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Assessment of Cognitive Function in Elderly Patients Undergoing Hemodialysis

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Abstract

Cognitive impairment is often not properly managed, which may lead to complications such as Alzheimer's disease, sleep disorders, depression, increased risk of falls, difficulty in decision making, decreased quality of life, and increased mortality risk. This study aimed to identify cognitive impairment among elderly patients undergoing hemodialysis. This study used a descriptive quantitative design. A total of 101 respondents were selected using a total sampling technique. The inclusion criteria were patients who routinely underwent hemodialysis twice a week, were aged ≥55 years, were conscious and oriented, and were able to read and write. Cognitive function was assessed using an electronic-based Mini-Mental State Examination (MMSE). Data were analyzed using univariate analysis and Spearman's rank correlation test. Spearman's correlation was selected because the numerical variables were not normally distributed. The mean age of the respondents was 62.11 years, and the mean duration of hemodialysis was 4,252 hours. Most respondents were male (55.4%), had undergone hemodialysis for more than 24 months (49.5%), and had hypertension as the most common underlying disease (55.4%). Most respondents had normal cognitive function (76.2%). Spearman's rank correlation analysis showed a significant negative correlation between age and MMSE score (r_s = −0.241, p = 0.015) and between hemodialysis session duration and MMSE score (r_s = −0.198, p = 0.047). In contrast, the length of undergoing hemodialysis was not significantly correlated with MMSE score (r_s = 0.123, p = 0.222). Age and hemodialysis session duration were significantly associated with cognitive function, whereas the length of undergoing hemodialysis was not significantly associated with MMSE scores. Periodic cognitive ass essment should therefore be considered, particularly among older patients and those undergoing longer hemodialysis sessions.

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1. INTRODUCTION

Hemodialysis is a renal replacement therapy used to replace impaired kidney function by filtering and purifying the blood through a dialysis machine. This therapy is commonly used in patients with end-stage renal disease (ESRD), either as temporary treatment while awaiting kidney transplantation or as lifelong therapy when transplantation is not feasible (Sulistyaningrum et al., 2023). Recently, the number of patients initiating dialysis has increased. Early initiation of dialysis before the onset of severe uremic symptoms has been reported to improve patients' quality of life (Mudeshwar & Anjum, 2021).

Data from the United States Renal Data System showed that the number of new ESRD patients increased from 99,956 in 2002 to 131,194 in 2022, representing a 31.3% increase (United States Renal Data System, 2024). In 2022, based on age distribution, there were 11 patients aged 0–17 years, 116 patients aged 18–44 years, 582 patients aged 45–64 years, 1,174 patients aged 65–74 years, and 1,461 patients aged ≥75 years. Meanwhile, according to the Indonesian Renal Registry, the highest proportion of new ESRD patients was found in the 55–64-year age group (31.19%), followed by 45–54 years (29.36%), ≥65 years (16.01%), and <45 years. These findings indicate that ESRD is more prevalent among older adults and that elderly patients represent an important population requiring greater clinical attention.

Aging is generally associated with progressive decline in organ function due to degenerative processes (Zhang et al., 2023). Elderly patients undergoing hemodialysis often experience a high burden of functional impairment, comorbidities, and reduced physiological reserves (Prieto-Oliveira, 2021). These conditions may increase vulnerability to complications during and after hemodialysis (Seto et al., 2022). Excessive and rapid fluid removal during hemodialysis can lead to hemodynamic instability, including decreased cardiac volume and mean arterial pressure. These hemodynamic changes may result in ischemic brain injury (Abdelwahab et al., 2022). Furthermore, reduced cardiac output during hemodialysis can cause systemic hypoperfusion, subclinical ischemia, and cerebral hypoxia, thereby increasing the risk of cognitive dysfunction (Park & Jung, 2025).

Cognitive impairment is one of the important complications among patients undergoing hemodialysis (Xu et al., 2024). A study involving 60 patients who had undergone hemodialysis for at least three months reported a 70% Assessment of cognitive decline (Abdelwahab et al., 2022). Another study found that 36 out of 40 hemodialysis patients experienced cognitive impairment, with the highest proportion observed in the 50–55-year age group (30.5%). Cognitive impairment in hemodialysis patients is often underdiagnosed and poorly managed (Sulistini et al., 2024). If not identified early, this condition may lead to various adverse outcomes, including increased risk of falls, poor adherence to treatment, depression, difficulty in decision-making, decreased quality of life, and increased risk of mortality (Abdelwahab et al., 2022).

