7. 1 point for each correct. Stop after 5 answers. Alternatively spell —World‖ backwards.	5
Recall Ask for 3 objects repeated above. 1 point for each correct answer.	3
Language Name a pencil; name a watch Repeat the following —No ifs, ands, or buts. Follow a three-stage command -Take a paper in your right hand, fold it in half, and put it on the floor. Read and obey the following - Close your eyes. Write a sentence.	 2 1 3 1 1
Copy a design.	1

follow a three-stage command. A constructional task is also included in the language section where the subject must copy overlapping pentagons. Each discrete subtask completed correctly earns 1 point toward a maximum score of 30.

The researcher had a face-to-face interview with each participant during a 4-hour dialysis session which took 10-15 minutes to complete. The purpose of the interview was a requirement as per the research instrument because the researcher had to ask the participants oral questions as contained in the MMSE.

Participants

All patients with chronic kidney disease on dialysis who met the inclusion criteria were eligible to participate in the study. The researcher recruited one hundred and fifty-one (n = 151) haemodialysis (HD) and peritoneal dialysis (PD) patients (males and females of the ages of 18 and above). A minimum of 151 patients (Figure 1) was recommended and was adequate taking into consideration the total population of dialysis patients at the Steve Biko Academic Hospital.

The sample size of 151 participants for this study, which included both hemodialysis and peritoneal dialysis patients, appeared relatively small compared to larger epidemiological studies. However, the current study employed a descriptive research design and used purposive sampling to target the specific population of all chronic kidney disease patients undergoing dialysis at Steve Biko Academic Hospital in South Africa.

In this context, the smaller sample size may have been considered adequate for the research objectives, as purposive sampling helps to ensure that the chosen sample met the specific criteria that were relevant to the research questions. In this study, the focus on cognitive impairment and its association with the severity of kidney disease justified the targeted sampling of dialysis patients.

Given the nature of the study and the setting (Steve Biko Academic Hospital), logistical factors such as time, funding, and human resources may have limited the feasibility of recruiting a larger sample size. A purposive sampling approach yielded adequate insights. As this study assessed cognitive impairment in CKD patients, the initial research served as a preliminary investigation to establish foundational data. The small sample size may be justified as a stepping stone for future, larger-scale studies that could build off of the findings for more comprehensive investigations.

The following criteria were employed: Inclusion criteria: (1) Diagnosis of chronic kidney disease; (2) Currently undergoing dialysis (either hemodialysis or peritoneal dialysis). Exclusion criteria: (1) Individuals with pre-existing neurological or psychiatric conditions were excluded so that the study would allow for a clearer assessment of cognitive impairment specifically attributable to kidney disease. This was crucial in establishing a direct link between CKD and cognitive changes.

Given the urban setting of the study within the chronic kidney disease population in Steve Biko Academic Hospital in Pretoria, Gauteng Province, the study focused on patients in Pretoria. As Pretoria is predominantly an urban area, no rural patients were included in the study. The dialysis centre caters to patients from the surrounding geographical area.

A hypothetical comparison between urban versus rural patients in this context would be as follows: Urban patients often have better access to healthcare facilities, continuous monitoring, and a wider range of healthcare services. This accessibility could lead to more regular screening for cognitive impairment. Urban living may also involve greater exposure to stressors, such as higher living costs, noise, and pollution, which can potentially exacerbate cognitive decline. Rural patients often face geographic barriers to healthcare access, which can result in less frequent monitoring and delayed diagnosis. This can lead to a higher risk of undiagnosed cognitive impairment. Limited healthcare facilities can affect the timely access to dialysis and other treatment options, thus potentially worsening kidney disease and related cognitive outcomes.

Urban patients may have a more diverse social network and support due to higher population density. However, they may also experience feelings of isolation despite being surrounded by many people, which can affect mental health and cognitive functioning. Rural communities may foster stronger social ties and networks, leading to enhanced support systems. This close-knit environment may contribute to better management of chronic conditions, including mental health and cognitive health. Conversely, these communities might have less access to cognitive health resources or educational programs.

Generally, urban populations tend to have higher levels of education and greater access to information about health, possibly influencing their cognitive health positively. Rural populations may have varying levels of education, with some residents lacking access to higher education opportunities. This may impact health literacy and awareness of cognitive health issues.

