Original Article

Comparison of the Charlson Comorbidity Index and Wright-Khan Index for predicting mortality in continuous ambulatory peritoneal dialysis (CAPD) patients

Erdilian JP. Pratama[1*], Nur Samsu[2] and Achmad Rifai[2]

[1]Department of Internal Medicine, Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia; [2]Division of Nephrology and Hypertension, Department of Internal Medicine, Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia

*Corresponding author: erdilianj@gmail.com

Abstract

Mortality among patients receiving continuous ambulatory peritoneal dialysis (CAPD) remains substantial, and comorbidity burden is considered an important determinant of adverse outcomes. This study aimed to compare the associations of the Charlson Comorbidity Index (CCI) and Wright-Khan Index (WKI) with mortality among CAPD patients. A retrospective study was conducted using medical records of CAPD patients treated at Saiful Anwar Hospital, Malang, between August 1, 2019 and July 31, 2023. Baseline characteristics, CCI and WKI scores, and mortality status were collected. Logistic regression was performed to evaluate the association of each index with mortality, and Kaplan-Meier analysis was used to estimate survival probability across risk categories. A total of 377 CAPD patients were included, comprising 89 deaths and 288 survivors. No significant association was observed between CCI and mortality across the low-, moderate-, and high-risk categories (p=0.974, p=0.857, and p=0.845, respectively). In contrast, WKI was significantly associated with mortality in the low-risk group (odds ratio (OR)=0.40; 95% confidence interval (CI): 0.22-0.72; p=0.002) and moderate-risk group (OR=3.13; 95%CI: 1.49-6.54; p=0.002), whereas no significant association was identified in the high-risk group (p=0.664). Kaplan-Meier analysis further showed that the low-risk WKI category had the most favorable survival probability, whereas the moderate- and high-risk categories showed lower survival over follow-up. Overall, WKI showed a stronger association with mortality than CCI in this CAPD cohort and may provide greater utility for clinical risk stratification.

Keywords: CAPD, mortality, comorbidity, risk assessment, Charlson Comorbidity Index

Introduction

Continuous ambulatory peritoneal dialysis (CAPD) is an established renal replacement therapy for patients with end-stage chronic kidney disease (CKD) and is frequently selected as an alternative to hemodialysis because of its flexibility and potential quality-of-life advantages [1]. Despite these benefits, mortality among patients receiving CAPD remains a major clinical challenge [2]. Global estimates indicate substantial variation in CAPD-related mortality, with differences across regions likely reflecting heterogeneity in patient characteristics, comorbidity profiles, access to care, and dialysis-related complications [3,4]. A study in Indonesia reported a 5-year mortality rate of 29.5% among CAPD patients, with cardiovascular disease and sepsis due to peritonitis identified as the leading causes of death [6]. These findings suggest that, beyond procedural and infectious complications, the burden of coexisting disease is likely to play an important role in determining prognosis in this population.

Received: February 3, 2026 - Accepted: March 28, 2026 - Published online: March 31, 2026

Comorbidity refers to the presence of additional clinical conditions that coexist with the index disease and influence prognosis, treatment complexity, and outcome [7]. In CKD, diabetes mellitus, hypertension, cardiovascular disease, and other systemic disorders have been shown to increase mortality risk and complication burden through cumulative physiological stress and multi-organ injury [8]. Several indices have therefore been developed to quantify comorbidity burden and to support prognostic assessment [9]. Among these, the Charlson Comorbidity Index (CCI) is widely used to estimate mortality risk on the basis of weighted comorbid conditions [10], whereas the Wright-Khan Index (WKI) incorporates both age and comorbidity burden and has also been applied in dialysis populations [11]. Although both indices have been used to predict mortality in CKD and dialysis cohorts, direct comparative evidence regarding their performance specifically in CAPD patients remains limited [12].

The aim of this study was therefore to compare the association of the CCI and WKI with mortality among patients undergoing CAPD. The findings are expected would help identify the more informative index for mortality risk stratification in this population and thereby support prognostic assessment and clinical decision-making in CAPD care.