The urgency of this study lies in the increasing number of elderly patients undergoing hemodialysis and their high vulnerability to cognitive dysfunction. Hemodialysis is not only a life-sustaining therapy but also a procedure that may cause repeated hemodynamic changes, which can affect cerebral perfusion and brain function. In elderly patients, these changes may have more serious consequences because aging is associated with decreased physiological compensation and greater susceptibility to neurological impairment. Therefore, early identification of cognitive impairment is essential to support clinical decision-making, improve nursing care, strengthen patient safety, and prevent further decline in functional status and quality of life among elderly patients undergoing hemodialysis.

Despite the clinical importance of this issue, cognitive impairment in elderly hemodialysis patients has not received sufficient attention, particularly in routine nursing assessment (Cheng et al., 2024). Many hemodialysis services still focus mainly on physical and biochemical parameters, while cognitive function is rarely assessed systematically (Winarti et al., 2024). Based on preliminary interviews conducted with elderly patients at Klinik Ginjal dan Hipertensi “Lestari”, several patients reported memory problems, frequent forgetfulness, reduced concentration, and occasional disorientation to time. These symptoms indicate the possibility of cognitive problems that may affect patients’ ability to comply with treatment, manage daily activities, and make appropriate health-related decisions. This condition highlights the need for structured cognitive Assessment among elderly patients undergoing hemodialysis.

Previous studies have examined cognitive function in hemodialysis patients, but few have specifically focused on elderly patients, often using small samples and varied instruments such as MoCA-Ina (Alirudin et al., 2020). Indonesian studies have also largely described cognitive impairment without emphasizing elderly-specific characteristics, dialysis duration, underlying diseases, or practical electronic-based assessment. This study addresses this gap by systematically assessing cognitive function among elderly patients undergoing hemodialysis at a clinic-level facility, where cognitive assessment is not yet routinely performed despite its potential impact on health education, treatment decisions, self-care, and quality of life. This study aims to identify cognitive impairment among elderly patients undergoing hemodialysis. The findings are expected to provide local evidence to support early detection, periodic monitoring, and nursing interventions to prevent cognitive decline and improve quality of life.

2. METHODS

This study employed a descriptive research design with univariate analysis to describe respondent characteristics and the distribution of the variables under study. The sample consisted of 101 respondents selected using a total sampling technique. Inclusion criteria included patients undergoing routine hemodialysis twice weekly, aged ≥55 years, possessing a conscious and alert mental state (compos mentis), and being able to read and write. The age threshold was selected based on the classification by the Indonesian Ministry of Health, which defines the 55-and-older age group as "pre-elderly", a demographic facing an increased risk of degenerative diseases.

The research instrument used was the electronic Mini-Mental State Examination (MMSE) a digital adaptation of the conventional MMSE that retains the original content, question sequence, scoring system, and score interpretation. The electronic MMSE demonstrates high concurrent validity and reliability, making it suitable for use as a cognitive function screening tool. This study received ethical approval from the Telogorejo University Semarang Research Ethics Committee (reference number 104/VIII/EC/P3M/STIKES/2025).

Data were analyzed using univariate and bivariate analyses. Univariate analysis was performed to describe respondent characteristics and the distribution of cognitive function. Numerical variables were assessed for normality using the Shapiro–Wilk test. The results showed that age, length of undergoing hemodialysis, duration of hemodialysis sessions, and MMSE scores were not normally distributed ($p < 0.05$). Therefore, Spearman’s rank correlation test was used to examine the relationships between age, length of undergoing hemodialysis, duration of hemodialysis sessions, and MMSE scores. Statistical significance was determined at $p < 0.05$.

3. RESULTS AND DISCUSSION

Table 1. Distribution of respondent characteristics based on age and duration of hemodialysis at Klinik Ginjal dan Hipertensi "Lestari", September 2025 (n=101).

Variable	N	Red ± SD	Median	Min – Max	CI 95%	
					Min	Max
Age	101	62.11 ± 5,623	61.00	55 – 80	61.00	63.22
Duration of hemodialysis	101	4.252 ± 0.2883	4.000	4.0 – 5.0	4.196	4.309

Table 1 presents the mean age of the respondents, which was 62.11 years (range: 55–80 years). Meanwhile, the mean duration of each hemodialysis session was 4.25 hours (range: 4–5 hours).