Ethical considerations

The study commenced after obtaining the consent of the Tshwane University of Technology Faculty Committee for Research Ethics (Ref: FCRE 2022/11/010 (SCI) (FCPS 02)) and the written permission of the University of Pretoria and Steve Biko Academic Hospital (Ref: GP- 202211-075) where the study was conducted. Informed consent of the HD and PD-treated participants making up the study group was obtained after the aim of the study and the fact that participation was voluntary was explained. The study posed no harm to the participants' health. The study had a basic language of understanding. No financial, rewards, incentives, or compensation were offered. The study posed no discrimination pertaining to level of education, gender, race, etc.

All or most patients were English literate and the researcher assisted those participants who required assistance to complete the questionnaire. Participants had the right not to participate in the study. Participants had the right to withdraw from the study at any stage without it affecting their continued care with the medical team. The study exercised confidentiality and anonymity throughout.

Data analysis

A Statistical Analyst from the Directorate of Research and Innovation, Tshwane University of Technology was consulted for sample size and data analysis determination. Descriptive statistics including means and corresponding standard deviations for normal data are given. Alternatively, medians and interquartile range will be reported for non-normal data. Nominal data was described using frequencies and associated percentages. The proportion with their corresponding 95% confidence intervals was undertaken to determine the treatment adherence level and cognition. All statistics will be evaluated at a 5% level of significance.

Results

Table 2 shows the gender distribution of both the HD and PD groups combined, predominantly 87 patients (58%) were males and 64 patients (42%) were females. Participants were aged between 19 and 61 years with a mean age of 37.69 years (±10.56).

The common reported etiology in the medical history of participating subjects was hypertension (43%), polycystic kidney disease (20%), systemic diseases (14%), glomerular diseases (11%), unknown (7%), and diabetic nephropathy (5%). The majority of participants (66%) were found to be on dialysis for at least two years and the longest-treated participant (1%) was on dialysis for 14 years. The majority of participants (96%) graduated high school and only 1% attended university. One hundred and forty-nine (99%) participants reported to be unemployed, while 146 (97%) were single and all (100%) were living with family.

Table 2: Patient characteristics – Demographics.

Characteristics	Number of observations (n)	Characteristics	Number of observations (n)
Gender		**Dialysis Modality**	
Females	64	Haemodialysis	76
Male	87	Peritoneal Dialysis	75
Education Background		**Aetiology of Kidney Disease**	
No school	1	Glomerular Diseases	17
Primary school	2	Hypertensive Kidney Diseases	65
High School	146	Idiopathic	10
Tertiary	2	Polycystic Kidney Diseases and Systemic Diseases	51
Spoken Dialect		**Dialysis Vintage(Years)**	
Afrikaans	14	1	10
English	11	2	100
Ndebele	17	3	36
Sepedi	23	4	3
Sesotho	16	5	1
Setswana	13	14	1
Swati	2		
Xhosa	5		
Xitsonga	3		
Zulu	47		
Employment Status		**Living Arrangements**	
Unemployed	149	Living with family	151
Employed	2		
Marital Status		**Age**	151
Single	146	19-30	30
Married	5	31-40	42
		41-50	41
		51-61	38
		Mean age 37.69 years (±10.56).	

Participants within the study area were found to speak 10 South African official languages with a majority representation of Zulu at 31%, Sepedi (15%), Ndebele (11%), Sesotho (11%), Setswana (9%), Afrikaans (9%), English (7%), Xhosa (3%), Xitsonga (2%) and Swati (1%). The majority of participants were English literate.

According to the MMSE total scores obtained from the population shown in Table 3 for the 151 individuals recruited to participate in the study, cognitive impairment was categorized /classified and distributed as follows: 150 participants were found to have no cognitive impairment (MMSE score; 24-30); mild cognitive impairment was found in 1 participant (MMSE score; 18-23); and severe cognitive impairment was not applicable to the study population (MMSE score; 0-17). Utilizing the summary statistic for numeric data, the reported mean MMSE score for the entire group was 27.1 (±1.65), with a minimum score of 22 and a maximum score of 30, respectively.

Table 3 further depicts the number (%) of subjects with correct answers on each MMSE subtest. In the orientation dimension, a hundred and two participants (67.6%) demonstrated to be fully orientated and 3 participants (2%) obtained lower scores, scoring six out of ten. More than half of the population scored full points in the registration (65%), attention & calculation (56.95%), recall (64%), and language (52%) components. Disorientation in temporal and spatial orientation demonstrated challenges with calculation in serial 7 subtractions, which appear to serve as a marker for problems with attention/ concentration. These results suggested that there were different impairment features in the cognitive profiles of patients. In the sixth dimension of the instrument, copying of the design (copy a pair of intersecting pentagons), 143 participants (94.7%) scored full marks and 8 participants (5.3%) answered incorrectly or couldn't remember the design.