Methods

Study design and setting

A retrospective analytical observational study was conducted to compare the association of the CCI and WKI with mortality among patients with CKD undergoing CAPD. The study was performed at the CAPD Clinic of Saiful Anwar Hospital, Malang, Indonesia. The study covered the observation period of August 1, 2019 to July 31, 2023. The study was conducted in accordance with the principles of the Declaration of Helsinki. Reporting was aligned with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [13].

Participants and eligibility criteria

The study population comprised patients with CKD who underwent CAPD at Saiful Anwar Hospital during the observation period. A total sampling approach was applied, and all eligible patients were included. The minimum required sample size was estimated using G*Power version 3.1 and was calculated to be 98 patients. Patients aged 18 years or older with complete medical records for all study variables were included. Patients with incomplete data or without ascertainable mortality outcomes during follow-up were excluded.

Data collection

Data were collected at CAPD Clinic of Saiful Anwar Hospital, Malang, during March-April 2024. Medical records from patients who underwent CAPD between study period were reviewed using a structured data extraction form. The extracted data included demographic characteristics, anthropometric measurements, smoking history, duration of CAPD, comorbidity profile, CCI and WKI components, and survival status during the observation period. Mortality status was determined from documented clinical records within the hospital database. To improve data consistency, records were reviewed systematically and entries with major discrepancies or incomplete information for key study variables were excluded from the analysis. Data extraction was performed by EJPP, and all patient identifiers were removed prior to analysis to maintain confidentiality.

Study variables

The primary outcome of this study was all-cause mortality during the observation period. All-cause mortality was defined as death from any cause occurring in patients undergoing CAPD between the study period regardless of the specific underlying mechanism or immediate clinical cause. Mortality status was classified as a binary outcome: died or survived at the end of follow-up. Patients with documented death were included in the deceased group, whereas patients who remained alive throughout the study period were included in the surviving group. No cause-specific mortality classification was applied.

The main independent variables were CCI and WKI. CCI was calculated from comorbid conditions documented in the medical records and categorized as low risk (0–2), moderate risk (3–4), and high risk (≥5). WKI was determined on the basis of age and comorbidity burden and categorized as low risk (age <70 years without comorbidities), moderate risk (age 70–80 years or one comorbidity), and high risk (age >80 years, ≥2 comorbidities, or cardiopulmonary disease).

Covariates

Additional variables were also collected to characterize the study population and to provide clinical context for the mortality analysis. These variables included age (in years at the time of CAPD assessment), sex (male or female), body weight (in kilograms), height (in centimeters), and body mass index (BMI), which was calculated as body weight in kilograms divided by height in meters squared. Smoking history was recorded from the medical records and classified according to documented smoking status. Duration of CAPD was defined as the length of time the patient had undergone CAPD therapy during the study period. In addition, major comorbid conditions documented in the medical records were collected, including diabetes mellitus, hypertension, heart failure, chronic obstructive pulmonary disease, rheumatologic disease, peptic ulcer disease, hepatitis B or C, coronary heart disease, stroke, and peripheral arterial disease.

Statistical analysis

Data were presented as mean and standard deviation (SD) for normally distributed numerical variables, median (interquartile range) for non-normally distributed numerical variables, and frequency (percentage) for categorical variables. Normality was assessed using the Shapiro-Wilk test. Baseline characteristics between the deceased and surviving groups were compared using the Chi-square test for categorical variables, the independent t-test for normally distributed numerical variables, and the Mann-Whitney test for non-normally distributed numerical variables. The association between CCI and WKI risk categories and mortality was analyzed using logistic regression to obtain odds ratios (OR) and 95% confidence intervals (CI). Survival probability according to risk category was estimated using the Kaplan-Meier method. A two-sided $p<0.05$ was considered statistically significant. All analyses were performed using GraphPad Prism (GraphPad Software, Inc., California, USA).