Table 2. Distribution of respondent characteristics based on gender, length of hemodialysis, underlying disease, and cognitive function at Klinik Ginjal dan Hipertensi "Lestari", September 2025 (n=101).

Variable	Categories	n	%
Gender	Men – men	56	55.4
	Women	45	44.6
	Total	101	100.0
Long undergoing hemodialysis	< 12 months	24	23.8
	12 - 24 months	27	26.7
	> 24 months	50	49.5
	Total	101	100.0
Underlying diseases	Hypertension	56	55.4
	Diabetus Mellitus	37	36.6
	Other	8	7.9
	Total	101	100.0
Cognitive Function	Normal	77	76.2
	Probable cognitive impairment	18	17.8
	Definite cognitive impairment	6	5.9
	Total	101	100.0

Table 2 shows that the majority of respondents were male (55.4%; 56 respondents). The largest proportion of respondents had been undergoing hemodialysis for more than 24 months (49.5%; 50 respondents). Hypertension was the most common underlying disease (55.4%; 56 respondents). In terms of cognitive function, most respondents were classified as having normal cognitive function (76.2%; 77 respondents).

Table 3. Spearman's rank correlation between age, hemodialysis-related characteristics, and MMSE scores among elderly patients undergoing hemodialysis.

Variable	Spearman's rho (r_s)	p-value	Interpretation
Age and MMSE score	−0.241	0.015*	Weak negative correlation
Length of undergoing hemodialysis and MMSE score	0.123	0.222	Very weak positive correlation
Duration of hemodialysis session and MMSE score	−0.198	0.047*	Very weak negative correlation

Table 3 shows the results of Spearman's rank correlation analysis. Age was significantly and negatively correlated with MMSE score (r_s = −0.241, p = 0.015), indicating

that increasing age was associated with lower cognitive function scores. The strength of this correlation was weak. The length of undergoing hemodialysis showed a very weak positive correlation with MMSE score (r_s = 0.123); however, this relationship was not statistically significant (p = 0.222). The duration of each hemodialysis session was significantly and negatively correlated with MMSE score (r_s = −0.198, p = 0.047). Although the correlation was very weak, longer hemodialysis sessions tended to be associated with lower MMSE scores.

The results of this study showed that the mean age of the respondents was 62.11 years, with an age range of 55–80 years. In elderly patients, the impact of kidney dysfunction is often more complex because aging is also associated with reduced physiological reserves and multiple comorbidities. As a result, elderly patients undergoing hemodialysis may experience greater vulnerability to complications, including cardiovascular instability, fatigue, functional decline, and cognitive problems. The decline in kidney function that occurs with age may also contribute to the accumulation of uremic toxins, which can affect neurological function. Therefore, the finding that most respondents were elderly supports the need for more comprehensive assessment in hemodialysis care, not only focusing on physical and biochemical parameters but also on cognitive function.

This finding is consistent with the Indonesian Renal Registry, which reported that the majority of patients undergoing hemodialysis were in the age group of 55–64 years. Age is one of the important factors associated with declining kidney function. The kidneys play an essential role in maintaining body homeostasis by regulating fluid balance, electrolyte levels, acid-base balance, and excretion of metabolic waste products. However, with increasing age, the kidneys undergo structural and functional changes, including decreased renal mass, reduced number of functioning nephrons, decreased renal blood flow, and reduced glomerular filtration rate. These physiological changes make elderly individuals more vulnerable to chronic kidney disease and progression to end-stage kidney disease (Costanzo, 2021). However, with aging, the kidneys undergo structural and functional changes (Ray & Reddy, 2023). Renal mass decreases significantly after the age of 50. Increasing age is closely related to progressive structural and functional changes in the kidneys. Physiologically, aging is associated with a decrease in renal mass, nephron number, renal blood flow, and glomerular filtration rate. These changes may increase the susceptibility of older adults to chronic kidney disease and progression to end-stage kidney disease. Therefore, elderly patients represent a vulnerable group requiring continuous monitoring during hemodialysis therapy.