Table 3: MMSE frequencies with the percentage of all the categorical data.

Demographics					
Employment Status	**Frequency**	**Percentage**		**Cumulative**	
Employed	2	1.32		1.32	
Unemployed	149	98.68		100	
Marital Status					
Married	5	3.31		3.31	
Single	146	96.69		100	
Components of MMSE					
Orientation (Total points=10)					
6	3	1.99		1.99	
7	9	5.96		7.95	
8	19	12.58		20.53	
9	18	11.92		32.45	
10	102	67.55		100	
Total	151	100			
Registration (Total points =3)					
0	1	0.66		0.66	
1	8	5.30		5.96	
2	44	29.14		35.10	
3	98	64.90		100	
Total	151	100			
Attention & Calculation (Total points =5)					
2	3	1.99		1.99	
3	24	15.89		17.88	
4	38	25.17		43.05	
5	86	56.95		100	
Total	151	100			
Recall (Total points = 3					
0	2	1.32		1.32	
1	6	3.97		5.30	
2	46	30.46		35.76	
3	97	64.24		100	
Total	151	100			
Language (Total points = 8)					
4	1	0.66		0.66	
5	7	4.64		5.30	
6	20	13.25		18.54	
7	44	29.14		47.68	
8	79	52.32		100	
Total	151	100			
Copying					
0	8	5.30		5.30	
1	143	94.70		100	
Total	151	100			
MMSE Grouping					
Mild cognitive impairment	1	0.66		0.66	
No cognitive impairment	150	99.34		100	
Total	151	100			
SUM of MMSE Scoring	Total Score	Minimum Observation	Maximum Observation	Mean	Standard deviation
	30	22	30	27.1	1.65

Discussion

The demographic characteristics of study participants played a significant role in understanding the generalizability and applicability of study research findings. These characteristics provided insights into the representativeness of the sample. Potential biases and the context within which the study was conducted were also considered. Understanding the demographic characteristics of dialysis patients is crucial. Healthcare providers need this information to develop appropriate interventions. It also aids in improving patient outcomes.

South Africa is a linguistically diverse country, with 11 official languages. Within this study area, participants were found to speak 10 of these languages, with the most common being Zulu (31%), Sepedi (15%), Ndebele (11%), Sesotho (11%), and Setswana (9%). English was also widely represented (7%) and remained the majority language in written communication, reflecting the importance of English literacy for access to healthcare information and services.

The present study finding was consistent with a study done by Andrews *et al.*(2015) This revealed the importance of cultural competence in patient care. Patients may prefer to communicate in their native language. Language barriers may impact the quality of care received [24].

Cognitive impairment is a significant public health issue that can affect individuals of all ages, although it is more prevalent in the elderly population. The early detection of cognitive impairment is crucial in managing and slowing down the progression of the condition. The Mini-Mental State Examination (MMSE) scale is a widely used and validated tool that assesses various aspects of cognitive functioning. The current investigation aimed to establish the prevalence of cognitive impairment in the study population using the MMSE (Table 1).

The current document findings demonstrated a high level of cognitive functioning among the participants, with only one participant falling in the mild cognitive impairment range. Analysis of the MMSE subtest results reveals varying levels of impairment in different cognitive domains, highlighting the heterogeneity in cognitive profiles among the individuals

(Table 3). The majority of participants in the present investigation population (99.3%) exhibited no cognitive impairment, indicating a relatively low prevalence of severe cognitive deficits (Table 3). The reported mean MMSE score for the entire group was 27.1 (±1.65), with a minimum score of 22 and a maximum score of 30, respectively (*Table* 3). The finding confirmed that most participants had no cognitive impairment, and, when impairments did occur, they tended to be minor.

The causal relationships between hypertension, CKD, and dementia are particularly complex as hypertension could be potentially both a confounder and mediator in the relationship between CKD and dementia.

Many observational studies report hypertension to be an important risk factor for dementia [25,26,27], and in a recent meta-analysis of randomized clinical trials, blood pressure lowering with antihypertensive agents compared with controls was significantly associated with a lower risk of incidental dementia or cognitive impairment [28]. The relationship between hypertension and cognitive decline may be mediated through cerebrovascular disease or via augmentation of neurodegenerative mechanisms [29,30].