Results

Baseline characteristics and comparation between deceased and survivor groups

A total of 377 CAPD patients were included during the study period, comprising 89 patients who died and 288 who survived. The detailed baseline characteristics are presented in **Table 1**. Among the assessed baseline characteristics, significant differences between the deceased and surviving groups were observed for diabetes mellitus ($p=0.001$) and heart failure ($p<0.001$) (**Table 1**). In contrast, sex distribution did not differ significantly between groups ($p=0.135$). Likewise, no significant between-group differences were observed for body weight ($p=0.952$), height ($p=0.245$), body mass index ($p=0.281$), duration of CAPD ($p=0.120$), or smoking history ($p=0.169$). Hypertension and the other recorded comorbid conditions were also not significantly associated with mortality (**Table 1**).

Table 1. Baseline characteristics and comparations between deceased and survivor groups of patients with continuous ambulatory peritoneal dialysis (CAPD)

Characteristic	Deceased group (n=89)	Survivor group (n=288)	*p*-value
	Frequency (%)	Frequency (%)	
Age (year), mean±SD	44.78±16.82	40.72±14.34	0.021[c]
Sex			
Male	50 (13.2)	187 (49.6)	0.135[a]
Female	39 (10.3)	101 (26.7)	0.135[a]
Weight, mean±SD	57.39±8.13	58.86±11.20	0.952[b]
Height, mean±SD	158.62±5.63	160.4±8.08	0.245[b]
Body mass index (kg/m²), mean±SD	22.74±2.51	22.74±3.16	0.281[b]

Characteristic	Deceased group (n=89)	Survivor group (n=288)	*p*-value
	Frequency (%)	Frequency (%)	
Duration of CAPD treatment, mean (month)	17.64	21.23	0.120[b]
Smoking	1 (0.3)	12 (3.2)	0.169[a]
Comorbidity			
Diabetes	9 (2.4)	80 (21.2)	0.001[a]
Hypertension	89 (23.6)	286 (75.9)	0.431[a]
Heart failure	13 (3.4)	131 (34.7)	0.000[a]
Malignant lymphoma	0 (0.0)	0 (0.0)	-
Leukemia	0 (0.0)	0 (0.0)	-
Chronic obstructive pulmonary disease	1 (0.3)	5 (1.3)	0.687[a]
Dementia	0 (0.0)	0 (0.0)	-
Rheumatology (SLE, RA, SSc, Sjogren)	1 (0.3)	6 (1.6)	0.558[a]
Peptic ulcer	2(0.5)	4 (1.1)	0.572[a]
Hepatitis B/C	0 (0.0)	9 (2.4)	0.091[a]
Coronary heart disease	1 (0.3)	1 (0.3)	0.378[a]
Stroke	4 (1.1)	4 (1.1)	0.076[a]
Peripheral arterial disease (PAD)	1 (0.3)	0 (0.0)	0.072[a]

RA: rheumatoid arthritis; SD: standard deviation; SLE: systemic lupus erythematosus; SSc: systemic sclerosis
[a] Analyzed with Chi-square test
[b] Analyzed with Mann-Whitney test
[c] Analyzed with independent t-test

Association between Charlson Comorbidity Index (CCI) and CAPD mortality

Logistic regression analysis showed no significant association between CCI risk category and mortality among CAPD patients. No statistically significant association was observed in the low-risk category (p=0.974), the moderate-risk category (p=0.857), or the high-risk category (p=0.845). The detailed results are presented in **Table 2**.