The results also showed that the mean duration of hemodialysis among respondents was 4.25 hours. These findings are consistent with the study by Reisha et al. (2023), which reported that most patients with end-stage kidney disease require approximately 4 hours per dialysis session. According to the Indonesian Renal Registry (2023), the duration of hemodialysis is generally more than 4 hours (63%). Hemodialysis is typically recommended to be performed twice a week, with each session lasting 4 to 5 hours (Hasanuddin, 2022). Although hemodialysis is essential for sustaining life, the procedure may also cause intradialytic physiological changes. Rapid or excessive ultrafiltration can trigger hemodynamic instability, such as decreased blood pressure, reduced cardiac output, and impaired systemic perfusion. In elderly patients, these changes may have greater consequences because their cardiovascular compensation mechanisms are often reduced. Repeated episodes of intradialytic hypotension and systemic hypoperfusion may affect cerebral blood flow and increase the risk of subclinical cerebral ischemia. This mechanism may contribute to cognitive decline, particularly in elderly patients who already have age-related changes in brain structure and function.

The results showed that the majority of respondents were male (55.4%). These findings are consistent with the study by Cahyani et al. (2022), which reported that most patients undergoing hemodialysis are male. Similarly, the Indonesian Renal Registry (2023) indicates that the majority of hemodialysis patients are male (55%). Declining kidney function can occur in both men and women with aging. However, while the incidence of chronic kidney disease is reported to be higher in women, end-stage kidney disease is more commonly observed in men (Mayne et al., 2023). The annual decline in glomerular filtration rate is also greater in males (−1.43 mL/min/1.73 m²) compared to females (−1.09 mL/min/1.73 m²). In addition, women produce estrogen, which helps maintain vascular and renal function, thereby reducing the risk of chronic kidney disease (Ma et al., 2021). Gender differences in hemodialysis patients should not be interpreted only from a biological perspective. Behavioral and lifestyle factors may also contribute to the higher proportion of male patients, including smoking, dietary patterns, occupational exposure, delayed health-seeking behavior, and lower adherence to preventive health checks. These factors may increase the risk of uncontrolled hypertension, diabetes mellitus, and progressive kidney damage. Therefore, the predominance of male respondents in this study may reflect the combined influence of biological, lifestyle, and healthcare-seeking factors.

The results also showed that the largest proportion of respondents had been undergoing hemodialysis for more than 24 months (49.5%). These findings are in line with the study by Sulistyaningrum et al. (2024), which reported that most respondents had undergone hemodialysis for more than 24 months (50%). Hemodialysis serves as a life-sustaining therapy for patients with end-stage kidney disease and is generally required for life (Ok et al., 2023). One study reported that patients' quality of life begins to improve after initiating dialysis and stabilizes after approximately 12 weeks. In fact, the longest reported duration of hemodialysis is 317 months. However, longer duration of hemodialysis may also increase cumulative exposure to dialysis-related complications. Repeated intradialytic hemodynamic instability, chronic inflammation, anemia, vascular calcification, and uremic toxin accumulation may contribute to systemic and neurological complications. In relation to cognitive function, long-term hemodialysis may affect the brain through recurrent changes in cerebral perfusion and metabolic disturbances. Therefore, patients who have undergone hemodialysis for more than 24 months require continuous monitoring, including assessment of cognitive status, emotional condition, functional ability, and quality of life (Karami et al., 2025).

The results further showed that hypertension was the most common underlying disease (55.4%). According to the Indonesian Renal Registry (2023), hypertension is the leading cause of end-stage kidney disease in Indonesia (35%). Hypertension increases arterial pressure within the kidneys, leading to reduced blood flow to the glomeruli and resulting in ischemia. This ischemic condition contributes to endothelial and nephron dysfunction, ultimately reducing the number of functional nephrons (De Bhailis & Kalra, 2022). Uncontrolled hypertension can further accelerate the progression to end-stage kidney disease. Hypertension is also closely related to cognitive function. As a vascular risk factor, hypertension may contribute to cerebral small vessel disease, reduced cerebral blood flow, and ischemic brain injury. In elderly hemodialysis patients, the combination of hypertension, aging, and repeated hemodynamic changes during dialysis may increase the risk of cognitive impairment (Tsirigotis et al., 2022). Therefore, blood pressure control in hemodialysis patients is not only important for preventing cardiovascular and renal complications but also for maintaining cerebral perfusion and cognitive function.