Stroke is associated with an increased risk of subsequent dementia. In a large meta-analysis of symptomatic stroke patients, 10% of patients had dementia before their first stroke, 10% developed new dementia soon after their first stroke, and more than a third had dementia after recurrent stroke [31].

There are also strong associations reported between CKD and cerebrovascular disease [32]. Meta-analyses of cohort studies and trials indicate that reduced GFR is associated with a 40% greater risk of stroke and that proteinuria is associated with a 70% greater risk, even after adjusting for traditional cardiovascular risk factors [33]. In terms of potential mechanisms, there is a high prevalence of shared vascular risk factors including hypertension, diabetes mellitus, and atrial fibrillation but "non-traditional" risk factors such as anemia, hyperuricemia, and mineral-bone disorders may also play a role [34]. Importantly, several of the predictors of post-stroke dementia [31] are common in the CKD population including older age [35], low educational attainment [36], premorbid disability [37], and vascular risk factors such as diabetes mellitus and atrial fibrillation [38]. In addition, CKD is associated with several stroke-specific factors [31], that are predictive of post-stroke dementia including higher stroke severity and greater risk of recurrence [39].

Cerebral small vessel disease is a major etiologic factor in dementia [40]. This may relate to a reduction in cerebral blood flow [41], and impaired cerebral autoregulation [42]. Small vessel disease and Alzheimer's Disease pathology are thought to interact in important ways [43]. Chronic cerebral inflammation due to vascular risk factors exposure and genetic modulators (Apolipoprotein E4) may lead to increased antibody production while chronic small vein disease (arteriosclerosis, cerebral amyloid angiopathy) and vascular inflammation may drive perivascular and cell-mediated antibody clearance [44].

A recent meta-analysis of over 2 million participants showed that individuals with type 2 diabetes mellitus are at 60% greater risk for the development of dementia compared with those without diabetes [45]. Those with a younger age of diabetes onset and cardiovascular comorbidity are particularly at risk [46]. Several mechanisms for the link between diabetes and dementia have been proposed including brain metabolic dysfunction as a driver for Alzheimer's Disease pathology [47], with impairments in insulin transport through the blood-brain barrier, insulin signaling, and resultant decreased cerebral glucose utilization [48]. In addition, hyperglycemia may lead to neurotoxicity, vascular injury, and accumulation of advanced glycation end products [49]. Nearly one-third of CKD is attributable to diabetic nephropathy [50], and even patients with mild to moderate stages of diabetic kidney disease have been found to have occult neurocognitive disorders [51], highlighting the role of diabetes as a potential confounding factor in this pathway.

Increasing evidence suggests that obesity, highly prevalent in the CKD population [52], and estimated to account for 20– 25% of kidney disease worldwide [53], is also an independent risk factor for dementia. Similar to diabetes though, excess adiposity is linked with a change in brain energy metabolism, the accumulation of brain lesions, and brain volume loss leading to neurodegeneration [54].

Sleep disorders are also highly linked to cognitive impairment and dementia and are often representative of underlying brain pathology [55]. The glymphatic system is responsible for clearance of ˜60% of b-amyloid clearance and since this occurs primarily during sleep [56], which is altered during CKD, it has been proposed that glymphatic fluid transport may be suppressed in CKD, leading to an accumulation of potentially neurotoxic waste products [57].

The accumulation of uraemic toxins is proposed to cause cerebral endothelial dysfunction and contribute to cognitive disorders in CKD [58]. High uraemic toxin concentrations of guanidine compounds such as creatinine, guanidine, guanidinosuccinic acid, and methylguanidine have been found in CKD patients in strategic brain regions responsible for cognition, such as the thalamus, mammillary bodies, and cerebral cortex [59].

Inflammation has also been suggested as a mediator of cognitive decline in CKD [60]. The intensity of systemic inflammation, as indicated by elevations in multiple markers of inflammation, including interleukin-1b, interleukin-6,

tumor necrosis factor-a, and C-reactive protein, appears to increase as kidney function declines [61].

A published meta-analysis of 42 studies covering 3,522 participants found that people treated with haemodialysis had poorer cognition, particularly in attention/processing speed and memory than the general population [62]. In the current evaluation, the impairments in memory and language domains tended to be less alarming. A postulation explaining why no cognitive impairment was detected in the population, might be attributed to the fact that the population in the present study was younger with a mean age of 37.69 years (±10.56) as compared to the data in the literature around the world.