Table 2. Logistic regression analysis showing the associations between Charlson Comorbidity Index (CCI) categories and CAPD mortality

Charlson Comorbidity Index	Outcome		Odds ratio	95% confidence interval	*p*-value
	Deceased (n=89)	Survivor (n=288)			
Low risk, n (%)	79 (21.0)	256 (67.9)	1.013	0.477–2.151	0.974
Moderate risk, n (%)	7 (1.9)	21 (5.6)	0.921	0.378–2.245	0.857
High risk, n (%)	3 (0.8)	11 (2.9)	1.138	0.310–4.174	0.845

Association between Wright-Khan Index and CAPD mortality

Associations between WKI and CAPD mortality are presented **Table 3**. WKI was significantly associated with mortality among CAPD patients. In the low-risk category, lower odds of mortality were observed compared to moderate- and high-risk categories (OR=0.400; 95%CI: 0.221-0.723; p=0.002). In the moderate-risk category, higher odds of mortality were identified (OR=3.130; 95%CI: 1.497-6.545; p=0.002) compared to low- and high- risk categories. By contrast, no significant association was observed in the high-risk category (p=0.664) (**Table 3**).

Table 3. Logistic regression analysis showing the associations between Wright-Khan Index (WKI) categories and CAPD mortality

Wright-Khan index	Outcome		Odds ratio	95% confidence interval	*p*-value
	Deceased (n=89)	Survivor (n=288)			
Low risk, n (%)	73 (19.4)	186 (49.3)	0.400	0.221–0.723	0.002
Moderate risk, n (%)	9 (2.4)	75 (19.9)	3.130	1.497–6.545	0.002
High risk, n (%)	7 (1.9)	27 (7.2)	1.212	0.509–2.885	0.664

Survival analysis based on CCI and WKI

Kaplan-Meier analysis demonstrated differences in survival probability across the risk categories of both indices (**Figure 1**). For CCI, the high-risk category showed the most pronounced decline in survival compared with the low- and moderate-risk categories (**Figure 1A**). For WKI, the low-

risk category showed the highest and most stable survival probability throughout follow-up, whereas the moderate- and high-risk categories showed a greater decline over time (**Figure 1B**).