The study results indicate that the majority of respondents (76.2%) possess normal cognitive function. However, this finding contrasts with other research showing that up to

80% of hemodialysis patients aged 55 and older experience moderate to severe chronic cognitive impairment (Van Zwieten et al., 2018; Karakizlis et al., 2022). Cognitive impairment in hemodialysis patients varies widely and is influenced by various factors.

Physiologically, as age advances, blood flow to the brain decreases, leading to atrophy and a reduction in neurotransmitters. Consequently, abilities related to memory, concentration, and speed of thought gradually decline. However, the results of this study indicate that a high proportion of hemodialysis patients in the pre-elderly group (≥55 years old) still exhibit cognitive function within the normal range. These findings suggest that while chronic kidney disease and hemodialysis therapy contribute to an increased risk of cognitive impairment, not all patients undergoing hemodialysis experience a decline in cognitive function. This outcome may be influenced by the fact that the respondents were relatively younger than the advanced elderly group; thus, neurodegenerative processes associated with aging had not yet progressed significantly, and cognitive reserve remained sufficient to maintain cognitive function. For instance, a longitudinal study by Drew et al., (2017) demonstrated an MMSE score decline of 0.02 points per year over a five-year period for individuals aged 65, contrasting with a decline of 0.57 points per year for those aged 85.

In addition to physiological factors (such as age), biological factors also contribute to the decline in cognitive function among hemodialysis patients. In patients with end-stage renal disease, the accumulation of toxins (uremia) exerts neurotoxic effects that can impair neuronal and cognitive functions. Hemodialysis involves fluctuations in blood pressure and cerebral blood flow that can cause brain tissue damage, thereby triggering a decline in cognitive function. Hemodialysis patients exhibit smaller hippocampal and amygdala volumes. They also experience reduced cortical thickness across multiple brain regions bilaterally throughout the cortex including the frontal, temporal, parietal, and occipital lobes, as well as the precuneus (Chiu et al., 2019). However, the results of this study indicate that the majority of respondents had been undergoing hemodialysis for more than 24 months. Previous research (Drew et al., 2017) has shown that patients with end-stage renal disease who are just beginning hemodialysis therapy tend to experience more severe cognitive impairment. This is thought to be influenced by the accumulation of uremic toxins, clinical instability during the initial phase of therapy, and high rates of concurrent hospitalization.

Another risk factor potentially influencing cognitive impairment in hemodialysis patients is hemoglobin level (Huang et al., 2025). Anemia reduces oxygen supply to the brain an organ highly sensitive to oxygen levels thereby disrupting cerebral metabolism. Anemia can also increase oxidative stress and inflammation, potentially damaging brain tissue and leading to cognitive decline. Furthermore, anemia can affect cerebral blood flow, reducing the delivery of oxygen and nutrients. These mechanisms may gradually affect cognitive domains such as memory, attention, concentration, orientation, language, and executive function (Burdelis & Cruz, 2023). Nevertheless, further research is needed to understand this risk factor.

This study highlights the importance of cognitive assessment in hemodialysis units, particularly for elderly patients. In many clinical settings, routine hemodialysis care focuses mainly on physical complaints, vascular access, fluid balance, blood pressure, laboratory results, and dialysis adequacy. Cognitive function is often not assessed systematically, even though cognitive impairment can affect treatment adherence, self-care ability, decision-making, and patient safety. Therefore, cognitive Assessment should be considered as part of routine nursing assessment in elderly patients undergoing hemodialysis. From a nursing perspective, early identification of cognitive impairment is essential. Nurses have an important role in observing changes in patient behavior,

communication ability, memory, orientation, and treatment adherence during routine hemodialysis sessions. Cognitive Assessment can help nurses identify patients who need additional education, repeated explanations, simplified instructions, family involvement, or referral for further evaluation. Family involvement is particularly important because elderly patients with cognitive decline may require assistance in daily activities, medication management, transportation to dialysis sessions, and monitoring of symptoms at home (Chu et al., 2024).