The scattered profile of cognitive performance across the different domains emphasized the need to assess various cognitive domains in determining cognitive function, as impairments can manifest differently in individuals. Utilizing the MMSE as a standardized screening tool allows healthcare professionals to monitor cognitive function over time and provide timely interventions, as needed.

In terms of variation in cognitive impairment, 98.7% of HD patients showed no cognitive impairment compared to 100% of PD patients. Only 1.3% of HD patients and 0% of PD patients showed cognitive impairment. The *p*-value of 0.994 for HD patients and 1.000 for PD patients indicates no statistically significant difference in MMSE scores between the two groups (Table 4).

The total median MMSE score is 27 with an interquartile range of 26-29. A total of 99.3% of patients showed no cognitive impairment, while only 0.7% showed some degree of cognitive impairment. Despite slight variations, the MMSE scores and the prevalence of cognitive impairment are not statistically different between PD and HD patients (*Table 4*). However, the complete absence of cognitive impairment amongst the entire PD patient population of this study highlights the fact that peritoneal dialysis may have certain protective factors against cognitive decline when compared to haemodialysis.

The current study provides valuable insights into the prevalence of cognitive impairment and the distribution of cognitive functioning in various cognitive domains using the MMSE scale. The absence of CI in the present study population is a significant finding, particularly in light of the increasing prevalence of CI in the general population. The Mini-Mental State Examination scores obtained from the study population suggested that the majority of participants had no cognitive impairment, while a small number exhibited mild cognitive impairment. However, the subtest results revealed a wide range of cognitive difficulties, even among those with no cognitive impairment.

Table 4: Variation MMSE Scores between HD and PD patients.

Dialysis Type	MMSE Score (Median and IQR)	No Cognitive Impairment (n, %)	Cognitive Impairment (n, %)	*p* - value
Haemodialysis	27 (26-28)	75(98.7%)	1 (1.3%)	0.994
Peritoneal Dialysis	27 (26-29)	75 (100.0%)	0 (0.0%)	1.000
Total	27 (26-29)	150 (99.3%; 95.4%-99.9%)	1(0.7%;0.1%-4.6%)	-

Sarnak, et al., in 2013 evaluated the cognitive function of 314 haemodialysis patients from six Boston area haemodialysis units and found that the patients on dialysis had significantly poorer executive function, but not memory performance, compared to population norms [63]. This current study could be one of the largest to date to focus on the issue of cognitive impairment in adult dialysis patients in Gauteng province, South Africa.

Previous studies indicated that haemodialysis patients are at increased risk of cognitive impairment because of their older age, low level of education, and a high prevalence of cardiovascular risk factors [64]. However, the risk factors associated with cognitive impairment are not clear, especially concerning the role of some haemodialysis-related factors [65]. The mean age of the current study population was younger than other publications, this distribution of the population to a younger demographic could also impact the level of cognitive impairment found. Further, the current study results showed that age, comorbidities, and longer dialysis vintage were independent risk factors for both mild and severe cognitive impairment.

Disorientation in temporal and spatial orientation, as well as challenges with calculation in serial 7 subtractions, suggest potential problems with attention and concentration. However, nearly one-third of the population exhibited mild impairment in orientation dimensions, with challenges in serial 7 subtraction serving as a potential indicator of difficulties in sustained attention or mental concentration.

Apart from previously known associated factors, such as age, education level, and history of stroke and hypertension, the current study showed that some dialysis-related factors, such as dialysis vintage, were not correlated with cognitive impairment. In another study, evaluating cognitive function in 676 haemodialysis patients in Italy, cognitive impairment occurred in 70.1% of participants, and the co-occurrence patterns of impairment across domains were not similar to findings in the present study, with only 25.9% of participants impaired on a single cognitive domain [66]. The findings of our study were not consistent with previous studies by van Zwieten in 2018 that demonstrated a high prevalence of cognitive impairment in dialysis patients and the current study reported no cognitive impairment in 99% of the participants [66].

Among mature and older adult participants screened for cognitive impairment in a study conducted by Gela, et al. (2020), 43.8% were positive for cognitive impairment in Ethiopia (38.8–48.7%) [67], which was higher than the

studies performed in Cameroon (33.3%) [68], the Central Africa Republic (37.9%) [69], Nigeria (19.7%) [70], India (14%) [71], France (42%) [72], and the Republic of Congo (237.9) [69]. All the prior studies were not consistent with the current study's findings.