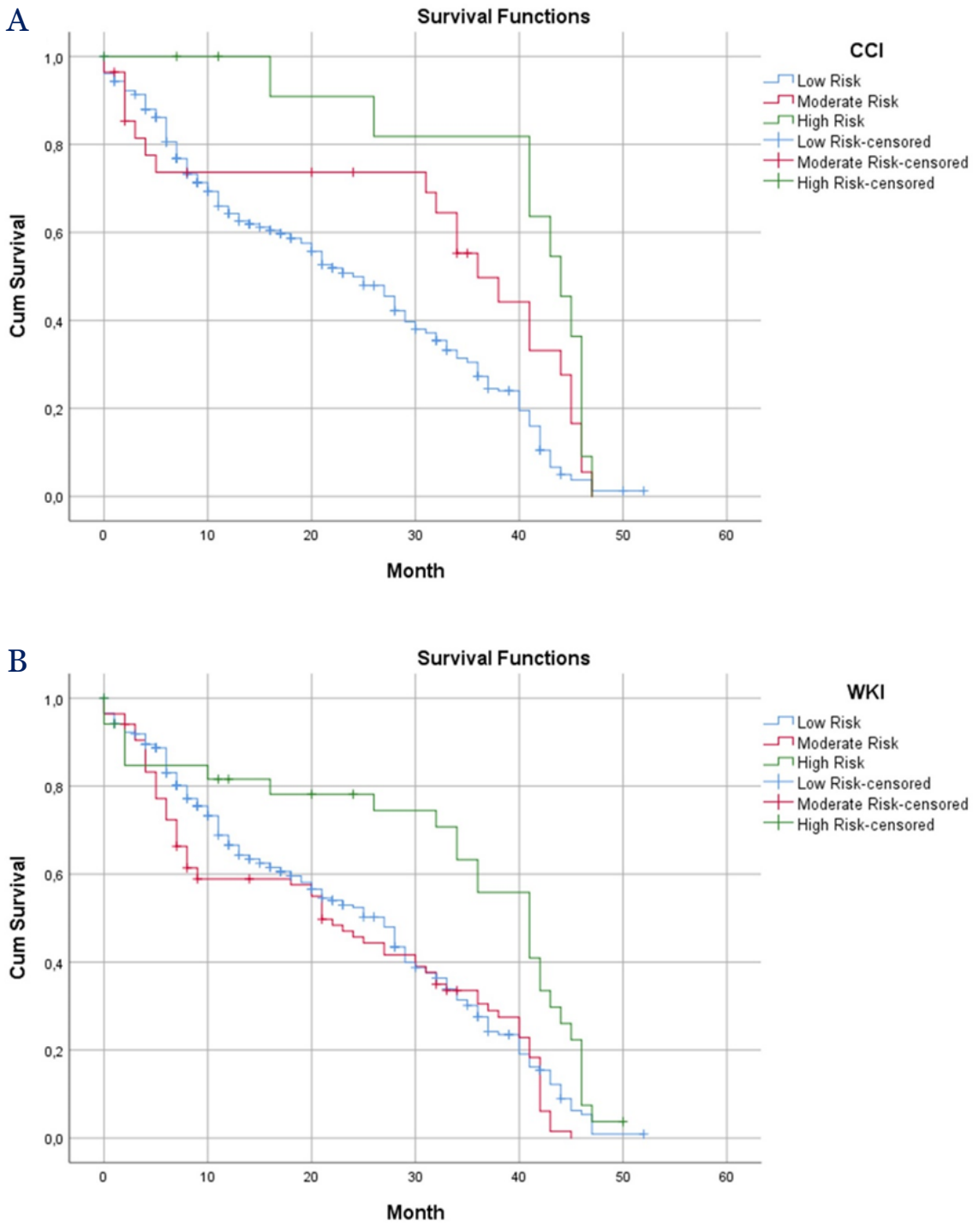

Figure 1. Survival probability of continuous ambulatory peritoneal dialysis (CAPD) patients according to Charlson comorbidity index (CCI) and Wright-Khan index (WKI) risk categories. (A) Survival analysis according to CCI categories. (B) Survival analysis according to WKI categories.

Discussion

This study included 377 patients undergoing CAPD and showed that WKI had a stronger association with mortality than CCI in this cohort. This finding suggests that an index incorporating both age and comorbidity burden may provide better mortality discrimination than an index based primarily on weighted comorbid conditions. Previous studies have shown that the prognostic performance of comorbidity indices varies across CKD populations and that indices

incorporating additional clinical dimensions, including age, may show improved predictive utility [14-16]. However, because the present analysis was based primarily on unadjusted associations, these findings should be interpreted as comparative associations rather than definitive evidence of superior predictive performance. Potential confounding variables were not fully adjusted for and may have influenced the observed differences between indices.

When WKI risk categories were examined separately, significant associations with mortality were observed in the low- and moderate-risk groups, whereas the high-risk category did not reach statistical significance. This pattern may indicate that the discriminatory utility of WKI was greater among patients with low to moderate baseline risk than among those with a very high disease burden. A similar reduction in discriminative performance in high-risk strata has been reported for comorbidity indices in other dialysis populations and may reflect a ceiling effect, limited subgroup size, or the influence of non-comorbidity factors such as nutritional status, dialysis adequacy, inflammatory burden, infection, and quality of care [17,18]. The lack of significance in the high-risk category should therefore be interpreted cautiously and not be taken to indicate the absence of clinical risk in this subgroup.

The association between comorbidity burden and mortality in CAPD patients can be understood through the concepts of multimorbidity, reduced physiological reserve, and cumulative biological stress [19]. Advanced CKD is accompanied by cardiovascular, metabolic, inflammatory, and immunologic disturbances that reduce homeostatic reserve and increase vulnerability to adverse events [20]. Comorbid conditions such as diabetes mellitus, cardiovascular disease, and heart failure may amplify this vulnerability through endothelial dysfunction, chronic inflammation, malnutrition, hemodynamic instability, and multi-organ injury [21,22]. In addition, age - a component explicitly incorporated into WKI - is closely linked to frailty, immunosenescence, reduced resilience, and increased susceptibility to infectious and cardiovascular complications [23,24]. From this perspective, an index that integrates both age and comorbidity burden may be biologically more aligned with mortality risk in CAPD patients than an index that quantifies comorbid disease burden alone [26].