Despite the high Assessment of cognitive impairment among hemodialysis patients, it is often underdiagnosed and inadequately managed. Cognitive impairment can reduce patients' adherence to medication and treatment, interfere with daily functioning, cause emotional distress, and significantly increase mortality risk (Chippa & Roy, 2023). Overall, this study shows that cognitive function among elderly patients undergoing hemodialysis was mostly within the normal category. However, the presence of probable and definite cognitive impairment indicates that cognitive decline remains an important clinical issue in this population. Preventive efforts are needed to reduce the risk of further cognitive dysfunction. These efforts may include regular cognitive Assessment, optimal blood pressure control, anemia management, prevention of intradialytic hypotension, patient and family education, psychosocial support, and multidisciplinary collaboration. By integrating cognitive assessment into hemodialysis care, healthcare providers can improve patient safety, treatment adherence, and quality of life among elderly patients undergoing hemodialysis.

The bivariate analysis demonstrated a significant negative correlation between age and MMSE score ($r_s = -0.241$, $p = 0.015$). This finding indicates that cognitive function tended to decrease with increasing age, although the strength of the relationship was weak. Aging is associated with several structural and functional changes in the brain, including reduced cerebral blood flow, brain atrophy, and changes in neurotransmitter activity, which may affect memory, attention, concentration, and processing speed. In elderly patients undergoing hemodialysis, these age-related changes may be compounded by chronic kidney disease, uremic toxin accumulation, vascular abnormalities, and recurrent alterations in cerebral perfusion during dialysis.

The duration of hemodialysis was not significantly correlated with MMSE score ($r_s = 0.123$, $p = 0.222$), suggesting that cumulative treatment duration alone does not determine cognitive status, which is influenced by multiple factors such as age, anemia, cardiovascular risk, uremic toxin burden, intradialytic hypotension, cerebral perfusion, nutritional status, and comorbidities. In contrast, longer hemodialysis sessions were significantly but very weakly associated with lower MMSE scores ($r_s = -0.198$, $p = 0.047$), possibly reflecting hemodynamic changes and reduced cerebral perfusion during ultrafiltration, particularly among older patients. However, the cross-sectional design and weak correlation preclude causal interpretation. These findings suggest that most elderly patients had normal cognitive function, but older age and longer dialysis sessions may warrant closer cognitive monitoring as part of comprehensive nursing care.

The main limitation of this study is its cross-sectional design, which limits the ability to establish causal relationships between age, hemodialysis characteristics, and cognitive function. Therefore, the observed associations should be interpreted cautiously. Future studies should use longitudinal designs to examine changes in cognitive function over time and clarify the temporal and causal relationships between hemodialysis characteristics and cognitive decline.

4. CONCLUSION

These research findings highlight the importance of integrating routine cognitive function assessment into the comprehensive care of elderly patients undergoing hemodialysis. Implementing periodic assessment is expected to facilitate the early detection of cognitive impairment, thereby supporting clinical decision making, the planning of appropriate care interventions, and the optimization of patients' quality of life.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Danny Putri Sulistyaningrum contributed to study conceptualization, design, implementation, data collection and analysis, interpretation, and manuscript drafting. Maya Cobalt Angio Septianingtyas contributed to study design, methodology, data collection, interpretation, and critical manuscript review. Rusmiyati supervised the study, reviewed the analysis and interpretation, critically revised the manuscript, and ensured its scientific quality and integrity. All authors approved the final manuscript and accepted responsibility for its accuracy and integrity.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

The author utilized generative artificial intelligence (AI) technology to a limited extent to enhance the language quality, clarity, readability, and structure of the manuscript, including paraphrasing specific sections without altering the scientific substance.

REFERENCES

Abdelwahab, M. M. A., Sabri, Y., Elkalla, I. H. R., Nassar, M. K., Abdel-Gawad, S. M., & Gomaa, Z. A. E. (2022). Cognitive impairment in different hemodialysis techniques. *Middle East Current Psychiatry*, *29*(1), 1-10. https://doi.org/10.1186/s43045-022-00258-1

Alirudin, C., Hendellyn, A., Sumada, I., Yuliani, D., Sunaka, I., & Neurologi, D. (2020). Profile of cognitive impairment in hemodialysis patients at Wangaya Regional General Hospital. *Callosum Neurology Journal*, 3, 43-48.