As expected, different factors are capable of predicting cognitive impairment. A study by Gela *et. al.* (2020), showed that aging was associated with cognitive decline [67] and was in line with studies conducted in Cameroon [68], Jamaica [73], and Ethiopia [74]. However, the current study's findings were not in line with the above-mentioned findings as we showed higher cognitive functioning, hypothesized to be associated with the mean younger age (37.69 years) of the research population.

Our results were not consistent with a previous study done by Miyazaki *et al.*(2023) showing a high prevalence of CI in HD patients ranging between 25% to 80% [75].

Limitations and future directions

While this study provides valuable insights into the prevalence of cognitive impairment among chronic kidney disease patients undergoing dialysis at Steve Biko Academic Hospital in Pretoria, Gauteng Province, South Africa, there are several limitations to consider.

Firstly, the use of the Mini-Mental State Examination as a screening tool for cognitive impairment may have limitations. Although the MMSE is widely used and well-established, it may not capture certain aspects of cognitive functioning, such as executive functioning or attention, and may not be sensitive to subtle changes in cognition. Additionally, the MMSE may be subject to cultural and educational biases, which could potentially impact the results in this population. Further studies may benefit from using a more comprehensive cognitive assessment battery, such as the Montreal Cognitive Assessment (MoCA) or a neuropsychological assessment, which would provide a more detailed evaluation of cognitive functioning.

Secondly, the sample size of 151 participants may not be representative of the entire chronic kidney disease population in South Africa or other regions. Future research may benefit from including a larger and more diverse sample, including patients from multiple centers or regions, to establish a more robust estimate of the prevalence of cognitive impairment in this population.

Thirdly, the study focused on patients undergoing dialysis and did not include patients with earlier stages of chronic kidney disease. Further research is needed to establish the prevalence of cognitive impairment across the entire spectrum of kidney disease, from early stages to end-stage renal disease.

Conclusion

The study findings underline the importance of thorough neurocognitive assessment in identifying specific areas of deficiency, even when overall cognitive performance appears to be strong. This heterogeneity in cognitive profiles emphasizes the importance of comprehensive neuropsychological assessments to identify specific areas of impairment.

With regards to the current study stratifying patients according to dialysis vintage did not significantly alter the influence of the age, gender, and dialysis vintage factors, which were still significantly associated with higher risks of either mild or severe cognitive impairment. However, the associations between cognitive impairment, education background, socio-economic factors, and history of etiology of kidney disease were affected to varying degrees, and in most cases the associations became non-significant.

Furthermore, the study highlighted the importance of assessing cognitive impairment via a comprehensive tool such as the MMSE, which examined cognitive functioning across multiple dimensions. This approach allowed for a more precise diagnosis and understanding of the profile of cognitive impairment within a given population.

Lastly, the results from the MMSE subtests revealed that even when cognitive impairment was absent, specific deficits could still be identified, such as challenges with attention and concentration. This finding underscores the complexity of cognitive functioning and highlights the need for continued research into the various features of cognitive impairment and their underlying causes.

The MMSE score distribution and subtest results provided valuable insight into the cognitive functioning of the study population. By utilizing these findings, clinicians can personalize treatment plans and design interventions that target specific cognitive domains.

It is pertinent to note that 99% of the participants reported no cognitive impairment, which might present a different limitation on its own. This figure suggested that dialysis does not significantly affect cognitive abilities in the studied demographic, or could point to a limited or insensitive method of assessing cognitive abilities, or potentially a mixture of both.

Lay summary

The study aimed to determine the prevalence of cognitive impairment in dialysis patients (haemodialysis and peritoneal dialysis) utilizing the Mini Mental State Examination tool. The study analyzed potential associations between 151 participants' characteristics (males and females ranging from the ages of 19-61 years old) and cognition. The study took place from January 2023 to September 2023. The

research positioned the study within the context of South Africa in Gauteng province, highlighting socioeconomic and healthcare challenges faced by dialysis patients in this region. Cognitive impairment is a significant public health issue that can affect individuals of all ages, although it is more prevalent in the elderly population. The early detection of cognitive impairment is crucial in managing and slowing down the progression of the condition. The study findings revealed a high level of cognitive functioning (99%) among the participants. The mean age (37.69 years (±10.56)) of the current study population was younger than other publications.

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