Several clinical implications may be drawn from this study. First, the WKI may provide a practical approach for identifying CAPD patients at increased risk of death. Second, more accurate risk stratification may facilitate closer surveillance and more individualized clinical follow-up, particularly among patients in the moderate- and high-risk categories. Third, these findings may support the development of broader prognostic models that combine comorbidity burden with other important clinical factors, including nutritional status, inflammatory burden, and dialysis adequacy. Finally, improved risk stratification may help optimize resource allocation and strengthen the long-term management of CAPD care.

Several limitations should be acknowledged when these findings are interpreted. The retrospective design based on medical records may have introduced information bias. The relatively small number of patients in the high-risk WKI subgroup may have reduced statistical power and limited the precision of the estimates in that category. Because the study was conducted at a single center, the generalizability of the findings to other CAPD populations may be limited. In addition, several potentially important confounding variables, including nutritional status, inflammatory burden, dialysis adequacy, and treatment adherence, were not included in the analysis. Only 2 comorbidity indices were evaluated, and formal discrimination analyses, such as area under the receiver operating characteristic curve, were not performed.

Conclusion

WKI showed a stronger association with mortality than CCI among patients undergoing CAPD, particularly in the low- and moderate-risk categories. Its incorporation of both age and comorbidity burden may better reflect mortality risk in CAPD patients. However, further multicenter studies with larger sample sizes, more complete adjustment for confounding variables, and formal predictive performance analyses are needed before either index can be recommended as the preferred prognostic tool in CAPD practice.

Ethics approval

This study was approved by the Ethics Committee of RSUD Dr. Saiful Anwar Malang (approval number: 400/029/K.3/102.7/2024). Patient confidentiality was maintained and no direct intervention was performed. The data were used only for research purposes, and all patient information was coded to ensure anonymity.

Acknowledgments

None.

Competing interests

The authors declare that there are no competing interests.

Funding

This study received no external funding.

Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

Artificial intelligence tool, ChatGPT, used for language refinement. All AI-assisted output was critically reviewed and edited by the authors, and full responsibility for the accuracy, interpretation, and final content of the manuscript was retained by the authors.

How to cite

Pratama EJP, Samsu N, Rifai A. Comparison of the Charlson Comorbidity Index and Wright-Khan Index for predicting mortality in continuous ambulatory peritoneal dialysis (CAPD) patients. Narra Intern Med 2026; 1(1): e6 - http://doi.org/10.52225/narraim.v1i1.6.

References

1. Vale L, Cody J, Wallace S, *et al*. Continuous ambulatory peritoneal dialysis (CAPD) versus hospital or home haemodialysis for end-stage renal disease in adults. Cochrane Database Syst Rev 2004;2004(4):CD003963.
2. Wulandari W, Alfaqeeh M, Zakiyah N, *et al*. Health-related quality of life in patients end-stage kidney disease with hypertension: Hemodialysis vs continuous ambulatory peritoneal dialysis using EQ-5D-5L at a tertiary center in Indonesia. Int J Nephrol Renovasc Dis 2025;18(1):387-402.
3. He J, Wu B, Zhang Y, *et al*. Prognosis of urgent initiation of peritoneal dialysis: A systematic review and meta-analysis. Ren Fail 2024;46(1):2312533.
4. Hustrini NM, Susalit E, Lydia A, *et al*. The etiology of kidney failure in Indonesia: A multicenter study in tertiary-care centers in Jakarta. Ann Glob Health 2023;89(1):36.
5. Zhang F, Liu H, Gong X, *et al*. Risk factors for mortality in Chinese patients on continuous ambulatory peritoneal dialysis. Perit Dial Int 2015;35(2):199-205.
6. Sianturi DA, Gunawan A. Peritonitis as the cause of death of CAPD patients at RSUD Dr. Saiful Anwar Malang 2014-2020. Clin Res J Intern Med 2022;3(1):239-244.
7. Harrison C, Fortin M, van den Akker M, *et al*. Comorbidity versus multimorbidity: Why it matters. J Multimorb Comorb 2021;11(1):2633556521993993.
8. Wang L, He Y, Han C, *et al*. Global burden of chronic kidney disease and risk factors, 1990-2021: An update from the global burden of disease study 2021. Front Public Health 2025;13(1):1542329.
9. Alonso J, Vilagut G, Chatterji S, *et al*. Including information about co-morbidity in estimates of disease burden: Results from the World Health Organization World Mental Health Surveys. Psychol Med 2011;41(4):873-886.
10. Comoglu S, Kant A. Does the Charlson comorbidity index help predict the risk of death in COVID-19 patients? North Clin Istanb 2022;9(2):117-121.
11. Fayez R, Roy M, Villeneuve S, *et al*. Canadian surgery forum. Can J Surg 2012;55(4 Suppl 1):S63-S135.