Burdelis, R. E. M., & Cruz, F. J. S. M. (2023). Assessment and predisposing factors for fatigue in patients with chronic renal disease undergoing hemodialysis: a cross-sectional study. *Sao Paulo Medical Journal*, *141*(5), 1-9. https://doi.org/10.1590/1516-3180.2022.0127.R1.01122022

Cahyani, A. A. A. E., Prasetya, D., Abadi, M. F., & Prihatiningsih, D. (2022). A profile of diagnoses among pre-hemodialysis patients at Wangaya Regional General Hospital, 2020–2021. *Jurnal Ilmiah Hospitality,* 11(1), 661-666.

Cheng, M., He, M., Ning, L., Gan, H., Liu, H., Liu, Q., Shi, F., Luo, Y., & Zeng, Z. (2024).

Association between frailty and adverse outcomes in patients undergoing maintenance hemodialysis: a systematic review and meta-analysis. *Renal Failure, 46*(2), 1-12. https://doi.org/10.1080/0886022X.2024.2367716

Chippa, V., & Roy, K. (2023). *Geriatric cognitive decline and polypharmacy.* Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK574575/

Chu, W.-M., Tsai, H.-B., Chen, Y.-C., Hung, K.-Y., Cheng, S.-Y., & Lin, C.-P. (2024). Palliative care for adult patients undergoing hemodialysis in Asia: challenges and opportunities. *Journal of Hospice and Palliative Care*, *27*(1), 1-10. https://doi.org/10.14475/jhpc.2024.27.1.1

Costanzo, L. (2021). *Costanzo physiology e-book: costanzo physiology e-book.* Elsevier *Health Sciences*. https://books.google.com/books?id=lkdFEAAAQBAJ

De Bhailis, Á. M., & Kalra, P. A. (2022). Hypertension and the kidneys. *British Journal of Hospital Medicine*, *83*(5), 1-11. https://doi.org/10.12968/hmed.2021.0440

Drew, D. A., Weiner, D. E., Tighiouart, H., Duncan, S., Gupta, A., Scott, T., & Sarnak, M. J. (2017). Cognitive decline and its risk factors in prevalent hemodialysis patients. *American journal of kidney diseases,* 69(6), 780–787. https://doi.org/10.1053/j.ajkd.2016.11.015

Hasanuddin, F. (2022). *Hemodialysis adequacy in patients with chronic kidney disease*. Pekalongan: Penerbit NEM.

Huang, L., Zhang, Y., Wang, J., Tang, H., & Zhou, J. (2025). Association of anemia and cognitive impairment in patients undergoing maintenance hemodialysis: a cross-sectional study. BMC Nephrology, 26(1), 387. https://doi.org/10.1186/s12882-025-04336-4

Indonesian Renal Registry. (2023). *13th annual report of Indonesian Renal Registry 2020.* Bandung: Indonesian Renal Registry. https://www.indonesianrenalregistry.org/media/laporan%20IRR%202020.pdf

Karakizlis, H., Bohl, K., Ziemek, J., Dodel, R., & Hoyer, J. (2022). Assessment of cognitive impairment and related risk factors in hemodialysis patients. *Journal of nephrology*, 35(3), 931–942. https://doi.org/10.1007/s40620-021-01170-3

Karami, H., Rahmati, M., & Abbasi, P. (2025). Investigating the relationship between perceived social support and resilience in patients undergoing hemodialysis: a cross-sectional study. *BMC Nephrology*, *26*(1), 1-8. https://doi.org/10.1186/s12882-025-04204-1

Ma, H. Y., Chen, S., & Du, Y. (2021). Estrogen and estrogen receptors in kidney diseases. *Renal Failure*, *43*(1), 619–642. https://doi.org/10.1080/0886022X.2021.1901739

Mayne, K. J., Sullivan, M. K., & Lees, J. S. (2023). Sex and gender differences in the management of chronic kidney disease and hypertension. *Journal of Human Hypertension*, *37*(8), 649–653. https://doi.org/10.1038/s41371-023-00843-9

Mudeshwar, H., & Anjum, F. (2021). *Hemodialysis*. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK563296/

Ok, E., Demirci, C., Asci, G., Yuksel, K., Kircelli, F., Koc, S. K., ... & Keleş, M. (2023). Patient survival with extended home hemodialysis compared to in-center conventional hemodialysis. Kidney International Reports, 8(12), 2603-2615. https://doi.org/10.1016/j.ekir.2023.09.007

Park, Y., & Jung, S. (2025). Predictors of self-management behaviors among patients undergoing hemodialysis. *Scientific Reports*, *15*(1), 1-11. https://doi.org/10.1038/s41598-025-97414-4