12. Aljawadi MH, Babaeer AA, Alghamdi AS, *et al*. Quality of life tools among patients on dialysis: A systematic review. Saudi Pharm J 2024;32(3):101958.
13. Cuschieri S. The STROBE guidelines. Saudi J Anaesth 2019;13(Suppl 1):S31-S34.
14. McArthur E, Bota SE, Sood MM, *et al*. Comparing five comorbidity indices to predict mortality in chronic kidney disease: A retrospective cohort study. Can J Kidney Health Dis 2018;5(1):2054358118805418.
15. Soos B, Williamson T, McBrien K, *et al*. Considerations for selecting and implementing comorbidity indices when using secondary data sources: A guide for health researchers. Int J Popul Data Sci 2025;6(1):2973.
16. Sakaci T, Ahbap E, Koc Y, *et al*. Clinical outcomes and mortality in elderly peritoneal dialysis patients. Clinics (Sao Paulo) 2015;70(5):363-368.
17. Yu Y, Li F, Wang Z, *et al*. Predictive accuracy of comorbidity index models in assessing mortality risk among hemodialysis patients: A comprehensive single-center observational cohort study. Aging Med (Milton) 2024;7(6):737-743.
18. Jia W, He W, Chen Z, *et al*. Determinants of dialysis adequacy in maintenance hemodialysis patients: A cross-sectional study on modifiable risk factors and clinical interventions. BMC Nephrol 2025;26(1):369.
19. Gomez AT, Kiberd BA, Royston JP, *et al*. Comorbidity burden at dialysis initiation and mortality: A cohort study. Can J Kidney Health Dis 2015;2(1):34.
20. Rapa SF, Di Iorio BR, Campiglia P, *et al*. Inflammation and oxidative stress in chronic kidney disease-potential therapeutic role of minerals, vitamins and plant-derived metabolites. Int J Mol Sci 2019;21(1):263.
21. Tomic D, Shaw JE, Magliano DJ. The burden and risks of emerging complications of diabetes mellitus. Nat Rev Endocrinol 2022;18(9):525-539.
22. Cozzolino M, Magagnoli L, Ciceri P. From physicochemical classification to multidimensional insights: A comprehensive review of uremic toxin research. Toxins (Basel) 2025;17(6):295.
23. Goyani P, Christodoulou R, Vassiliou E. Immunosenescence: Aging and immune system decline. Vaccines (Basel) 2024;12(12):1314.
24. Grigoras G, Ilie AC, Turcu AM, *et al*. Resilience and intrinsic capacity in older adults: A review of recent literature. J Clin Med 2025;14(21):7729.
25. Fogel DB. Factors associated with clinical trials that fail and opportunities for improving the likelihood of success: A review. Contemp Clin Trials Commun 2018;11(1):156-164.
26. Imam Z, Odish F, Gill I, *et al*. Older age and comorbidity are independent mortality predictors in a large cohort of 1305 COVID-19 patients in Michigan, United States. J Intern Med 2020;288(4):469-476.