Prieto-Oliveira, P. (2021). Telomerase activation in the treatment of aging or degenerative diseases: a systematic review. In *Molecular and Cellular Biochemistry*, *476*(2). https://doi.org/10.1007/s11010-020-03929-x

Reisha, R. A. D., Ningsih, W. T., & Nugraheni, W. T. (2023). The relationship between hemodialysis duration and anxiety levels in patients with chronic kidney disease in the hemodialysis unit at Dr. R. Koesma Tuban Regional General Hospital. *Jurnal Keperawatan Widya Gantari Indonesia*, *7*(2), 154–160. https://doi.org/10.52020/jkwgi.v7i2.5522

Ray, N., & Reddy, P. H. (2023). Structural and physiological changes of the kidney with age and its impact on chronic conditions and COVID-19. *Ageing Research Reviews*, *88*(2023)*, 1-8*. https://doi.org/10.1016/j.arr.2023.101932

Seto, Y., Kimura, M., Matsunaga, T., Miyasita, E., & Kanno, Y. (2022). Long-term body composition changes in patients undergoing hemodialysis: a single-center retrospective study. *Renal Replacement Therapy*, *8*(1), 1-8. https://doi.org/10.1186/s41100-022-00448-x

Sulistini, R., Pratama, Y., Febriani, I., Susanti, E., & Erman, I. (2024). Stressful conditions increase fatigue during undergoing hemodialysis. *JKEP*, *9*(1), 109-115. https://doi.org/10.32668/jkep.v9i1.1490

Sulistyaningrum, D. P., Septianingtyas, M. C. A., Nurhanifah, T., & Izza, N. (2023). The effect of using fluid balance application on interdialytic weight gain in stage V chronic kidney disease patients undergoing hemodialysis. *Babali Nursing Research*, *4*(1), 161–169. https://doi.org/10.37363/bnr.2023.41222

Sulistyaningrum, D. P., Septianingtyas, M. C. A., & Sutejo, M. N. (2024). The effect of buerger allen exercise on muscle cramps in preventing intradialysis emergency. *babali nursing research*, *5*(4), 695–704. https://doi.org/10.37363/bnr.2024.54388

Tsirigotis, S., Polikandrioti, M., Alikari, V., Dousis, E., Koutelekos, I., Toulia, G., Pavlatou, N., Panoutsopoulos, G. I., Leftheriotis, D., & Gerogianni, G. (2022). Factors associated with fatigue in patients undergoing hemodialysis. *Cureus, 14*(3)*,* 1-15. https://doi.org/10.7759/cureus.22994

United States Renal Data System. (2024). *2024 annual data report.* https://usrds-adr.niddk.nih.gov/2024/end-stage-renal-disease/1-incidence-prevalence-patient-characteristics-and-treatment-modalities

Van Zwieten, A., Wong, G., Ruospo, M., Palmer, S. C., Barulli, M. R., Iurillo, A., ... & COGNITIVE-HD study investigators. (2018). Prevalence and patterns of cognitive impairment in adult hemodialysis patients: the COGNITIVE-HD study. *Nephrology Dialysis Transplantation,* 33(7), 1197-1206. https://doi.org/10.1093/ndt/gfx314

Winarti, R., Hidayat, W., & Prasetya, C. H. (2024). The relationship between long time undergoing hemodialysis and stress levels in chronic kidney failure patients undergoing hemodialysis at Bendan Regional Hospital, Pekalongan City. *Global International Journal of Innovative Research*, *2*(4), 767-777. https://doi.org/10.59613/global.v2i4.138

Xu, Q., Huang, J., Liu, Q., Wang, X., Liu, H., Song, Y., Dou, F., Lv, S., & Liu, G. (2024). Short-term effect of low-dose roxadustat combined with erythropoiesis-stimulating agent treatment for erythropoietin-resistant anemia in patients undergoing maintenance hemodialysis. *Frontiers in Endocrinology*, *15,* 1-7. https://doi.org/10.3389/fendo.2024.1372150

Zhang, L., Wu, J., Zhu, Z., He, Y., & Fang, R. (2023). Mitochondrion: a bridge linking aging and degenerative diseases. *Life Sciences*, *322*(121666), 1-13. https://doi.org/10.1016/j.lfs.2023.121666